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Reasonably Foreseeable Development (RFD) Scenario
for
Potash in the Moab Master Leasing Plan Area

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Reasonably Foreseeable Development (RFD) Scenario for Potash in the Moab Master Leasing Plan Area (MMLPA), BLM Canyon Country District

I. SUMMARY

A reasonably foreseeable development (RFD) scenario for potash is a long term (15 year) projection of potash activity within the Moab Master Leasing Plan area (planning area). This document is intended to project a baseline scenario of potash exploration, development, production, and reclamation activities within the planning area. This information will aid the Bureau of Land Management (BLM) land use planning process by providing a mechanism to analyze the effects that discretionary leasing management decisions may have on pot ash development, local and regional economies, and important resource values such as air quality, cultural resources, wildlife, and recreation.

The planning area encompasses about 946,469 acres (all acreage calculations were generated in GIS) in Grand County and San Juan County, Utah. The majority of lands within the planning area (83 percent) are public lands administered by the BLM. State lands total about 14 percent of the planning area and the remaining 3 percent of the lands are in private ownership.

Potash is the generic term for a variety of ore-bearing minerals, ores, and refined products, all containing the element potassium in water-soluble form.

Potash resources within the planning area are found within the Paradox Formation deposited in the Paradox Basin during the Pennsylvanian Period. The entire planning area is underlain by the Paradox Formation. Twenty nine evaporite cycles containing salts have been identified in the Paradox Formation. Potash is known to be present in 18 of the evaporite cycles, but only 11 of these layers contain potentially commercial deposits.

Potash deposits in the Paradox Basin were initially discovered during the exploration for oil and gas during the 1920's. The onset of using radioactive logs while drilling for oil and gas in the 1950's increased the ability to identify potash zones in the well bore. The Cane Creek Mine, the only mine producing potash in the planning area and the Paradox Basin, began as a conventional underground mining operation in 1963 and converted to a solution mining and solar evaporation processing operation in the 1970s.

The BLM estimates that 129,999 acres of the planning area have a high development potential for potash and about 375,895 acres have a moderate to high potential for potash.

The United States is the largest consumer of potash and imports about 80 percent of the potash used mainly from Canada. About 85 percent of US potash sales are to the fertilizer industry and the principal use of potash worldwide is as an agricultural fertilizer. Growing world population and its need for food will require continued growth in both potash production and consumption.

Growing demand for potash in association with the sharp rise in potash prices in 2008 ($900 per tonne) and continuing high prices through 2012 ($470 per tonne) have sparked a renewed interest

in the potash resources of the Paradox Basin and the planning area. Though the price of potash dropped to $470 per tonne in 2012 and has slowly declined and hovered near $387 per tonne, the interest in potash resources within the Paradox Basin has remained high. The Paradox Basin contains over 25 percent of the known potash resources in the United States.

The baseline RFD scenario for potash within the planning area for the next 15 years is summarized as follows:

- Exploration drilling conducted on prospecting permits is projected at 74 wells and will require 4.5 acres of surface disturbance per well for a total surface disturbance of 333 acres. It is estimated that 50 percent of the wells will be successfully reclaimed during the life of the Moab Master Leasing Plan (15 years) for a total net surface disturbance of about 166 acres.
- Exploration drilling conducted within Known Potash Leasing Areas is projected at 19 wells and will require 4.5 acres of surface disturbance per well for a total surface disturbance of 86 acres. It is estimated that 50 percent of the wells will be successfully reclaimed during the life of the Moab Master Leasing Plan (Moab MLP) for a total net surface disturbance of about 43 acres.
- Two geophysical exploration operations for potash are projected over the next 15 years. This would amount to a total of about 1,200 acres of surface disturbance. It is estimated that the surface disturbance would be successfully reclaimed within the 15 year time frame, resulting in no net surface disturbance.
- Potash development will entail solution mining and processing methods utilizing solar evaporation and crystallization.
- Annual potash production is projected at 2.4 million tons. Out of this amount, 2 million tons will be processed annually by crystallization methods and 400,000 tons will be processed annually by solar evaporation methods.
- A total of 2,400 acres of surface disturbance will result from the construction of solar evaporation ponds. The associated processing plant(s) will result in an additional 1,316 acres of surface disturbance.
- A total of 500 acres of surface disturbance will result from the construction of a crystallization processing plant.
- Production drilling is projected at 32 wells per year where about 4 wells are drilled from a centralized pad which involves about 6 acres of surface disturbance. Eight pads a year will be developed beginning in Year 3 of the Moab MLP life for a total surface disturbance of about 624 acres.
- Drilling for water wells, disposal wells, and monitoring wells is projected at about 40 wells and will require 4.5 acres of surface disturbance per well for a total surface disturbance of 180 acres. Interim reclamation could reduce the net surface disturbance during the life of the Moab MLP to about 100 acres.

These baseline projections represent approximate activity levels over the next 15 years and are not intended to be thresholds for limiting future activity. Potash exploration and development activity tends to be sporadic over time due to market influences and other factors affecting the potash industry. Because of this, it is recognized that during the next 15 years there may be

some years when potash activity in the planning area would be much less than the projected average levels and other years when activity may be much greater.

II. INTRODUCTION

The BLM is preparing a reasonably foreseeable development (RFD) scenario for potash as part of the Moab Master Leasing Plan (Moab MLP) process established by Washington Office Instruction Memorandum No. 2010-117. Although this policy is specific to oil and gas leasing, the principals involved are also applicable to potash leasing within the planning area. The Moab MLP process will provide additional land use planning and analysis prior to new leasing of potash in the planning area. The BLM determined that the land use plans for the Moab and Monticello Field Offices completed in 2008 did not adequately address the magnitude of potash development now evident.

This RFD is a technical report intended to project a baseline scenario of potash exploration, development, production and reclamation to aid the BLM with land use planning. The RFD provides a mechanism to analyze the effects that discretionary leasing management decisions may have on potash development, local and regional economies, and important resource values such as air quality, cultural resources, wildlife, and recreation. The RFD projects the level of potash activity that can reasonably be expected to occur in the planning area over the life of the Moab MLP (15 years). As part of the planning process, the BLM will prepare an Environmental Impact Statement (EIS) to comply with the National Environmental Policy Act (NEPA). The RFD is neither a planning decision nor the "No Action Alternative" in the NEPA document.

The Moab MLP area (planning area) includes a total of approximately 946,469 acres of which approximately 783,381 acres are public lands administered by the BLM Moab and Monticello Field Offices within the Canyon Country District (Map 1). The planning area is located within Grand and San Juan Counties, Utah. Table 1 provides the status and acreage breakdown of all lands within the planning area.

Table 1. Status of Lands in the Planning Area

Land status	Moab FO	Monticello FO	Planning Area Total
	acres	acres	acres
BLM	579,438	203,943	783,381
State	93,971	32,310	126,281
State Parks	4,337	40	4,377
Private	17,873	14,557	32,430
Split Estate*	9,599	5,281	14,880
Total	**695,619**	**250,850**	**946,469**

*Acreage not Additive
Source: BLM Canyon Country District

Development projections in the baseline scenario assume that all potentially productive areas are open for leasing under standard lease terms and conditions except those areas designated as closed to leasing by law, regulation, or executive order. Since there are no lands within the planning area that are closed to leasing by such authority, the RFD baseline projections assume that all lands in the planning area are available for leasing with standard lease terms. This

includes lands where Federally owned minerals underlie surface acreage that is not administered by the BLM (split estate).

The rules regarding the management of potash resources on Federal lands are found in the Federal regulations at 43 CFR 3500 and the Mineral Leasing Act of 1920 as amended. The basic components of these rules involve competitive and noncompetitive leasing. Known Potash Leasing Areas (KPLAs) are areas of known valuable potash deposits. Potash resources within a KPLA are leased competitively. Potash resources outside a KPLA are leased through a noncompetitive process involving prospecting permits and preference right leases. If a valuable potash deposit is identified as the result of exploration conducted under a prospecting permit, then the permittee is eligible for a preference right lease.

III. DESCRIPTION OF THE GEOLOGY PERTAINING TO POTASH RESOURCES

Potash is the generic term for a variety of ore-bearing minerals, ores, and refined products, all containing the element potassium in water-soluble form. It was originally used to describe the mixture of potassium carbonate and potassium hydroxide crystals which were recovered in heated iron "pots" from boiling the washings of wood (or other plant) "ashes" (Warren, 2006), thus the term pot ash.

Potash resources within the planning area were deposited during the Pennsylvanian Period approximately 300 million years ago. The Pennsylvanian Period in the planning area is characterized by the active uplift of the Uncompahgre highland and the associated development of the rapidly subsiding Paradox Basin along the southwest margin of the uplift. The Paradox Basin (Map 2), which encompasses the entire planning area, is a northwest-southeast trending, oval-shaped, asymmetrical basin that is approximately 180 miles long and 100 miles wide (Merrell, 1979). The Paradox Basin is located primarily in Utah and Colorado with edges in Arizona and New Mexico. Northwest-trending zones of previous fracturing and weakness in the Precambrian basement controlled the location of faults bounding the Uncompahgre Uplift, as well as other salt-induced structures that developed within the Paradox Basin (Doelling and others, 1988). The northernmost, basin-bounding Uncompahgre fault has the greatest amount of displacement and differs from most other major faults in the Paradox Basin by having the down dropped block on the southwest side of the fault. The planning area includes the deeper, more complex portion of the Paradox Basin, termed the "fold and fault' belt portion, as opposed to the stable shelf part (Blanding sub-basin) that occurs outside the planning area to the south. The Pennsylvanian Period saw the deposition of 4,000 to 5,000 feet of open-marine shale and restricted-sea bedded salt and anhydrite deposits in the planning area.

Within the Paradox Basin portion of the planning area, potash (potassium bearing) deposits, comprised primarily of sylvite (potassium chloride) and carnallite (hydrated potassium magnesium chloride), and halite (sodium chloride) are found in the Pennsylvanian Paradox Formation. These minerals do not occur together everywhere within the Paradox Basin. Within the saline Paradox Formation facies, the area of potash mineralization is limited to the deeper part of the basin, an area totaling approximately 2,800 square mile (Dames and Moore, 1978). Both sylvite and carnallite occur in varying portions throughout most potash deposits, but

sylvite, with a higher weight percent of potassium, is dominant in those horizons under economic consideration (Hite, 1959; Dames and Moore, 1978; Gloyn and others, 1995).

The original non-deformed evaporite sequence ranged from 0 to 8,000 feet thick, progressing from the Paradox Basin's margins to its depositional center. Diapiric structures have locally created sections of salt up to 14,000 feet thick, but such flowage has often destroyed the continuity of the potash-bearing layers (Hite, 1964). Most of the interest in potash and salt deposits in the Paradox Basin has been concentrated outside the fold and fault belt. On the northeastern side of the Paradox Basin, anticlines such as the Moab and Salt Valley bring potash beds to the surface, but within these strongly folded diapiric structures the potash beds are so complexly faulted, folded, and contorted within the thickened salt section that their continuity is destroyed (Hite, 1960; Ritzma and Doelling, 1969). Non-diapiric salt anticlines outside the fold and fault belt are more attractive targets for potash deposits because they are characterized by structurally thickened salt cores where continuous potash beds are relatively close to the surface, The more simple or non-diapiric anticlinal structures occur towards the western portion of the Paradox Basin and the planning area. The only production of potash and by-product salt in the Paradox Basin (Cane Creek Mine) has occurred on one of these simple structures (Cane Creek anticline).

Twenty nine evaporite (salt) cycles have been identified in the Paradox Formation. The salt cycles are numbered 1 through 29 beginning with the uppermost cycle. Potash is one of the last salts to precipitate during evaporite formation, and if present, is generally found near the top of each evaporite cycle. Potash is known to be present in 18 of the saline cycles, but only 11 of these layers contain potentially commercial deposits (Hite, 1964; Dames and Moore, 1978). The limit of salt deposition and the limit of major potash deposition in the Paradox Basin are shown on Map 2.

IV. PAST AND PRESENT POTASH EXPLORATION ACTIVITIY

Potash deposits in the Paradox Basin were initially discovered during the exploration for oil and gas during the 1920's. The earliest documented discoveries of potash were from oil and gas wells drilled in 1922 south of Thompson and 1924 near Moab (Durgin, 2011; Ringbolt, 2012). An oil and gas well drilled by the Crescent Eagle Oil Company in 1924, near Thompson, Utah encountered salt at a depth of 3,150 feet. The salt was analyzed and found to contain a mixture of sylvite and carnallite (USGS, 1960 and Dyer, 1945). This discovery sparked interest in potash exploration and the Federal Government issued 68 prospecting permits. Most of the wells drilled under the prospecting permits did not encounter potash resources because they were shallow and did not intercept the potash zone (Dyer, 1945).

