Mineral Resource Assessment of Selected Areas in Clark and Nye Counties, Nevada, Edited by Steve Ludington
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Chapter D. Mineral Resource Potential of the Mormon Mesa Tortoise, Arrow Canyon, and Coyote Springs Tortoise Areas of Critical Environmental Concern, Clark County, Nevada

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Summary and Conclusions

The Mormon Mesa Tortoise Area of Critical Environmental Concern (ACEC) contains areas with high potential for limestone deposits and areas with moderate potential for stone and silica deposits. The potential for undiscovered deposits of other locatable and leasable minerals is low. The Mormon Mesa Tortoise ACEC has areas with high, moderate, and low potential for crushed-stone aggregate deposits and areas with high and moderate potential for sand and gravel aggregate deposits.

The Arrow Canyon ACEC has no known mineral deposits, and the potential for undiscovered deposits of locatable and leasable minerals is low. Arrow Canyon ACEC has areas with high and moderate potential for crushed-stone aggregate and moderate potential for sand and gravel aggregate.

The Coyote Springs Tortoise ACEC contains known deposits of stone and silica, and a part of it has moderate potential for additional silica deposits. The ACEC also has areas with high potential for limestone deposits. The potential for undiscovered deposits of other locatable and leasable minerals is low. The Coyote Springs Tortoise ACEC has areas with high, moderate, and low potential for crushed-stone aggregate deposits and high and low potential for sand and gravel aggregate deposits.

Introduction

This report was prepared for the U.S. Bureau of Land Management (BLM) to provide information for land planning and management and, specifically, to determine mineral resource potential in accordance with regulations at 43 CFR 2310, which governs the withdrawal of public lands. The Clark County Conservation of Public Land and Natural Resources Act of 2002 temporarily withdraws the lands described herein from mineral entry, pending final approval of an application for permanent withdrawal by the BLM. This report provides information about mineral resource potential on these lands.

The Mormon Mesa Tortoise, Arrow Canyon, and Coyote Springs Tortoise ACECs were studied in the field to confirm descriptions of the geology that were gleaned from the geologic literature. Samples were collected and analyzed, and known mineral deposits were visited and examined wherever possible. Definitions of mineral resource potential and certainty levels are given in appendix 1, and are similar to those outlined by Goudarzi (1984).

Lands Involved

The Arrow Canyon, Coyote Springs Tortoise, and Mormon Mesa Tortoise Areas of Critical Environmental Concern (ACECs) are contiguous, and they are located northeast of Las Vegas on the northwest side of Interstate 15 (fig. 1). A legal description of these lands is included in appendix 2.

The Mormon Mesa Tortoise ACEC is located northwest of the Virgin River and adjoins the north border of Clark County, about 90 km northeast of Las Vegas (fig. 1). Interstate 15 forms the south boundary of the ACEC for about 30 km and provides access to the area. The ACEC includes part of the Arrow Canyon Wilderness. It also overlaps part of the Arrow Canyon ACEC, that is, some lands are included within both ACECs (fig. 1).

The Arrow Canyon ACEC straddles Pahranagat Wash (fig. 1). The western part of the area is also included in the Mormon Mesa Tortoise ACEC and partially overlaps the Arrow Canyon Wilderness. Nevada State Highway 168 and Warm Springs Road both cross Pahranagat Wash to the east of the ACEC.

The Coyote Springs Tortoise ACEC adjoins the Mormon Mesa Tortoise ACEC on the west (fig. 1). It measures about 52 km north to south and is 2 to 6 km wide. The south tip of the ACEC is about 10 km northeast of the edge of Las Vegas. The ACEC encompasses the southern part of Coyote Springs Valley and also Hidden Valley to the southwest. U.S. Highway 93 bisects the ACEC from north to south.

Physiographic Description

Mormon Mesa forms a triangular highland between the Muddy and Virgin Rivers. The Mesa stands about 200 m