The onset of using radioactive logs while drilling for oil and gas in the 1950's increased the ability to identify potash zones in the well bore (Hite, 1977). Potassium, the key element in potash, has a radioactive isotope that appears as a peak on a gamma log. This makes it easier to identify the depth and thickness of the potash resources.

In 1949, Emmet Spencer filed prospecting permit applications on Federal lands in the Seven Mile area. These permits were issued in 1951. Based on the results of drilling on these permits,

preference right leases were issued in 1955. Delhi Oil, Texas Gulf Sulfur, and Freemont Petroleum, and others were involved with the exploration conducted on the prospecting permits.

Additional historical accounts of potash exploration in the planning area are as follows:

- 1953: Delhi Oil Company (Delhi) drilled 10 wells on one-half mile centers in the Seven Mile area (seven miles northwest of Moab) and identified a large source of potash.
- 1956: Delhi identified a large potash deposit at Cane Creek (Durgin, 2013).
- 1956: Exploration identifies large potash deposits in the Cane Creek anticline (Morgan and others, 1991).
- 1960: Delhi-Taylor Oil Corporation sold property at Cane Creek that was withdrawn from oil and gas leasing to encourage the development of potash to Texas Gulf Sulfur (Graham v. Texas Gulf Sulfur Company, 457 F.2d 418 (1972)).
- 1961: The BLM issued prospecting permits, on lands located at T. 25 S., R. 20 and 21 E., to Guy Pitts and a preference right lease was issued in 1965. Additional prospecting permits were issued and a well was drilled in 1964 (Well #7-2, lot 3, sec. 7, T. 25 S., R. 21 E.).
- 1962: The Long Canyon Unit #1 well was drilled to a depth of 6,000 feet and a substantial amount of brine (saline water) was encountered. In another well near the Long Canyon Unit #1 well, the brine was artesian and drilling had to be suspended (Dugin, 2011). This brine was analyzed at 468,000 total dissolved solids (mg/l) with a pH of 3.0.
- 1973: Buttes Resources filed prospecting permit applications (PPAs) on Federal lands in the Ten Mile area, which were located west of Arches National Park.
- 1984: Buttes Resources was issued four Federal potassium preference right leases.
- 1985: Reunion Potash, who acquired Buttes Resources, filed for an additional 11 PPAs adjacent to their leases. These PPAs are currently pending subject to the outcome of an appeal regarding the designation of the Ten Mile KPLA.

Since the preference right leases were issued in the 1980's, potash prices remained depressed and there was little interest in the exploration and mining for potash until potash prices rose sharply in 2008. This spike in potash prices resulted in renewed interest in the potash resources of the Paradox Basin which is evident by the submission of 223 PPAs to the BLM within the planning area. The following exploration activities have occurred in the planning area since 2008:

- 2011: Pinnacle Potash drilled a potash exploration well near Crescent Junction on State lands under the jurisdiction of the Utah State Institutional Trust Lands Administration (SITLA) (Stokes, 2012).
- 2011: K2O drilled three wells at Hatch Point on State lands that are under the jurisdiction of SITLA. It was reported that major potash deposits were found in two of the three wells (Potash Minerals Limited, 2012).
- 2012: K2O submitted an exploration plan to drill five wells on prospecting permit applications that it filed on Federal lands in 2008 near Hatch Point.
- 2012: American Potash submitted an exploration plan to drill four wells on prospecting permit applications that it filed on Federal lands in 2008 and 2012 near the Ten Mile Wash area.

- 2010 – 2012: American Potash submitted an exploration plan to drill four locations on State lands under the jurisdiction of SITLA, three locations have been bonded by the Utah Division of Oil Gas and Mining (Munson, 2012).

No Federal potash leases have been issued within the planning area since 1985.

In the past, geophysical exploration has occurred in all portions of the planning area. However, this exploration has been for oil and gas. Based on BLM records, none of the 16 geophysical projects completed within the planning area since 1982 (BLM, 2014) were for potash.

V. PAST AND PRESENT POTASH DEVELOPMENT ACTIVITY

The Cane Creek Mine is located along the northern bank of the Colorado River and began as a conventional underground (room and pillar) mining operation for potash in 1963. The mining operation was plagued by difficulties such as a methane explosion in August 1963 (Rogers-Iversen, 1963), floor heaves, sharp folding, brine pockets, and other issues. In 1970, the mine started changing over from conventional underground mining to underground in-place (in-situ) solution mining utilizing water from the Colorado River and solar evaporation ponds. Since 1972, the Cane Creek operation has been solution mining by pumping water from the Colorado River into the old workings of the Cane Creek Mine. The water dissolves the potash and the resulting brine is pumped to the surface. The salts, including sylvinite (a mixture of halite and sylvite), are precipitated in the solar ponds and then processed to produce sylvite. Halite (or "table-road salt") is also produced as a by-product. Currently, the operation produces about 100,000 tons of sylvite per year and has produced up to 260,000 tons of halite per year in the past.

Intrepid Potash, LLC acquired the Cane Creek Mine operation in the year 2000 and thereby obtained the only producing mine in the Paradox Basin. The mine is located within the Cane Creek KPLA which is comprised of State, private, and Federal lands. In 1985, the BLM issued a Federal potash lease within the KPLA which adjoins the Cane Creek Mine property. The lease was issued to the predecessors of Intrepid Potash.

In April 2002, well 27H was begun at the Cane Creek Mine and construction of a multilateral cavern system started when well 28H was drilled utilizing horizontal drilling techniques and technology. This cavern system was developed in salt cycle 9 by flushing the wells with fresh water, thus enlarging the wells to a sufficient diameter to begin commercial production. The greatest difficulty was keeping the drill bit in the ore horizon because the gamma meter, utilized for detecting potash, was 35 feet behind the drill bit (Harvey and others, 2006). This well is currently supplementing their production from the old workings in salt cycle 5. Solution mining in salt cycle 9 is expected to increase in the future and will provide additional production to the operation. In 2012, Intrepid Potash drilled a number of new wells into salt cycle 9 for the purpose of establishing production from the new wells.

In 1984, four preference right leases were issued to Buttes Resources (now owned by Reunion Potash). These leases have yet to go into production. One of the exploration wells used to

support the issuance of a preference right lease was not plugged and remains open and bonded for production purposes.

The leases in the Seven Mile area, now owned by Spencer and Pitts, are in the process of cancellation due to non-payment of rentals.

Conflicts with other Mineral Development

The planning area has a high potential for development of oil and gas. In addition to the high potential for development of oil and gas resources in the planning area, there is also a moderate potential for development of uranium and associated vanadium. A strong potash market in recent years has spurred activity in the planning area, including a total of approximately 223 PPAs since 2008 and four exploration drill holes on state lands since 2010. This activity suggests that potash development in the planning area during the next 15 years is also likely.

There is little potential for conflict between uranium mining operations and oil, gas or potash drilling. The Mesozoic sandstones which are the primary host to the uranium deposits in the planning area are much shallower (less than 2,000 feet) than are the deeper (6,000 – 9,000 feet) Paleozoic formations hosting the oil and gas reservoirs and potash deposits in the planning area. Although oil, gas and potash drilling would penetrate the potential uranium formations, uranium mines have been historically small enough that oil and gas exploration and development could easily be sited to avoid small underground uranium mining operations. In the past, there have been no unresolved conflicts between oil and gas and uranium operations. The same would be expected for uranium operations and any future potash drilling.

Nearly a quarter of the planning area is covered by Federal oil and gas leases. These leased lands overlap, in large part, with the area of pending potash prospecting permit applications (roughly 416,464 acres). Potash deposits occur in the Pennsylvanian Paradox Formation. Oil and gas wells penetrate potential potash bearing intervals in the Paradox Formation to reach the Cane Creek Shale interval and the deeper Paleozoic reservoirs. In most cases, there would be adequate leeway in selecting well sites for either oil and gas, or potash exploration drilling to avoid conflicts.

Due to the depth of the potash deposits within the planning area, future potash development is expected to use solution mining methods. Potash mining operations would be more problematic than exploratory drilling in terms of avoiding conflicts between oil and gas, and potash development. Underground voids created by solution mining in potash zones could introduce more challenges and costs to drilling for oil and gas in order to address lost circulation of drilling fluids and, to ensure adequate measures for well control. Oil and gas development may also be encumbered by surface facilities associated with potential potash solution mining operations, depending on size and location. However, potential conflicts between potash and, oil and gas development may be mitigated somewhat by enhanced horizontal drilling technology which provides greater latitude in well site selection.

Known Potash Leasing Areas (KPLAs) and Leasing Activity

In accordance with the Mineral Leasing Act of 1920, as amended (30 USC 181 et seq.), lands are classified as a KPLA where it is determined that a known valuable deposit of potash exists. The BLM was granted the authority for classifying lands as a KPLA, where leases are issued competitively, in the 1980s. Prior to this time, classifications were the responsibility of the United States Geological Survey.

Two KPLAs were established within the planning area in the 1960s as a result of exploration activity for both oil and gas and potash. The Seven Mile KPLA was established on May 18, 1960 and includes about 5,156 acres. The Cane Creek KPLA was established on March 15, 1965 and includes about 34,696 acres.

In January 2009, the BLM established new standards for defining a KPLA within the Paradox Basin. These standards are as follows:

- Potash identified with a minimum grade of 10 percent K_2O (potassium oxide) equivalent in a chloride ore bed (Note: Potash is sold on the basis of its oxide or K_2O equivalent content. For example, chemically pure KCl (potassium chloride) contains 52.44 percent K or 63.17 percent K_2O equivalent. Converting from K (potassium) to K_2O or vice versa is a simple calculation: percent K_2O = percent K x 1.2; percent K = percent K_2O x 0.83).

- Potash identified in a chloride ore bed that is at least 4 feet in thickness and located within a 2.5 mile radius of a drill hole.

The new Ten Mile KPLA (90,152 acres) was established within the planning area on May 5, 2012 utilizing the new standards and is based on two reports: Technical Evaluation of the Proposed Ten Mile Known Leasing are for Potassium, Paradox Basin of Grand County, Utah (Boleneus, 2007) and the Valuable Deposit Determination for the Proposed Ten Mile Known Potash Leasing Area, Paradox Basin of Grand County, Utah (Perkes, 2012).

No competitive leases have been issued within the KPLAs. However, the BLM recently received an expression of interest from two companies to competitively lease the entire Ten Mile KPLA. Preference right leases are located within the KPLAs that were issued prior to the establishment of the KPLAs.

Seven preference right leases have been issued within the planning area involving about 9,362 acres. The BLM has received 223 PPAs within the planning area which total about 416,464 acres. The KPLAs, potash preference right leases, and potash PPAs within the planning area are shown on Map 3.

VI. POTASH OCCURRENCE POTENTIAL

The potash occurrence potential for the planning area is classified using the system outlined in BLM Manual 3031. Under this system, the potash occurrence potential ratings are strictly based on the geologic likelihood of the potash to be present in the area and do not address the economic

feasibility of development of the resource. The ratings address the accumulation of mineral resources and certainty of data as follows:

Occurrence Potential Ratings

- High Occurrence Potential (H) - The geologic environment, the inferred geological process, the reported mineral occurrence and/or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The "known mines and deposits" do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

- Moderate Occurrence Potential (M) - The geologic environment, the inferred geologic process, and the reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.

- Low Occurrence Potential (L) - The geologic environment and the inferred geologic processes indicate low potential for accumulation of mineral resources.
- No Occurrence Potential (O) - The geologic environment, the inferred geologic processes, and the lack of mineral occurrence do not indicate potential for accumulation of mineral resources.

- Not Determined (ND) – Mineral potential not determined due to lack of useful data.

Certainty Ratings

- Data insufficient (A) - The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

- Indirect evidence (B) - The available data provide indirect evidence to support or refute the possible existence of mineral resources.

- Direct evidence (C) - The available data provide direct evidence but are quantitatively minimal to support or refute the possible existence of mineral resources.

- Abundant direct/indirect evidence (D) - The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

The occurrence potential is based upon a report by the Utah Geological Survey (UGS) titled "*Well database and maps of salt cycles and potash zones of the Paradox Basin, Utah*" (Massoth, 2012). In this report, the line delineating the limit of potash deposition within the Paradox Basin (previously delineated by Raup and Hite, 1992) is revised based on the most recent oil and gas drilling information and correlations of potash thickness for 7 salt cycles (5, 6, 9, 13, 18, and 19). The Massoth report also provides an up to date delineation of the "Fold and Fault Belt" which is an area where potash deposits are highly disrupted due to folding and faulting.

For this planning effort, all of the area within the potassium line as delineated by Massoth (2012) is rated as high (H) for the occurrence potential (Map 4). The certainty is rated as high (D) where the lands lie between the potash line and the line delineating the Fold and Fault Belt. For the lands located within the Fold and Fault Belt, the certainty is rated as moderate (C) due to the difficulty with correlating potash beds in this area. The area outside the potash line is rated as having no occurrence potential (O) for potash with a moderate certainty (C).
The breakdown of the ratings for potash occurrence potential and certainty within the planning area are found in Table 2 and are shown on Map 4.

Table 2. Potash Occurrence Potential and Certainty Ratings for the Planning Area

Potash Occurrence Potential and Certainty Ratings	Lands Included in the Planning Area (acres)
(HD) – High Occurrence Potential High Certainty	752,512
(HC) - High Occurrence Potential Moderate Certainty	154,254
(OC) – No Occurrence Potential Moderate Certainty	39,952
Total Area	**946,469**

VII. POTASH DEVELOPMENT POTENTIAL

The UGS has created a rating system for development potential which the BLM has utilized for other planning efforts within the State of Utah. The BLM will also utilize this system for the planning area and a description of the system is as follows:

- High (HD) - The geologic environment, the inferred geologic process, the reported mineral occurrences and/or valid geochemical/geophysical anomaly, the known mines or deposits, and market factors indicate high potential for development of mineral resources. The known mines and deposits do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

- Moderate (MD) - The geologic environment, the inferred geologic process, the reported mineral occurrences or valid geochemical/geophysical anomaly, and market factors indicate moderate potential for development of mineral resources.

- Low (LD) - The geologic environment, the inferred geologic process, and market factors indicate low potential for accumulation of mineral resources.

- None (OD) - The geologic environment, the inferred geologic process, the lack of mineral occurrences, and lack of positive market factors do not indicate potential for development of mineral resources.

- Not Determined (ND) - The mineral development potential is not determined due to the lack of useful data.

The development potential ratings are made on the basis of reasonable market assumptions for the next 15 years. None of the above development potential ratings are given a level of certainty qualifier because future development potential is subject to too many variables such as markets, financing, and legal constraints.

Areas rated as high development potential (HD) includes the 3 KPLAs (Ten Mile, Seven Mile, and Cane Creek). The BLM classifies an area as a KPLA where there is a known valuable deposit of potash.

Areas rated as moderate to high development potential (MHD) includes the prospecting permit applications (PPAs) that are currently located within the areas rated with an occurrence potential of HD.

Areas rated as moderate development potential (MD) includes the areas rated with an occurrence potential of HD where no PPAs are located. Also, areas are rated as moderate development potential where the areas are rated with an occurrence potential of HC and PPAs are located.

Areas are rated as low development potential (LD) where the areas are rated with an occurrence potential of HC and no PPAs are located.

Areas are rated as no development potential (OD) where the areas are rated with an occurrence potential of OC.

Table 3. Potash Development Potential Ratings for the Planning Area (15 year projection)

Potash Development Potential	Lands Included in the Planning Area (acres)
(HD) – High Development Potential	129,999
(MD to HD) – Moderate to High Potential	375,895
(MD) - Moderate Development Potential	275,607
(LD) – Low Development Potential	125,165
(OD) – No Development Potential	39,803
Total Area	**946,469**

VIII. RFD BASELINE SCENARIO ASSUMPTIONS

Potash Market

The United States (US) is the largest consumer of potash (PotashCorp, 2013) and imports about 80 percent (4.8 million tonnes in 2012) of the potash used mainly from Canada. About 85 percent of US potash sales are to the fertilizer industry (USGS, 2013). Due to Chinese and Indian consumption, the price of potash rose from $100 per tonne in 2004 to above $900 per tonne in the run up to the 2008 recession when the boom went bust and prices rapidly fell back to $350 per tonne. After trading in the $500 to $540 a tonne range for most of 2011, the price of potash steadily declined in 2012 to an average of around $460 to $470 per tonne (Stockhouse, 2013). Though the price of potash dropped to $470 per tonne in 2012 and has slowly declined

and hovered near $387 per tonne, the interest in potash resources within the Paradox Basin has remained high.

The principal use of potash is as an agricultural fertilizer (plant nutrient) because it is a source of soluble potassium, which is one of the three primary plant nutrients required for plant growth and maturation; the others are fixed nitrogen and soluble phosphorous. These three major plant nutrients have no cost-effective substitutes. Growing world population and its need for food will require continued growth in both potash production and consumption. World potash consumption for all uses is projected to increase at a rate of 3 percent per year through the year 2016 (USGS, 2013). The United Nations Food and Agriculture Organization (UNFAO) estimates that crop production must rise by 70 percent by the year 2050 in order to meet the food needs of the world population (UNFAO, 2009).

The sharp rise is potash prices in 2008 sparked renewed interest in the potash resources of the Paradox Basin and the planning area. According to the USGS (2013), the Paradox Basin contains over 25 percent of the known potash resources of the United States.

Projections for Exploration Drilling on Prospecting Permits

There are currently 223 prospecting permit applications (PPAs) within the planning area. If exploration and drilling conducted on a PPA proves the existence of a "valuable deposit" then the permittee is entitled to a preference right lease (Mineral Leasing Act of 1920, as amended).

Exploration for potash in the Paradox Basin uses similar drilling technology as is utilized in conventional oil and gas exploration and development. The potash deposits in the Paradox Basin will require drilling equipment that can reach depths of 8,000 feet using vertical drilling techniques. Horizontal drilling technology is not anticipated during the exploration phase. A typical potash exploration well will include a drill pad and an access road. The surface disturbance for a vertical well is estimated at about 3.0 acres for the drill pad and about 1.5 acres for the access road for a total of about 4.5 acres of surface disturbance per well.

The BLM's experience regarding proposed exploration drilling on PPAs is that there is an average of 15 drill holes (Federal and state) per 36 PPAs or one drill hole per every 2.4 PPAs. The BLM expects that not all PPAs will result in the issuance of a prospecting permit. In addition, PPAs are dropped based on drilling information acquired or the lack of company funding. It is estimated that 80 percent of the 223 PPAs within the planning area will result in about 178 prospecting permits. Therefore, based on 1 well per 2.4 prospecting permits, the exploration drilling on prospecting permits is estimated at about 74 wells. These 74 wells would amount to a total of about 333 acres (4.5 acres per well) of surface disturbance over the life of the plan.

Projections for Exploration Drilling within KPLAs

Exploration within a KPLA is conducted under an exploration license prior to competitive leasing. Potash operators may choose to conduct additional exploration drilling within a KPLA to obtain geologic and other pertinent data concerning potash deposits. Additional drilling may

also be necessary in order for potash companies to be listed on the Canadian and Australian stock exchanges. These two stock exchanges are important to potash companies because it helps them raise money to implement projects. In order to qualify on these exchanges, a potash company must meet the Canadian NI 43-101 standards or the Australian JORC standards. These standards may require a company to use a closer drill spacing to delineate an ore deposit as compared to the BLM drilling standards established for identifying a valuable potash deposit within the Paradox Basin. The 3 KPLAs within the planning area include a total of about 130,000 acres. The BLM standard for establishing a KPLA is one well per 2.5 mile radius or about 1 well per 19.6 square miles. This would amount to about 10 wells for the 130,000 acres (about 203 square miles) within the KPLAs. An exploration plan submitted to the BLM by a company for their prospecting permit applications involved about 1 well per 1.5 mile radius (1 well per 7.1 square miles) where the company has submitted NI-43-101 Technical Reports for listing on the Canadian stock exchange. By applying this well spacing to the 130,000 acres within the KPLAs results in about 29 wells. Therefore, an additional 19 wells (29 wells – 10 wells needed to establish the KPLAs) is anticipated for exploration drilling on exploration licenses within the KPLAs. These 19 wells would amount to about 86 acres (4.5 acres per well) of surface disturbance over the life of the plan.

Projections for Exploration Through Geophysical Surveys

A significant amount of geophysical data has been collected in the past for oil and gas operations. This data could be acquired by potash operators for use in assessing the economic viability of potash deposits. Though no geophysical exploration has been conducted specifically for potash, the BLM assumes that due to the high level of interest in potash resources within the planning area, some geophysical exploration could occur. Therefore, the BLM estimates that two geophysical operations would be conducted within the planning area within the next 15 years. A typical geophysical operation involves an average of average of 600 acres of surface disturbance. Surface disturbance involves cross-country travel with vibroseis trucks or drill buggies, drill hole locations, and staging areas.

Projections for Potash Mining Activity

Underground Mining

Based on the history of potash mining in the planning area, the BLM will not consider conventional underground mining methods for the RFD. Underground potash mining was initiated by Texas Gulf at the Cane Creek Mine. Potash extraction, from the time of the mine's commissioning in 1964 through 1969, was by conventional, large-scale, room and pillar underground mining; however, economic and mining problems related to explosive methane gas pockets, high temperatures, and a contorted ore zone resulted in the total conversion to in-situ solution mining between 1970 and 1972. The solution mining process consisted of pumping saline solution out of the intentionally flooded mine into large solar evaporation ponds on the surface where sylvite and halite are precipitated (BLM, 2005).

Solution Mining

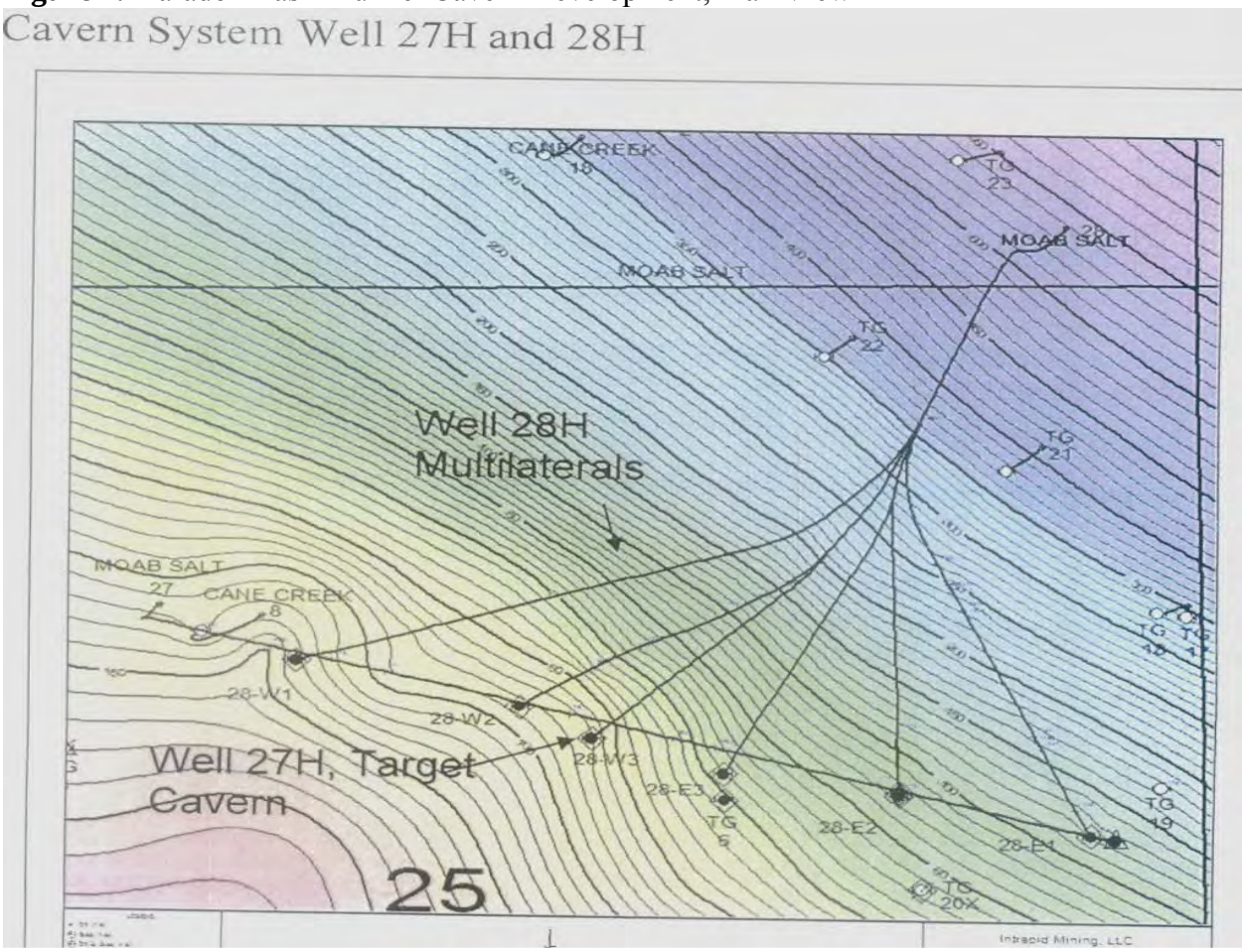
Solution mining of salt deposits involves dissolving salts at depth with water and pumping the resulting brine to the surface. Salts at depths greater than 400 to 500 meters (about 1,312 to 1,640 feet) and down to 2,000 meters (about 6,560 feet) are targets for solution mining. Basically, solution mining involves injecting water through a well drilled into a salt bed to etch out a void or cavern. The resulting saturated brine is then pumped to the surface for processing (Warren, 2006).