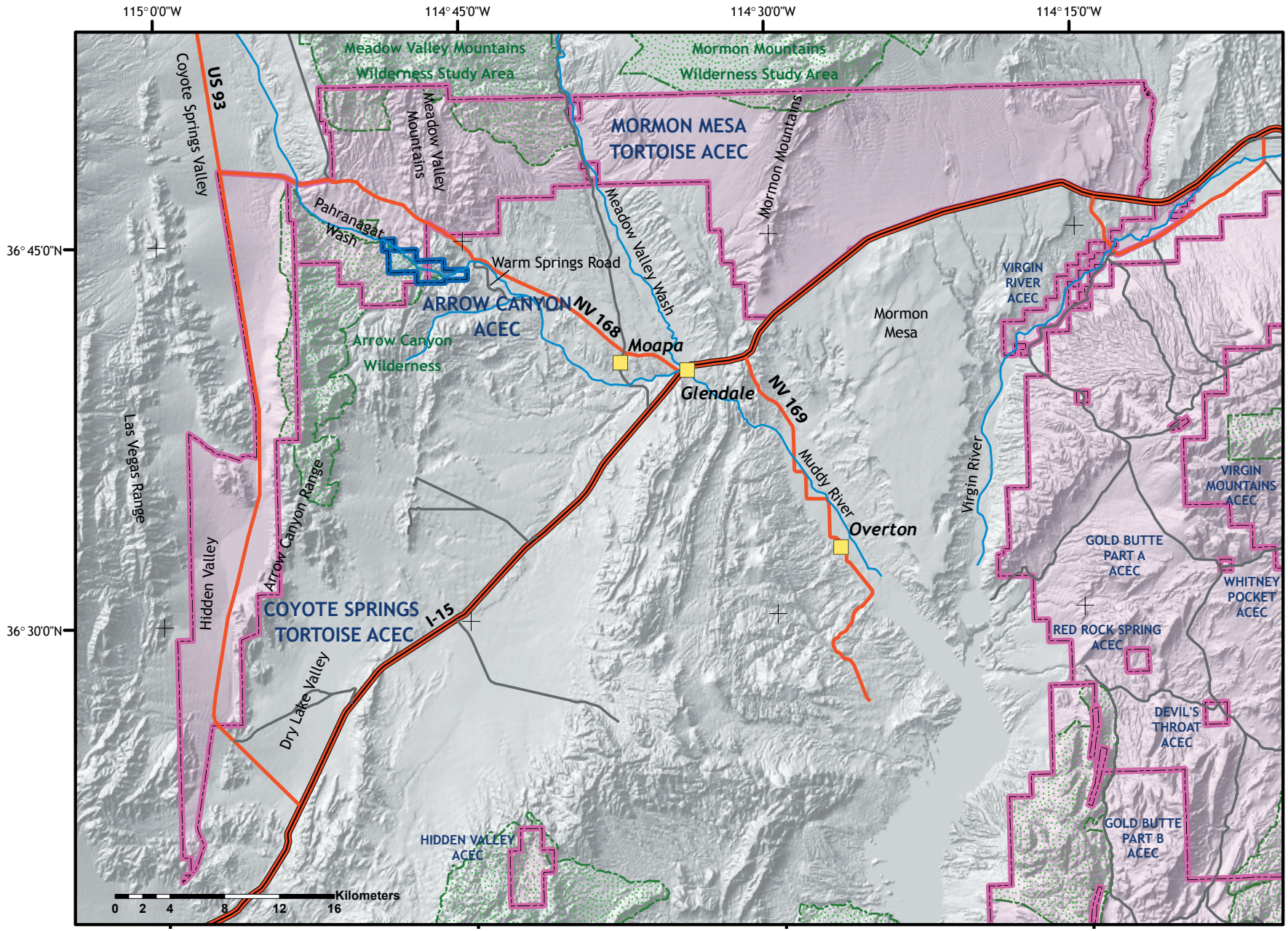

Figure 1. Index map of Mormon Mesa Tortoise, Arrow Canyon, and Coyote Springs Tortoise Areas of Critical Environmental Concern (ACEC; outlined in pink), showing towns and roads, wilderness areas, and wilderness study areas. Arrow Canyon ACEC boundary is shown in contrasting color (blue) to clarify the boundary overlap with the Mormon Mesa Tortoise ACEC.

above the riverbeds. From the Meadow Valley Mountains in the west, the Mormon Mesa Tortoise ACEC extends 60 km east across the mesa to the Virgin River Valley. The Meadow Valley Mountains have the most relief in the ACEC, reaching elevations of 1,500 m. The Mormon Mountains, in the central part of the ACEC, are lower in elevation. Much of the ACEC is a flat pediment at an elevation of about 750 m, with no streams or gullies and an average topographic gradient of less than 50 feet (18 m) per mile (Gardner, 1972).

Arrow Canyon is a narrow gorge that cuts through the northern Arrow Canyon Range for several miles. The Arrow Canyon ACEC contains part of the Arrow Canyon gorge (fig. 2) and the mouth of the Pahranagat Wash, which flows southeast (see also fig. 14). The canyon walls are about 120 m high in the gorge (Page and Dixon, 1997). Elevations in the ACEC range from about 570 m to about 840 m.

The Coyote Springs Tortoise ACEC contains most of southern Coyote Springs Valley and also part of Hidden Valley (fig. 1) to the south. The area is bounded by the Las Vegas Range on the west and the Arrow Canyon Range on the east. Perennial streams in the northern part of the ACEC flow northward into Coyote Springs Valley, where they join Pahranagat Wash at the north tip of the Arrow Canyon Range and flow east toward Arrow Canyon. The central part of the ACEC drains into the Hidden Valley alkali flat, and drainages in the south part of the ACEC drain eastward into Dry Lake Valley (fig. 1). The ACEC has little relief in the valleys (fig. 3) but it does include the western flank of the Arrow Canyon Range (up to 1,530 m elevation).

Geologic Setting

The three ACECs are located on the eastern edge of the Basin and Range Physiographic Province. The Colorado Plateaus Province lies to the east. The mountain ranges in all three ACECs are composed of Paleozoic sedimentary rocks (predominantly carbonates). These rocks underwent folding and thrust faulting during the late Cretaceous Sevier orogeny, followed by extensional basin and range faulting in the late Cenozoic. Large parts of the region are underlain by sedimentary deposits that blanketed low-lying areas during the late Miocene and filled intermontane valleys during the Quaternary. Figure 4 is a generalized geologic map of the three ACECs.

Figure 2. Cliffs of Paleozoic limestone at the mouth of Arrow Canyon.

Geology

Mormon Mesa Tortoise ACEC

Mormon Mesa is mostly covered by Quaternary alluvium but also has large exposures of Tertiary sedimentary rocks and smaller outcrops of Paleozoic sedimentary rocks (fig. 4). The Tertiary rocks include relatively minor exposures of the Oligocene to middle Miocene Horse Spring Formation and extensive exposures of the late Miocene Muddy Creek Formation. The Meadow Valley Mountains and Mormon Mountains within the area are composed primarily of Paleozoic carbonate

Figure 3. Starvation Flat, at the north end of the Coyote Springs Tortoise Area of Critical Environmental Concern (ACEC). Looking west, beyond the ACEC to the Las Vegas Range.