Within the planning area, two methods of cavern development are anticipated: 1) tunnel cavern development and 2) Canadian type cavern development.

Tunnel Cavern Development

Tunnel cavern development is utilized by Intrepid Potash at the Cane Creek Mine near Moab, Utah. As shown in Figure 1, one well (27) is drilled vertically down to the target depth and is turned horizontally at the bottom of the salt cycle. A second well (28) is drilled vertically to intercept the horizontal trajectory of the borehole made by the first well. The second well includes additional branches or laterals that also intercept the horizontal hole from the first well in a drilling technique referred to as side tracking. This technique will create a multi-chamber or tunnel pattern in the potash bed. Fresh water is injected into the lateral wells and saturated brine is extracted from the first well.

Figure 1. Paradox Basin Tunnel Cavern Development, Plan View

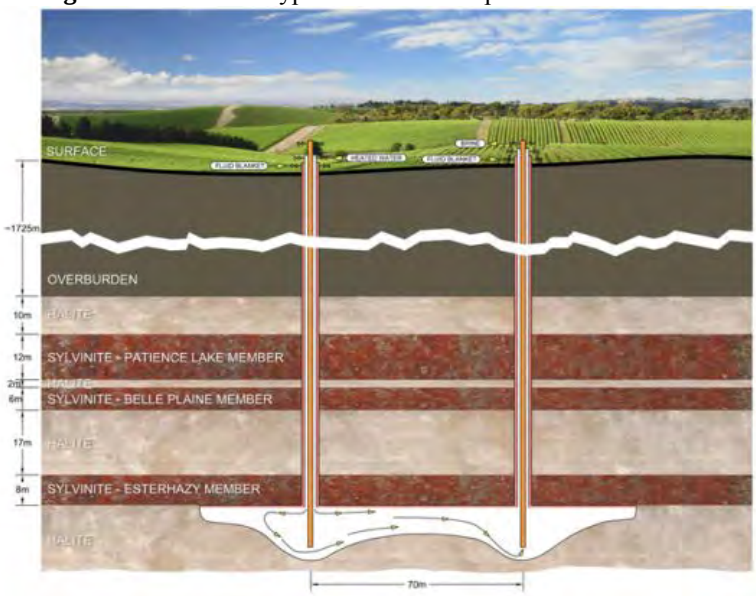


(Harvey and others, 2006)

Canadian Type Cavern Development

The cavern development typically utilized in Canada involves drilling two wells through the target zone as that shown for Western Potash (Figure 2). Water is injected through both wells to initiate caverns. The goal of this phase is to grow the caverns from each well below the potash zone so that the two individual well caverns connect. Connection of the two initial caverns creates a solution mining cavern. At this point, each of the two wells may be operated as either an injection well or as a production well. Fresh water is injected into the cavern from the designated injection well and saturated to partially saturated brine is recovered through the production well.

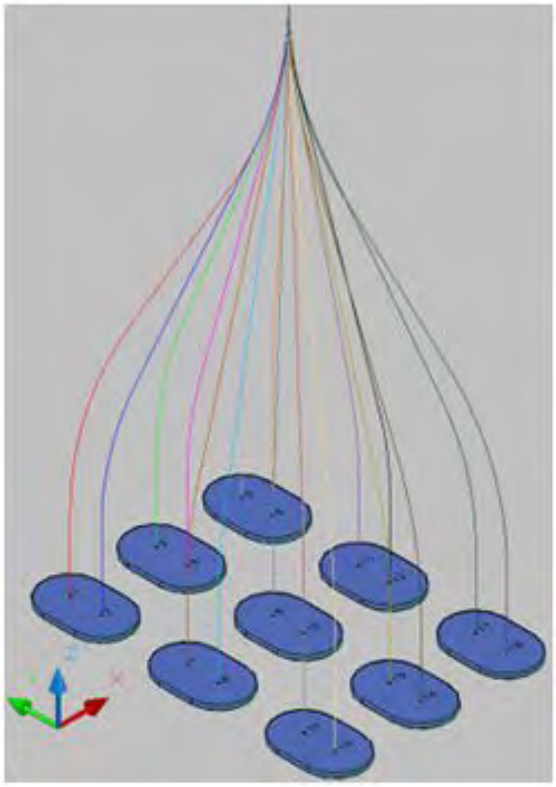
Figure 2. Canadian Type Cavern Development



(Western Potash, 2013)

The Potash One Legacy Project utilizes 18 wells to create nine caverns utilizing directional drilling from one centralized pad (Figure 3). The wells are separated at depth by about 80 m. Directional drilling from a centralized drilling pad limits the surface disturbance compared to the use of vertical wells drilled over each cavern. The pad size to accommodate the 18 wells is 100 m x 150 m (3.7 acres). This mine design also results in the development of small caverns that are estimated at 120 m to 160 m wide by 200 m to 240 m long. The caverns are placed on 240 m by 320 m centers leaving pillars 80 m to 100 m in width.

Figure 3. Canadian Type Cavern Design



(Potash One, 2010)

Phases of Solution Mining

There are two phases of potash extraction which are referred to as primary and secondary mining. Primary mining is defined as the solution mining of both sylvite and halite resulting in the creation of the cavern. During primary mining, a large volume of halite is generated which is moved to a tailings management area for storage and disposal. Primary mining utilizes large amounts of fresh water. Secondary mining entails injecting heated halite-saturated brine into the cavern where selective dissolution of sylvite is achieved from the cavern walls and roof, leaving much of the halite structure of the cavern in place (Potash One, 2010).

Subsidence

Subsidence can result from subsurface mining or the extraction of oil or groundwater. Subsidence is the sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal motion. The amount of subsidence is dependent on 1) percentage of mine extraction and the areal extent of mining, 2) thickness of the potash bed, 3) the mining method, 4) the residual material left in the caverns (salt and insolubles) 5) the strata above the mined areas, and 6) the depth of mining (Potash One, 2010).

Subsidence can develop over mined cavities at the same time as mining and will continue after mining as the caverns continue to close (Potash One, 2010). Subsidence of the ground surface over a cavern will deform into a shape resembling a wide shallow bowl. Bowl subsidence over

caverns is a response to movements at depth which are transferred to the surface with diminishing amplitude over a wide cone of influence. Subsidence of the land surface above a salt cavern is a normal and expected, especially above shallower caverns. The surface response is similar to trough subsidence at the surface above long-wall or room and pillar coal mining operations (Warren, 2006).

A specific subsidence analysis has not been performed for this RFD. However, the potential subsidence impacts to the surface resulting from potash solution mining within the planning area are expected to be negligible. This assessment is based on the experience obtained from solution mining of potash at the Cane Creek Mine near Moab, Utah where the potash beds are about 3,300 feet deep. The mine began as a conventional underground excavation in 1964, but was converted to a system combining solution mining and solar evaporation in 1970. As of 1984, no surface subsidence was reported at the mine (Gwynn, 1984). The BLM could not identify any other reports on subsidence up to the present time.

Projections for Production Drilling

Canadian potash mining operations are used as a basis for projecting production drilling within the planning area due to the greater amount of available information. The number of production wells expected is estimated on the amount of production required and the thickness and grade of the bedded deposits. For example, the Mosaic Belle Plaines operation in Saskatchewan, Canada is planning on producing 5.3 million tons of potash per year. The operation would entail the drilling of multiple wells from one large pad referred to as cluster sites. One cluster site is completed each year where pairs of wells are directionally drilled to the base of the potash deposits. Caverns are initially developed by injecting water down each of the wells and brine is pumped to the surface through extraction wells. Deposits are dissolved horizontally outwards from each well until a connection is made between the two paired wells. A cluster site includes 14 pairs of wells for a total of 28 wells per year. Based on the proposed potash production of the Belle Plaines operation of 5.3 million tons per year and 28 wells needed for development equates to about one well for every 190,000 tons of potash produced annually (5,300,000 tons of potash/28 wells = 190,000 tons of potash per well). For this estimate, the number is rounded up to 200,000 tons/well. This estimate is also confirmed by the Potash One Legacy Project located in Saskatchewan, Canada. For this project the drilling rate is 9 new caverns (18 wells) for every 3.3 million tons of potash produced or 183,000 tons of annual production per production well.

Because of the differences in the grade and thickness between the Canadian potash deposits and the Paradox Basin potash deposits, an increase in the number of production wells is required for the Paradox Basin deposits. The factor for estimating this increase is calculated by comparing the grade and thickness of the thickest Canadian deposits with the grade and thickness of the thickest Paradox Basin deposits (see Tables 4 and 5) as follows:

25.83m Canadian thickness ÷ 7.3m Paradox Basin thickness = 3.54 thickness factor
18.86% Canadian ore grade ÷ 26% Paradox Basin ore grade = 0.73 ore grade factor
3.54 thickness factor x 0.73 ore grade factor = 2.6* (rounded up) production well factor per 200,000 tons of annual production

Table 4. Potash Thickness and Grade - Paradox Basin (planning area)

Paradox Basin, Utah	**Salt Cycle 5**	**Salt Cycle 9**	**Salt Cycle 13**	**Salt Cycle 18**Upper	**Salt Cycle 18**Lower	**Salt Cycle 19**
Thickness	0-24 (ft) 7.3(m)	Similar to 5	0-10 (ft) 3.04 (m)	0-22 (ft) 6.7(m)	0-20 (ft) 6.1(m)	0-23 (ft) 7.0 (m)
Grade %K2O	0-26%	Similar to 5	0-28.77%	0-38%	0-38.8%	
% Carnallite	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
% Insolubles	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Depth	2500- 6000 ft					4000-11,500 ft

Taken from Boleneus, 2007, p. 31-32 and Potash Minerals Limited, 2012, p. 4.

Table 5. Potash Thickness and Grade – Saskatchewan, Canada

Saskatchewan, Canada	**Patient Lake zone**	**Belle Plains zone**	**Belle Plains to Patient Lake zone**
Thickness	11.56 (m)	6.86 (m)	25.83 (m)
Grade %K2O	21.13 %	20.06 %	18.86 %
% Carnallite	0.35 %	0.28%	0.30%
% Insolubles	10.80%	3.64%	8.15%
Depth	5,200 ft		

Taken from Agapito, 2011

Based on the production well factor, there would be 2.6 times more production wells drilled in the Paradox Basin for 200,000 tons of annual production as compared to those drilled in Canada. Therefore, the number of production wells drilled for the projected annual production of 2.4 million tons within the planning area amounts to a total of about 32 (2.4 million tons x 2.6/200,000 tons).

Production drilling in the Paradox Basin would require equipment that can reach depths of up to 8,000 feet. As stated for exploration drilling, the surface disturbance for drilling a vertical well to these depths is estimated at about 3.0 acres for the drill pad and another 1.5 acres for the access road. An additional 1.5 acres of surface disturbance may be necessary for the pad to allow for horizontal drilling, mud pits or cavern development pits, pumps, and storage tanks. Pipelines would be connected from the processing plant to the well field for injection water for cavern development and brine production. Pipelines and utilities would be grouped together along the existing road grid and should not contribute additional surface disturbance. Therefore, the total surface disturbance for a production well is estimated at about 6.0 acres.