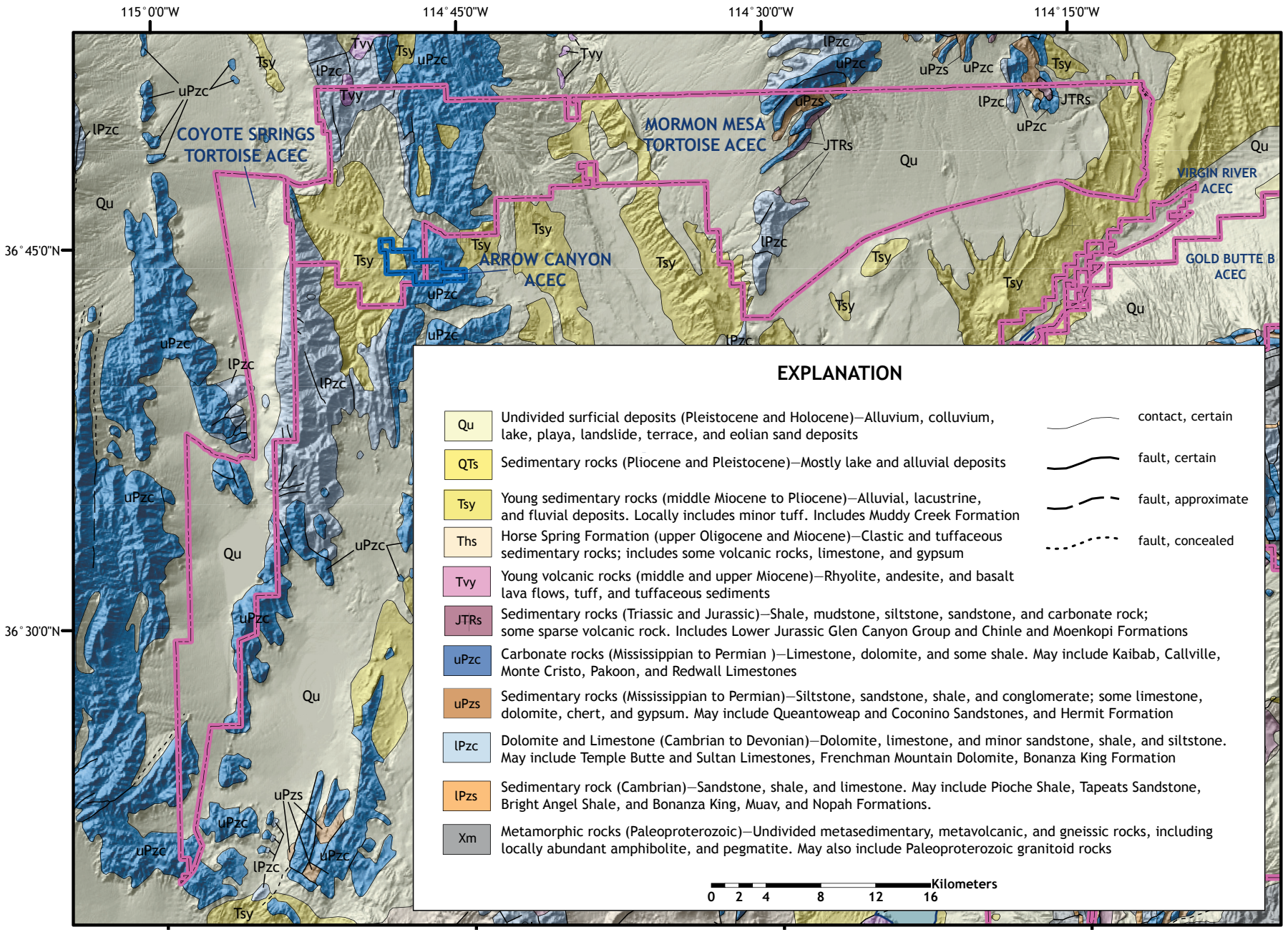

Figure 4. Generalized geology of the Mormon Mesa Tortoise, Coyote Springs Tortoise, and Arrow Canyon ACECs. Geology modified from Stewart and Carlson (1978).

rocks, but some Mesozoic siliciclastic rocks are also exposed, including the Triassic Moenkopi Formation and the Jurassic Aztec Sandstone (Page and Pampeyan, 1996; Schmidt, 1994; Schmidt and others, 1996). These units are cut by thrust faults associated with the Sevier orogeny and high-angle normal faults related to Cenozoic extension.

The young basin that underlies the eastern part of Mormon Mesa and areas to the east is known as the Virgin River Depression. Geophysical data (Langenheim and others, 2001) indicate that the basin is 5 to 10 km deep and filled with Tertiary and Quaternary sediments. A few Quaternary faults strike generally north in the central part of the basin (Langenheim and others, 2000).

The surface of Mormon Mesa (fig. 5) is a pediment cut on the Muddy Creek Formation and its reworked alluvial deposits (Gardner, 1972). Bedrock in the area is locally covered by caliche, an indurated layer of calcium carbonate that formed in the arid climate under aggrading conditions. The soil profile consists of a few meters of caliche, which transitions downward into the clastic parent material. This caliche is at least 890,000 years old, and it may be as old as 3 million years (Gardner, 1972).

Arrow Canyon ACEC

The walls of Arrow Canyon expose Mississippian, Pennsylvanian, and Permian strata. These carbonate rocks are especially well exposed and accessible in Arrow Canyon, giving it a reputation as one of the best-studied Paleozoic sections in the eastern Great Basin (Page and Dixon, 1997). Bedrock in the eastern part of the ACEC is the Permian Bird Spring Formation, which includes abundant marine fossils and a distinctive reddish marker bed near the top of the unit (Page and Dixon, 1997). The western part of the ACEC is composed of the Bird Spring Formation, the Indian Springs Formation, the Battleship Wash Formation, and the Monte Cristo Group (Page, 1992). These units are mostly limestone with beds of chert, except for the Bullion Dolomite member of the Monte Cristo Group (Page and Dixon, 1997). Continuous and extensive stratigraphic exposure has made Arrow Canyon a popular place to study stratigraphy. Conodont fossils from the Indian Springs Formation were used to define the boundary between the Mississippian and Pennsylvanian Periods (Brenckle and others, 1997).

Figure 5. Mormon Mesa pediment, as seen from Meadow Valley Wash. Moapa Peak, just north of the ACEC, in background.