The total surface disturbance for the estimated 32 production wells drilled on an annual basis for 2.4 million tons of production would amount to about 176 acres based on the assessment above. However, this foot print could be substantially lowered by utilizing cluster sites to drill multiple wells from one centralized pad. The Potash One Legacy Project anticipates placing 18 wells on a 3.7 acre pad. Intrepid has also implemented the use of drilling up to 6 wells on a centralized pad at the Cane Creek Mine. A reasonable assumption is that the practice of drilling multiple wells on a centralized pad would be utilized to some degree within the planning area. In addition, the size of the pad would be comparable to that estimated for a single horizontal well or about 4.5

acres and between 1 and 6 wells would be drilled from this pad. This would amount to an average of about 3.5 wells per pad or rounded up to about 4 wells per pad. The access road would add another 1.5 acres per pad for a total surface disturbance of about 6.0 acres per pad.

Projections for Potash Processing

Within the planning area, it is anticipated that potash processing would entail two basic methods to separate sylvite from halite: 1) solar evaporation and 2) crystallization. Following separation, the potash and salt are then dried and screened/compacted into various products.

Solar Evaporation

Solar evaporation involves the use of the sun to evaporate water and precipitate salt in the solution. It is the oldest method of salt production and is an inexpensive process because it uses the sun for solar energy and evaporation. Arid portions of the world are prime areas for this type of production of salts.

At the Cane Creek Mine, after a short primary mining period to develop the caverns, fresh water is brought in and mixed with halite (secondary mining) and pumped into the caverns. This nearly saturated solution picks up potassium and the saturated brine is extracted from the caverns to the surface where pipelines are used to transport the saturated water to shallow and lined evaporation ponds. Sunlight and low humidity result in evaporation of the water leaving potash and salt crystals in the ponds. The crystals from the ponds are sent to a mill where the potash is separated from the salt by a flotation process (Intrepid Potash, 2013). A flow diagram for potash processing at the Cane Creek Mine is provided in Figure 4.

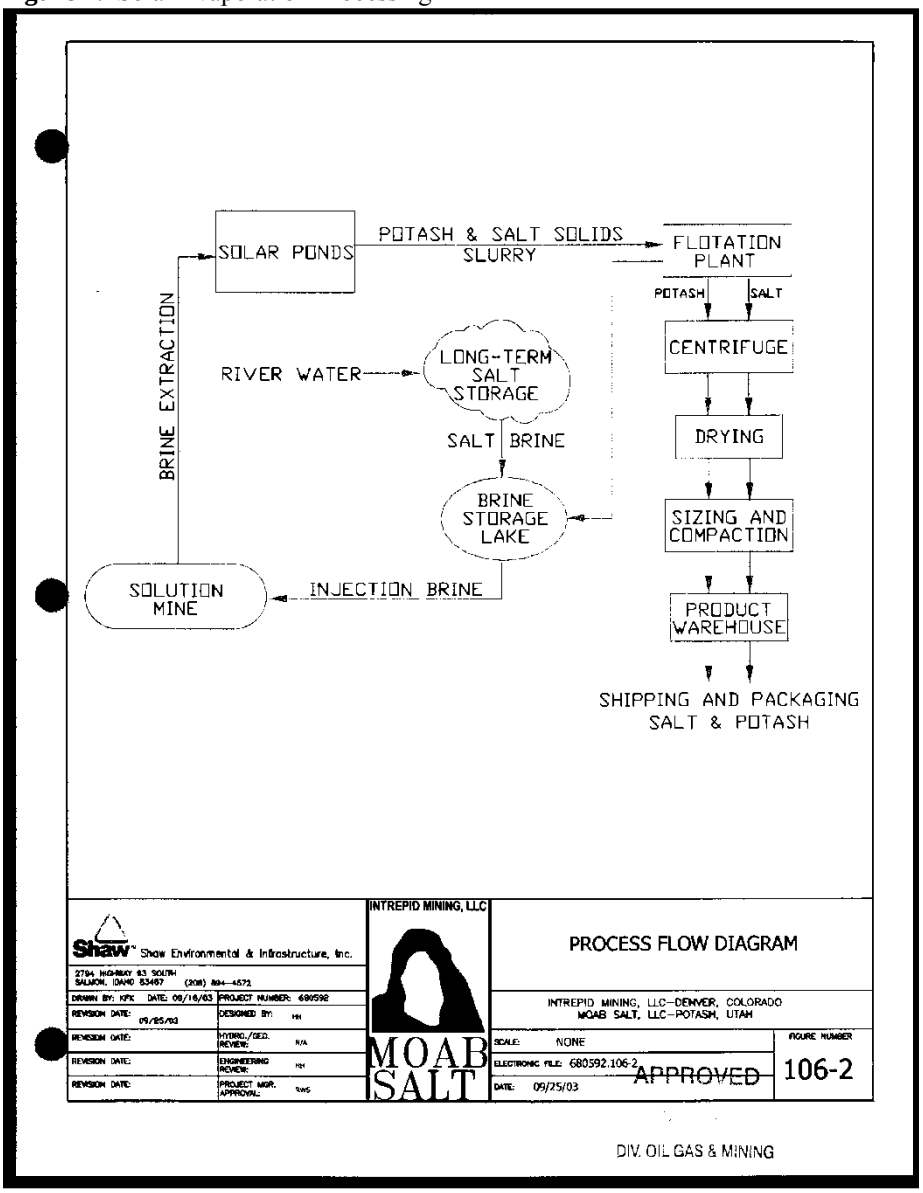
The flotation process is where reagents are added to the potash and salt mixture. The reagents enable potash to attach to fine air bubbles that are introduced in the bottom of flotation machines. The potash particles rise to the surface for collection and the salt remains on the bottom, where it is removed separately (PotashCorp, 2011).

The solar evaporation process segregates the salts through the process of evaporation. This segregation of salts as the water evaporates is a similar sequence to the deposition of the minerals in the first place. The sequence of salt precipitation at the Intrepid Potash operation at Wendover is 1) halite, 2) carnallite, and 3) sylvinite. A series of evaporation ponds are used to keep the salts separated (White, 2002).

Evaporation ponds are sized according to the grade of the sylvite brine that is removed in the mining operation and the desired production. For example, the Intrepid Potash operation at Wendover has a grade going into the primary pond of about 1 percent sylvite and this grade requires approximately 8,400 acres of ponds to produce about 100,000 tons of potash per year. The mined brine also contains carnallite which is separated utilizing additional ponds. Because the Intrepid Potash operation at Moab (Cane Creek Mine) has a much higher grade, just over 7 percent sylvite, it takes only about 450 acres of ponds for sequencing the brine to produce 100,000 tons per year of potash.

The geology of the potash deposits across the planning area is similar to that of the current Intrepid Potash operation at Moab. Therefore, it is anticipated that any new potash solution mining operation utilizing solar evaporation would require similar pond sizing for processing. However, some of the salt cycles in the planning area contain carnallite and therefore one or more of the processing operations may contain additional ponds to deal with the carnallite.

Figure 4. Solar Evaporation Processing



(Intrepid Potash, 2004)

Water Consumption

The water consumption for two solution mining operations utilizing solar evaporation processing is described below.

According to the Mine Plan submitted to the State of Utah for the Cane Creek Mine, the operation has a water allocation of 13.4 feet per second from the Colorado River. This equates to approximately 3.16 billion gallons of water annually. However, the operation only utilizes about 0.5 billion gallons annually for their production of approximately 100,000 tons of sylvite per year (York, 2012) or 5,000 gallons per ton.

The HB Mine project in Carlsbad, New Mexico involves a proposed solution mining operation conducted in old underground mine workings. The water consumption for the mining and processing of the potash is projected at 1,262 gallons per minute (BLM, 2012, p. 2-17). This would amount to about 0.66 billion gallons annually for the production of approximately 185,000 tons of sylvite per year or about 3,585 gallons per ton.

Energy Consumption

The BLM could not identify any specific information regarding the energy consumption of a typical solution mining operation utilizing solar evaporation processing. Solution mining will require energy from either natural gas or electricity to heat water saturated with halite prior to injecting it into the caverns. Heating the halite saturated solution increases the ability to selectively dissolve sylvite in the caverns.

Energy is also required in the mill for conveyors, flotation, dryers, compactors, and sizing operations. However, the concentration of salts utilizing solar energy is the most energy efficient in comparison to other potash processing methods.

Crystallization

At the Mosaic Belle Plains operation in Canada, fresh water is used for primary mining. Recycled brine from the crystallization process is utilized for secondary mining and is pumped into the caverns to enhance the dissolution of sylvite.

The brine pumped from the caverns in primary and secondary mining contains both sylvite and halite. This brine is sent to evaporators where the brine is boiled using either natural gas or electricity as an energy source to remove the water. The removal of the water results in halite precipitation and the halite is taken away. The remaining solution is supersaturated in sylvite and is cooled in crystallizers. As the solution cools, sylvite crystallizes and is recovered for drying in centrifuges. A flow diagram for crystallization processing at the Mosaic Belle Plaines operation is provided in Figure 5.

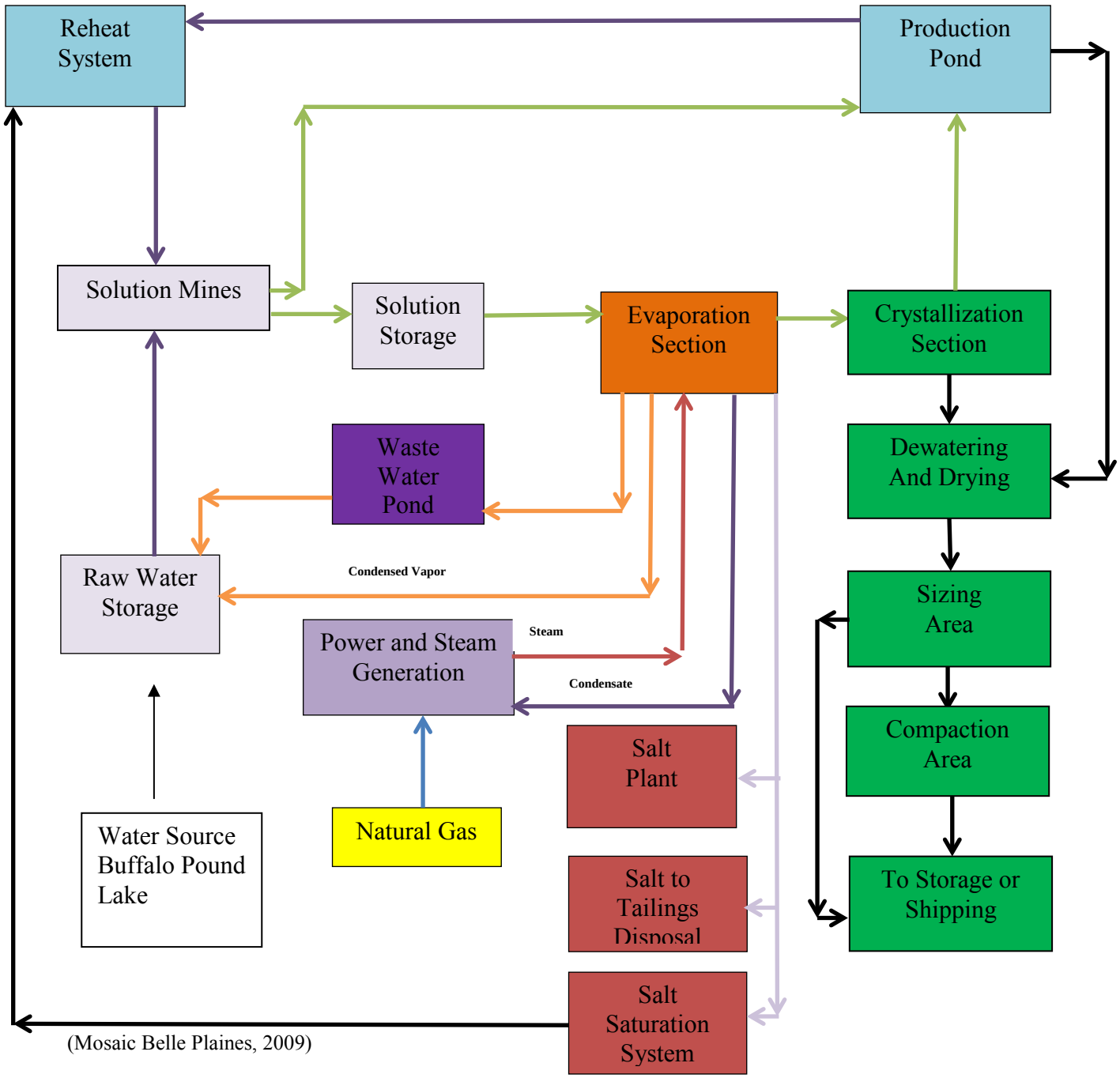
This process uses more fuel or electricity than the solar evaporation process. However, the water is contained in a closed system and is reusable as opposed to the solar evaporation process where the water is evaporated and lost into the atmosphere.