Coyote Springs Tortoise ACEC

Paleozoic carbonate rocks form the bedrock of the Coyote Springs Tortoise ACEC (fig. 4), but much of it consists of wide valleys filled with younger sediments (Eakin, 1964). Ordovician, Silurian, and Devonian carbonate rocks form the northern part of the Arrow Canyon Range that is exposed in the ACEC (Page, 1998). The Las Vegas Range on the west and the southern part of the Arrow Canyon Range expose the same Permian and Mississippian rock units as Arrow Canyon. Coyote Springs Valley contains Quaternary deposits of alluvium and playa sediments.

Numerous large and small folds in these Paleozoic rocks are evidence of regional compression during the Sevier orogeny. The Battleship Wash Syncline is an open fold whose axis crosses Arrow Canyon in the study area, and it is visible along the east side of the Arrow Canyon Range (Page and Dixon, 1997). Another major syncline is concealed by alluvium in Coyote Springs Valley (Page, 1992). The rocks are cut by thrust faults associated with the Sevier orogeny and high-angle normal faults related to Cenozoic extension.

Mining History

The only recorded mining activity within the boundaries of these three ACECs was at the Quartzite quarry (fig. 6) in the central part of Coyote Springs Tortoise ACEC. We found no information about dates or amounts of production at that quarry. The quartzite may have been mined as a source of silica or for building stone.

Quartzite was reportedly mined for several years from the Tiffany Minerals Co. quarry (fig. 6), which is about 2 km east of the Coyote Springs Tortoise ACEC (Murphy, 1954). No figures are available for total production, but in 1954 production was reported to be less than 2,000 short tons of quartzite per year. The quartzite was trucked to a mill on the Union Pacific Railroad, but the operation was abandoned because the abrasiveness of the rock caused high milling costs. In addition, building stone was mined about 10 km east of the Coyote Springs Tortoise ACEC.

The Apex limestone quarries and plant of Chemical Lime Inc. form the largest mining operation in the vicinity of the three ACECs. The limestone was drilled and evaluated in the 1930s (Hewett and others, 1936), and limestone was mined and shipped from the area by U.S. Lime Products Corp. and processed elsewhere. In the early 1950s, annual production