Carnallite poses a major problem in utilizing a crystallization process. This mineral is considered a significant impurity because it lowers the solubility of the sylvite. In some operations in Western Canada, a cut-off grade of 6% by weight of carnallite or 0.5% magnesium

is used for potash processing. If the feed to the crystallization processing plant exceeds 5% carnallite then additional treatments are necessary.

One possible way to lower the amount of carnallite in the processing system for both crystallization and solar evaporation methods is to conduct solution mining operations from many different underground caverns at the same time so the brine coming from areas of high carnallite can be blended with brines containing lower amounts of this impurity to dilute the contaminants (Agapito, 2011, p. 1-5, 7-13, 8-1).

Figure 5. Crystallization Processing



(Mosaic Belle Plaines, 2009)

Water Consumption

The water consumption for two solution mining operations utilizing crystallization processing is described below.

The Belle Plains operation in Canada is allocated 21,079 acre feet for a planned annual production of 5.3 million tons of potash. The current water usage is 9,728 acre feet with a production of 2.5 million tons of potash (Mosaic, 2009, p. 4) or about 1,300 gallons per ton.

The Potash One Legacy Project in Canada plans on initially consuming water at the rate of 1,354 gallons per ton for the mining and processing of 3.3 million tons of production. However, the operation would reach a steady state of 862 gallons per ton of water consumption due to recycling of water at the plant (Potash One, 2010).

Energy Consumption

The Potash One Legacy Project involves 3.3 million tons per year of potash production and crystallization processing. The natural gas consumption for the project is estimated at 49,627 normal cubic meters per hour. Natural gas will be used as a source of fuel for building heating systems, process dryers in the mill, and for steam boilers. The project will also require electricity consumption of approximately 1 million megawatt hours (Potash One, 2010, p. 38 - 39).

Processing Components Common to both Solar Evaporation and Crystallization

Drying

Drying is essential to the potash operations using either solar evaporation or crystallization. Both of the processing methods have the material coming out of the process wet. Centrifuges are utilized to remove the bulk of the moisture, but rotary or fluid bed dryers which are fired by natural gas are used to remove the remaining moisture from the product (Perucca, 2012).

Screening and Compaction

The dry potash mixture contains various sizes that are separated by mesh screens (PotashCorp, 2011). Product size in the potash industry determines the sales price and contain 60% K2O (65% being the highest possible) or over 90% pure. The most common potash sizes are as follows (Perucca, 2012):

- Granular - Greater than 1.19 mm. This is the most common size. It is used for the fertilizer industry and obtains a premium price in the market place.
- Coarse - Greater than 0.6 mm
- Standard - Greater than 0.21 mm
- Fine - 0.149 mm

Fine product can be compacted under high pressure between two rolls. The resulting solid "board" is broken into pieces and sized to form additional granular potash (PotashCorp, 2011).

Storage and Loadout

Finished product is transferred to onsite warehouses that have the capability to store several grades of potash. The potash is loaded onto railcars or trucks for delivery to customers (PotashCorp, 2011).

Salt (Halite) Tailings

The mining caverns are developed by solution methods; therefore, insoluble components of the potash beds are not brought to the surface as they are with conventional potash mining. Thus, the halite produced is a relatively pure product. Salt tailings, separated from the potash in the refinery, are hydraulically transported and deposited in the tailings management area. The tailings management area can consist of a tailings pile, brine pond, and control structures. Salt tailings can be used for secondary mining of potash. Excess salt can also be re-injected back into the mine or used to provide salt to the market. The size of the tailings management area will depend largely on the amount of production. The 100,000 ton per year solar evaporation operation at the Cane Creek Mine utilizes a tailings pond that is about 97 acres. The tailings management area for the crystallization operation at the Mosaic Belle Plains Mine is about 400 acres for the current annual production of about 2.5 million tons.

Waste and Waste Water

The Potash One Legacy Project involves about 3.3 million tons per year of potash production and crystallization processing. The project would generate about 2.2 tons of non-hazardous industrial waste during construction and about 1.1 tons per year during operation of the project. Non-hazardous industrial waste includes plastics, rubber, inert materials (e.g. wood), and metal. Recyclable material would be stored on-site in appropriate containers to prevent exposure until it is shipped off-site to a reputable off-site recycling center. The other waste products would be hauled to a permitted landfill for ultimate disposal.

The Legacy Project generates about 3.3 tons of hazardous waste and 50 tons of contaminated waste during construction. During operation, about 4.4 tons per year of hazardous waste and 50 tons of contaminated waste are anticipated. Hazardous waste and dangerous wastes are classified as chemicals, hydrocarbons, glycol, oil, fuels, acids, solvents, reagents, antifreeze, and batteries. Contaminated waste includes oil and/or fuel contaminated soil, pads, paper towels, and cardboard. Hazardous and contaminated wastes would be collected in designated containers and transported off-site for recycling or disposed of at a registered facility.

Based on the information above, an estimate of the waste that would be generated by potash production and processing facilities within the MLP area can be estimated by adjusting the amount of wastes proportionately according to the projected annual production.

Sewer and gray water can be collected from showers, toilets, wash basins sinks, and eyewash stations. These could be piped into sumps which could be pumped at intervals and disposed of at the proper off-site facility. Waste water generated from wash down activities could be cleaned by employing an oil-water separator to remove oil from the water and then recycling the water.

Projections for Potash Development

In May 2012, the BLM mailed a request to the potash operators in the planning area asking them to provide any information they may have regarding potential potash development. No specific plans for development of potash in the area were provided. However, the following conceptual potash mining projects within the planning area have been identified:

- Buttes Resources originally acquired the 4 preference right leases now held by Reunion Potash Corporation in the Ten Mile area. As part of acquiring these leases, the company submitted a mine plan for developing potash. In the full operational phase of the project, potash would be developed at depth by solution mining and directional drilling techniques. About 28 new wells would be needed each year, spaced at about 800 feet intervals, requiring 4.2 miles of new road each year and 5 acres cleared for each well (a total of about 140 acres per year). The operation would utilize solar evaporation processing and potash production would reach 1 million tons per year. About 80 evaporation ponds of 40 acres each was anticipated which would total about 3,200 acres. An additional 1,000 acres of surface disturbance was projected for the mill, roads, and other infrastructure. A 36 inch above the ground pipeline would carry water 14 miles from the Green River to the site. Potash would be transported to markets by railroad. A spur would be constructed to connect with the existing rail line (BLM, 1983).

- Reunion Potash Corporation submitted a preliminary Potash Solution Mining Project to the BLM in 2008 involving their 4 preference right leases. The project would consist of a well field with 3 well pads, a plant site for crystallization processing, and an interconnecting access road and pipeline. The well field would result in approximately 50 acres of surface disturbance, the plant site would disturb and addition 50 acres, and the access road and pipeline would contribute some additional surface disturbance. The project would entail about 100,000 tons per year of potash production and if successful the operation could expand to 500,000 tons per year (Reunion, 2008).

- A report prepared for American Potash entitled "Report on the Potash Potential of the Green River Potash Project Area, Grand County Utah" (Allen, 2009) includes a map that delineates potential solar evaporation pond sites that include about 1,200 acres. The size of the ponds would indicate the potential production of 200,000 tons per year of potash. This production number is based on a simple comparison with the Cane Creek Mine where there is about 600 acres of solar evaporation ponds for 100,000 tons per year of potash production.

- An article was posted on the investorIntel website on August 24, 2012 entitled "Potash Minerals Ltd and the Billion Ton Potential at Paradox Basin, Utah" (Bruno, 2012). This article states that Potash Minerals Limited intends on developing potash deposits by

solution mining in the Hatch Point area. Hot water would be injected into wells to a depth of about 6,000 feet deep to dissolve salt and potash and then pumped to the surface. Salt would be separated from the potash through a crystallization process. K2O Utah, who is 90% owned by Potash Minerals, intends to produce 2 million tonnes per year of potash from the property. The article also states that the property has onsite water, gas, electric, and transportation.

- Articles in the San Juan Record on April 27, 2011 and January 25, 2012 refer to statements made by Mr. Keith Price of K2O regarding development in the Hatch Point area. According to Mr. Price, the potash deposit is thousands of feet deep and would be mined by injecting hot water into bore holes under tremendous pressure. The liquefied potash would be pumped to the surface and dried with natural gas dryers. K2O plans to ship up to 2 million tons of potash annually to a railhead in Flagstaff, Arizona. A workforce of 250 full time employees is envisioned for the mining operation. It is anticipated that the mine would pay San Juan County up to $18,000,000 a year in taxes and royalties when fully operational (Buckley, 2011 and 2012).

Based on the information provided above, the BLM makes the following projections regarding potash development for the high development areas and the moderate to high development areas delineated within the planning area:

1. One or more solution mining operations utilizing solar evaporation processing with a total potash production of up to 400,000 tons per year.
2. One solution mining operation utilizing crystallization processing with a total potash production of up to 2 million tons per year.
3. Potash operations utilizing solar evaporation processing are more likely to occur in the northern portion of the planning area where the lower elevations are much more conducive to evaporation.
4. Potash operations located in the northern portion of the planning area are likely to utilize the existing rail line spur that runs from the Cane Creek Mine to Crescent Junction where it connects with the main line.

IX. ESTIMATED SURFACE DISTURBANCE

The estimations for future surface disturbance within the specified development areas of the planning area are based on the following assumptions:

1. A 40 year total operational potash mine life which exceeds the 15 year life of the MLP.
2. A 5 year startup phase. It would take approximately 5 years to come to full production if all permits are in place. In year 3, production drilling will commence with an anticipation of full production at the beginning of year 6.
3. A 30 year mine and processing facility life at full production.
4. A 5 year slow down and reclamation period.
5. All exploration and preproduction wells would be drilled during the 15 year life of the MLP.

Solar Evaporation Ponds

The estimates for the surface disturbance associated with the construction of solar evaporation ponds are based on Intrepid Potash's operation at the Cane Creek Mine (Intrepid, 2008). These solar evaporation ponds facilitate the annual production of 100,000 tons of potash and the acreage components are as follows:

- 452 acres for evaporation ponds
- 126 acres of borrow area utilized in pond construction and maintenance
- 8 acres of pond infrastructure

Total - 596 acres rounded up to 600 acres

The total annual potash production utilizing solar evaporation ponds within the planning area is projected at 400,000 tons. It is estimated that this production would require 4 times the acreage for evaporation ponds whether by 4 operations producing 100,000 tons of potash per year, or 1 operation producing 400,000 tons per year. No evaporation ponds would be reclaimed during the life of the MLP.

Total surface disturbance for the next 15 years - 4 x 600 acres = **2,400 acres**

Solar Evaporation Plant Site

The plant site at the Cane Creek Mine is used as the basis for estimating the surface disturbance associated with the processing of potash by solar evaporation. This plant site facilitates the annual production of 100,000 tons of potash and the acreage components are as follows (Intrepid Potash, 2004):

- 174 acres for processing facilities
- 58 acres for miscellaneous
- 97 acres for tailings pond

Total - 329 acres

For the projected annual potash production of 400,000 tons utilizing solar evaporation processing within the planning area, the surface disturbance is estimated to be 4 times as much as that for the Cane Creek Mine. The surface disturbance would be the same whether there is 4 operations producing 100,000 tons per year or 1 operation producing 400,000 tons per year. No plant sites would be reclaimed during the life of the MLP.

Total surface disturbance for the next 15 years - 4 x 329 acres = **1,316 acres**

Crystallization Plant Site

The Mosaic Belle Plains Mine and the Potash One Legacy Project are used to estimate the surface disturbance associated with the processing of potash by crystallization methods. The Mosaic operation currently has similar production to the 2 million tons of annual production projected for the planning area and utilizes a 400 acre tailings management area. The Legacy

Project involves 4.4 million tons of annual production and the surface disturbance associated with the crystallization plant and facilities is downsized proportionately to estimate the corresponding surface disturbance for the planning area. The projected plant site within the planning area would not be reclaimed during the life of the MLP. The surface disturbance is itemized as follows:

- 400 acres for salt tailings or salt management areas
- 100 acres for crystallization, compacting, drying, sizing, loading and storage

Total - 500 acres for the entire facility

Total surface disturbance for the next 15 years = **500 acres**

Production Drilling

The number of production wells drilled for the projected annual production of 2.4 million tons of potash within the planning area amounts to a total of about 32 per year. Based on established industry practice, the BLM estimates an average of about 4 wells would be drilled on a centralized pad of about 4.5 acres. The access road would add another 1.5 acres of surface disturbance for a total of about 6.0 acres per pad. About 8 pads per year would be constructed for a total annual surface disturbance of 48 acres. With the assumption that production drilling would not begin until Year 3 of the project, leaves 13 years of production drilling during the life of the MLP. It is also assumed that all production wells would remain in place during the life of the MLP.

Total surface disturbance for the next 15 years - 13 x 48 acres = **624 acres** for 2.4 million tons of annual production. This would amount to about **518** acres for 2 million tons of annual production (crystallization processing operation) and about **106** acres for 400,000 tons of annual production (solar evaporation processing operation/s).

The footprint of the pads could be reduced after drilling is completed through interim reclamation. However, due to the more extensive drilling that would take place on these pads and a lack of experience with this type of operation in the region, it is not known how much interim reclamation is possible. Therefore, no interim reclamation is projected.

Production drilling would continue until the end of the mine and processing life which is Year 35 for the operation. Therefore, there would be an additional 20 years of production drilling following the life of the MLP which would amount to another **960 acres** (20 x 48) of surface disturbance. Out of this surface disturbance, about **797** acres is attributable to a crystallization processing operation and about **163** acres is attributable to a solar evaporation processing operation(s). The reclamation of all surface disturbance associated with production drilling would not occur until after the end of the mine life.

Exploration Drilling on Prospecting Permits

The exploration drilling on prospecting permits is projected at about 74 wells over a 15 year period with an estimated surface disturbance of about 4.5 acres per well. These 74 wells would

amount to a total of about 333 acres of surface disturbance over the life of the plan. However, it is anticipated that about 50 percent of these wells would be successfully reclaimed by the end of the life of the MLP (15 years).
Total surface disturbance for the next 15 years: 74 x 4.5 acres = **333 acres**
Total surface disturbance reclaimed during the next 15 years: 50% x 333 acres = **167 acres**
Total net surface disturbance over the next 15 years: 333 acres - 167 acres = **166 acres**

Exploration Drilling within KPLAs

Exploration within a KPLA is conducted under an exploration license prior to competitive leasing. Potash operators may choose to conduct additional exploration drilling within a KPLA to obtain geologic and other pertinent data concerning potash deposits. The exploration drilling is estimated at about 19 wells with an estimated surface disturbance of 4.5 acres per well. These 19 wells would amount to a total of about 86 acres of surface disturbance over the life of the plan. It is anticipated that 50 percent of these wells would be successfully reclaimed by the end of the life of the MLP.

Total surface disturbance for the next 15 years: *19* x 4.5 acres = **86 acres**
Total surface disturbance reclaimed during the next 15 years: 50% x 86 acres = **43 acres**
Total net surface disturbance over the next 15 years: *86 acres - 43 acres* = **43 acres**

Geophysical Exploration

The BLM assumes that two geophysical operations would be conducted within the planning area over the next 15 years. A typical geophysical operation involves an average of 600 acres of surface disturbance. Due to the current technology with geophysical operations, the surface disturbance is minimized. Reclamation can usually be completed within a 3 year period depending on time of reclamation, soils, vegetation, and rainfall. Surface disturbance resulting from geophysical activity during the first 12 years would be successfully reclaimed over the 15 year life of the plan. Therefore, no residual impacts are expected by the end of the 15 year life of the plan.

Total surface disturbance for the next 15 years: *2 x 600 acres =* ***1,200 acres***
Total surface disturbance reclaimed during the next 15 years: 2 x 600 acres = ***1,200 acres***
Total net surface disturbance over the next 15 years: ***0 acres***

Miscellaneous Drilling

The BLM anticipates additional drilling for water wells, disposal wells, and monitoring wells pertaining to potash mining operations. The number of wells is estimated at about 40 over the next 15 years with a surface disturbance of about 4.5 acres per well (including access road) for a total of about 180 acres. However, interim reclamation could considerably reduce the surface disturbance down to about 2.5 acres per well for a net surface disturbance of about **100** acres during the life of the MLP.

A summary of the surface disturbance by the type of potash operation is provided in Table 6 and a summary of the surface disturbance for wells (non-production) drilled during the life of the MLP is provided in Table 7.

Table 6. Summary of Surface Disturbance by Type of Potash Operation

Action	Solar Evaporation Processing	Crystallization Processing
Potash annual production (tons per year)	400,000	2,000,000
Solar evaporation ponds (acres disturbed)	2,400	
Processing plant(s) (acres disturbed)	1,316	500
Production wells (acres disturbed)	106	518
Total surface disturbance during life of the MLP (Years 1-15)	3,822	1,018
Production wells; years 16-35 (acres disturbed)	163	797
Total (Years 1-35)	**3,985**	**1,815**
Solar evaporation ponds; years 35-40 (acres reclaimed)	2,400	0
Processing plant; years 35-40 (acres reclaimed)	1,316	500
Production wells; years 35-40 (acres reclaimed)	269	1,315

Table 7. Summary of Surface Disturbance for Wells (non-production) Drilled During the Life of the MLP

Type of Wells	Number	Surface Disturbance Per Well	Total Surface Disturbance (acres)	Reclamation (acres)	Net Surface Disturbance (acres)
Exploration Wells on Prospecting Permits	74	4.5 acres/well	333	167	166
Exploration Wells within KPLAs	19	4.5 acres/well	86	43	43
Miscellaneous Wells	40	4.5 acres/well	180	80	100
Total			**599**	**190**	**309**

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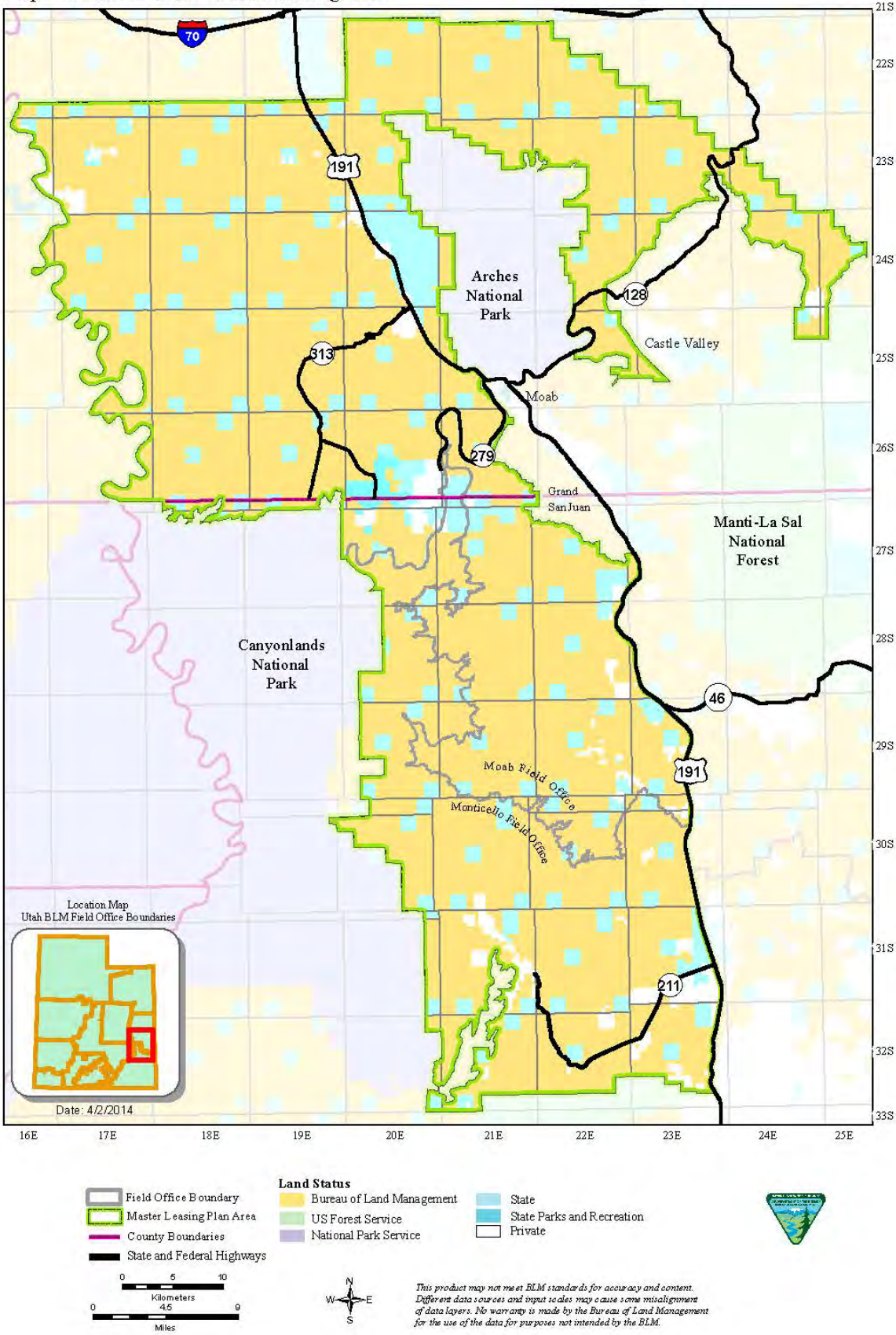
MAPS

Maps 1-5

Map1 - Status of Lands in the Planning Area



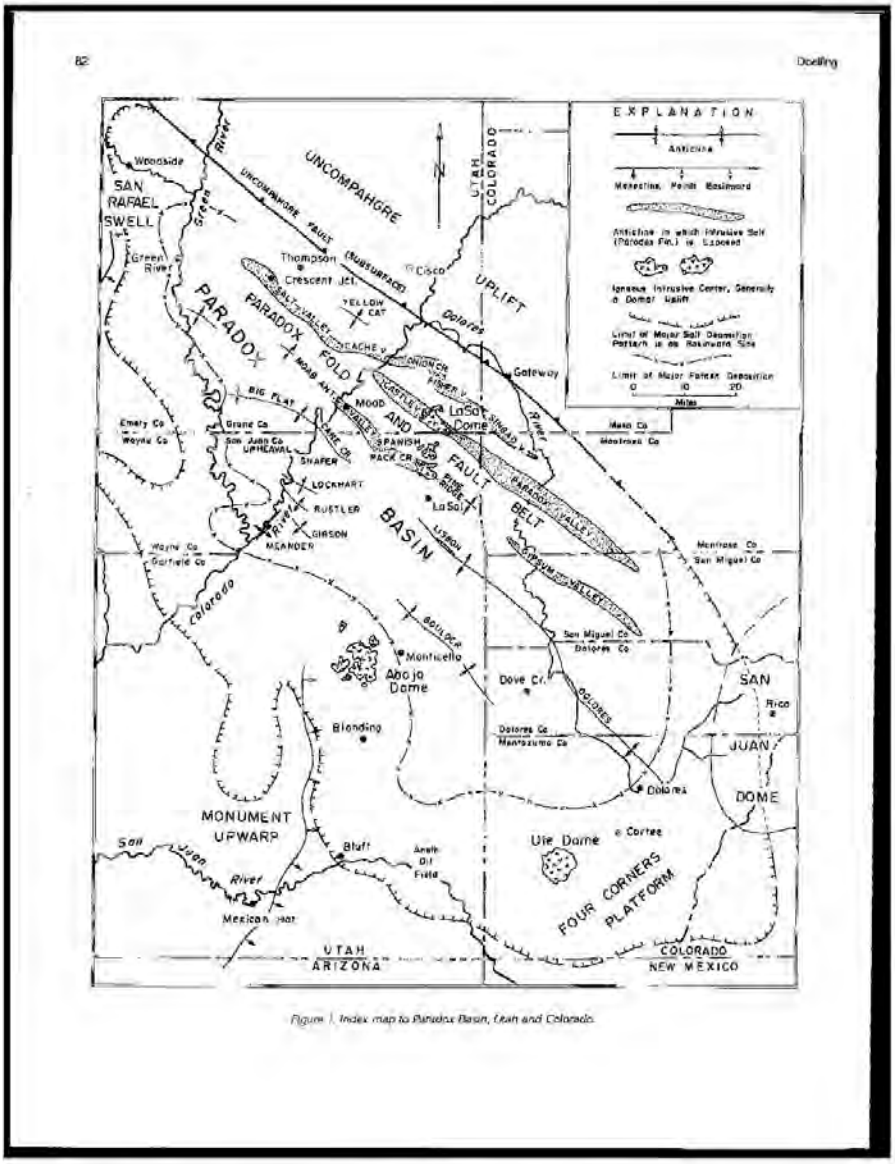
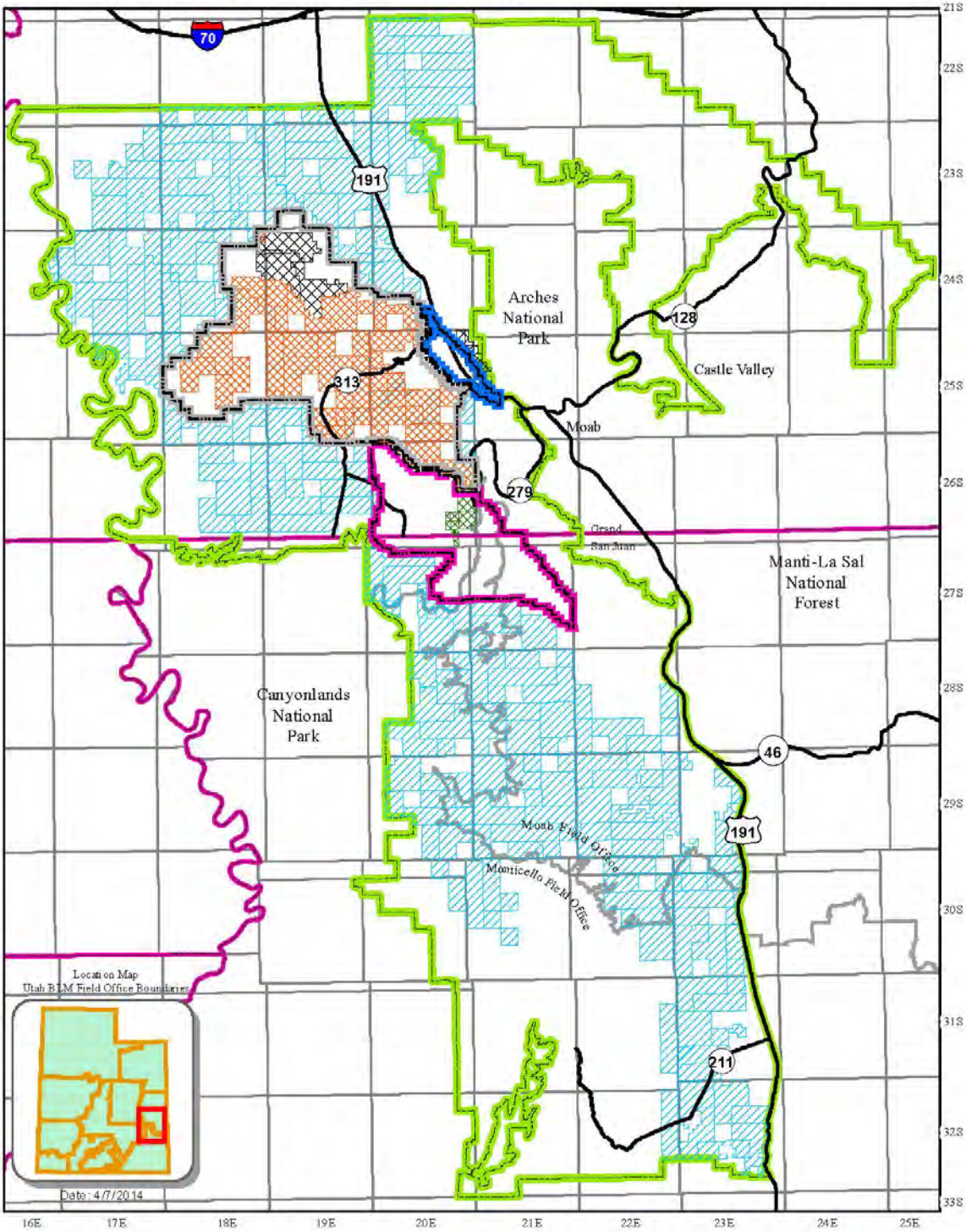


Figure 1. Index map to Paradox Basin, Utah and Colorado.

Map 2 – Paradox Basin and Limits of Deposition (Doelling, 1983)

Map 3 - Known Potash Leasing Areas, Potash Preference Right Leases, and Potash Prospecting Permit Applications



Potash Preference Right Leases
Intrepid Potash Moab Operation
Potash Prospecting Permit Applications
Potash Prospecting Permit Applications Rejected - Currently Under Appeal

Known Potash Leasing Areas
Ten Mile
Cane Creek
Seven Mile

Field Office Boundary
Master Leasing Plan Area
County Boundaries
State and Federal Highways

0 5 10 Kilometers
0 4.5 9 Miles

N W E S

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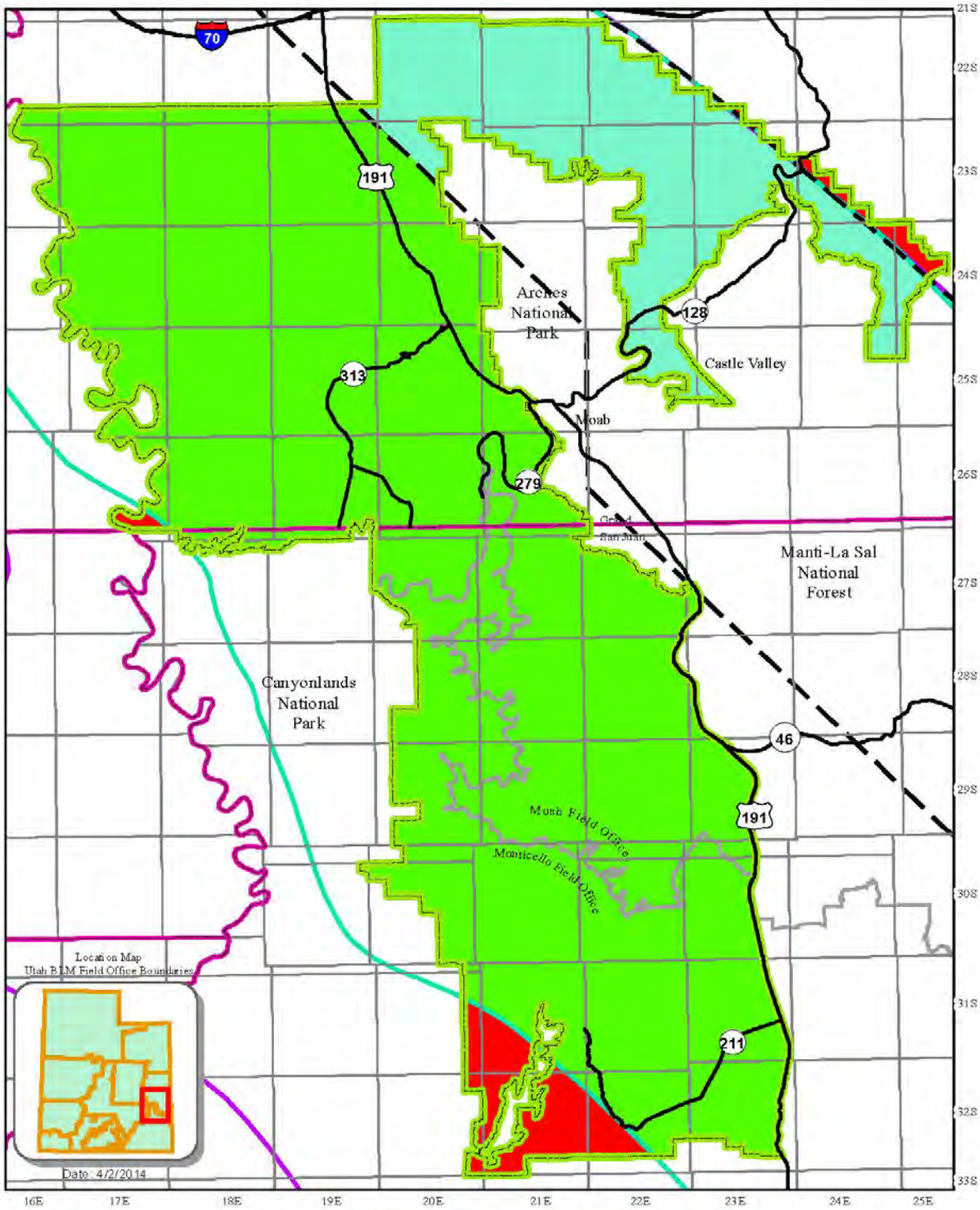
Map 4 - Potash Occurence Potential and Certainty Ratings



Fold and Fault Line
Paradox Basin Potash Line
Paradox Basin Halite Line
High Occurrence Potential Abundence Evidence (HD)
High Occurence Direct Evidence (HC)
No Occurence Potential Direct Evidence (OC)
Field Office Boundary
Master Leasing Plan Area
County Boundaries
State and Federal Highways

0 5 10 Kilometers
0 4.5 9 Miles

N W E S

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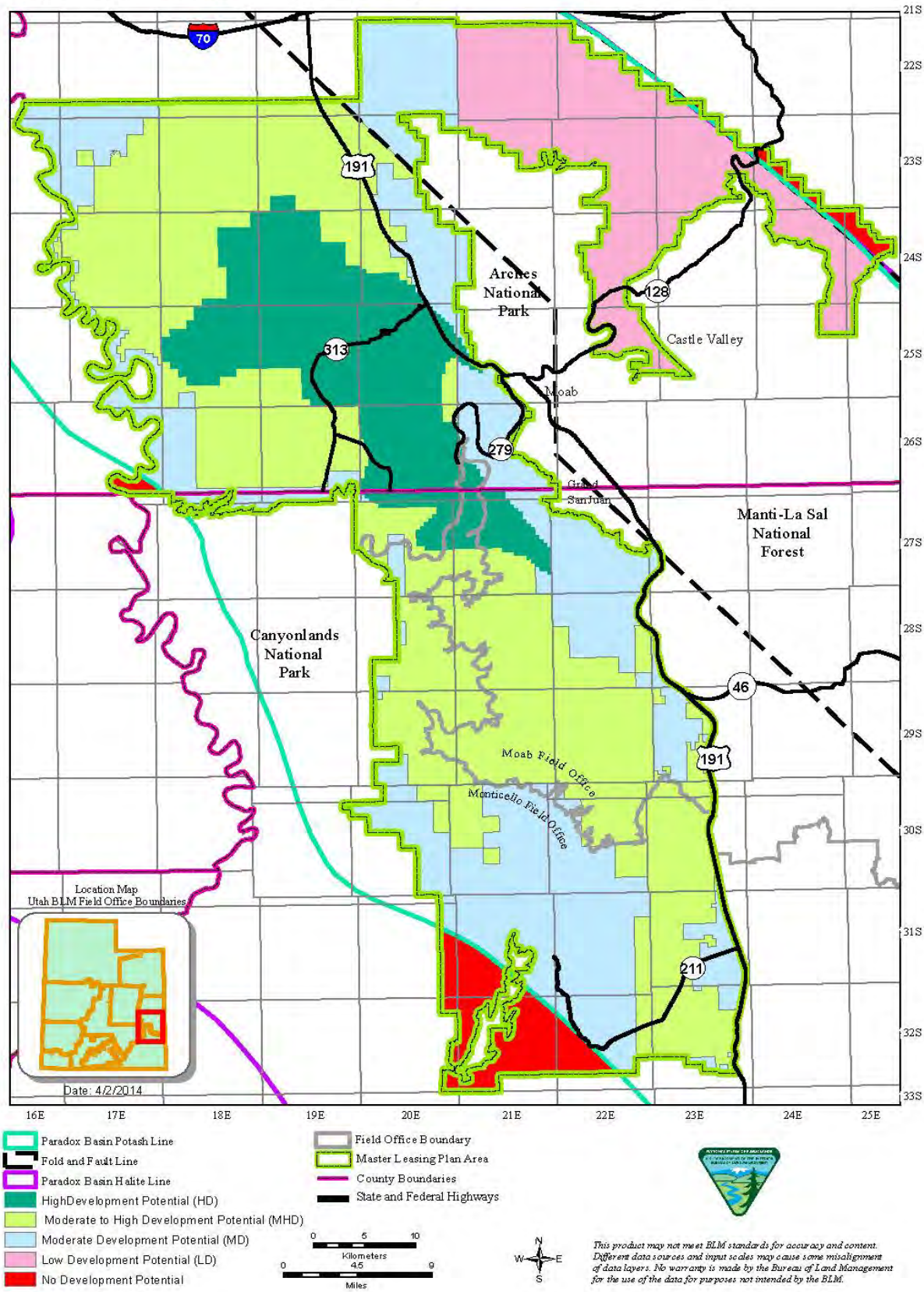
Map 5 - Potash Development Potential Ratings