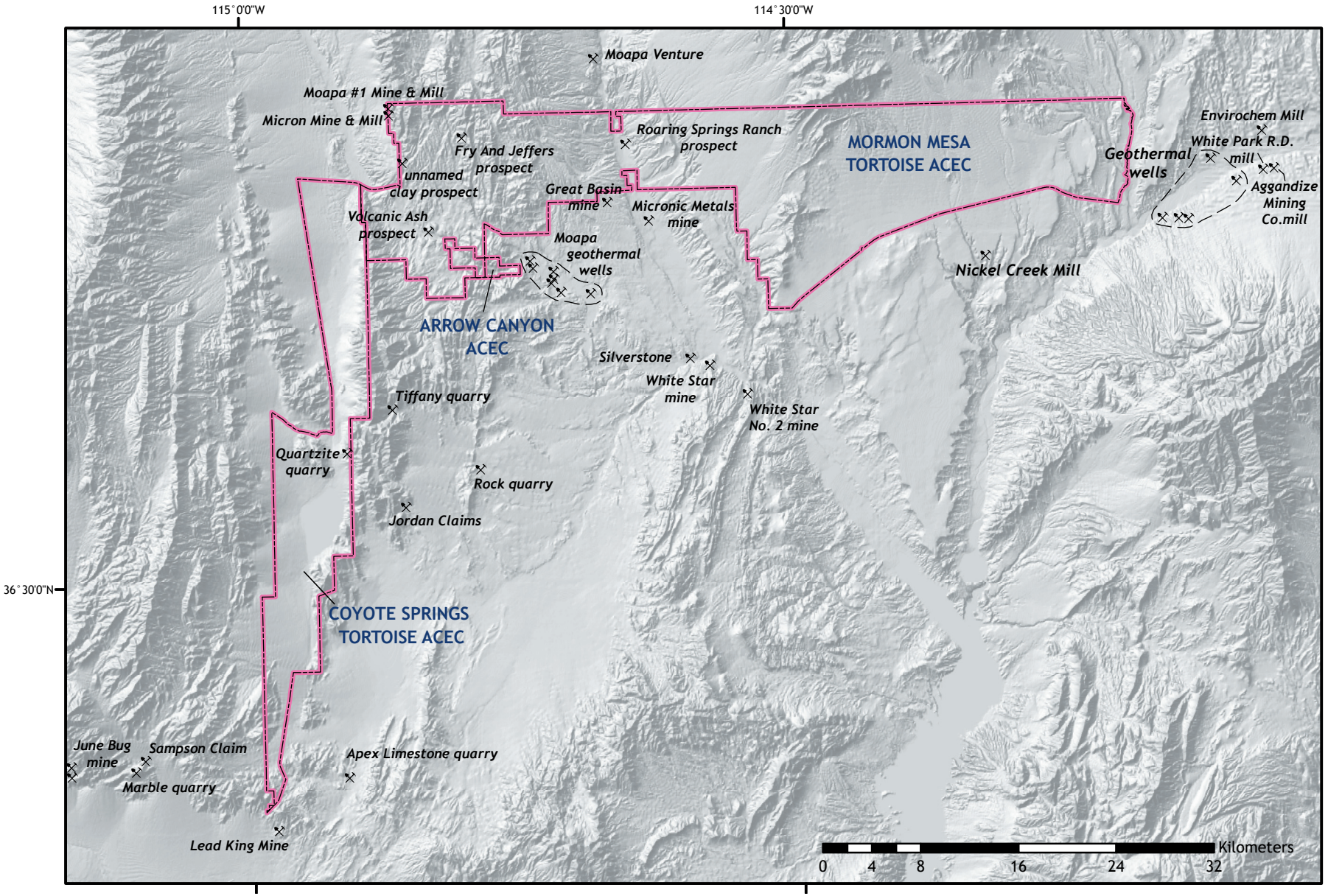

Figure 6. Mines and prospects in and near the Mormon Mesa Tortoise, Arrow Canyon, and Coyote Springs Tortoise Areas of Critical Environmental Concern (ACEC; outlined in pink).

was given by the U.S. Bureau of Mines at more than 500,000 short tons. In 1958, after acquisition of the operation by the Flintkote Co., a lime plant was constructed. In 1980 the operation was acquired by Genstar Lime and Cement Inc., which was succeeded by Chemstar Lime Inc. in 1986 and by Chemical Lime Inc. in 1994. The most recent production figure for the operation is 195,000 short tons of quicklime in 1990 (Nevada Department of Minerals and Nevada Bureau of Mines and Geology, 1991).

Although we found no direct evidence of placer gold, it is possible that there has been some placer gold mining along Meadow Valley Wash, which bisects the Mormon Mesa Tortoise ACEC. There has been no other known mining within the boundaries of the three ACECs, although moderately extensive mining of silica and dimension stone has taken place a few kilometers east of Coyote Springs Tortoise ACEC. In addition, exploration drilling for geothermal energy has taken place immediately east of the Arrow Canyon ACEC and southeast of the Mormon Mesa ACEC, along the Virgin River (fig. 6).

Mineral Deposits

Mormon Mesa Tortoise ACEC

The mines database of the Nevada Department of Environmental Protection locates the Roaring Springs Ranch gold prospect within the Mormon Mesa Tortoise ACEC, on Meadow Valley Wash (fig. 6), but provides no further information. A field visit to the indicated site revealed no evidence of exploration or mining aside from a primitive road off the Meadow Valley Wash road (fig. 7). Another source (Nevada Department of Industrial Relations, 1987) indicates that the Moapa #1 mine and mill was under construction in 1986 by the Roaring Springs Ranch Company, but that the site of this mine and mill was 20 km to the west, in section 6 of T13S, R64E. There are no other references to these developments.

In the far northwestern corner of the area, the Moapa #1 mine and mill (gold) and the Micron mine and mill (gold) were reportedly in operation in the mid 1980s (Nevada Department of Industrial Relations, 1987, 1988). Given the geologic context, these could have exploited polymetallic vein or replacement deposits in Paleozoic limestone. They are located at the south end of the Meadow Valley Mountains district (Tingley, 1989). Two visits to this area (fig. 6) yielded no evidence of gold mining activity (fig. 8). A shallow gravel pit was noted in the area, as well as some possible claim markers (fig. 9).

Clay deposits occur in the Muddy Creek Formation in the western part of the Mormon Mesa Tortoise ACEC. According

Figure 7. Purported site of Roaring Springs Ranch gold prospect.

Figure 8. Purported site of the Micron Mine and mill; Paleozoic carbonate rocks in hills on right. Looking north along former U.S. Highway 93.

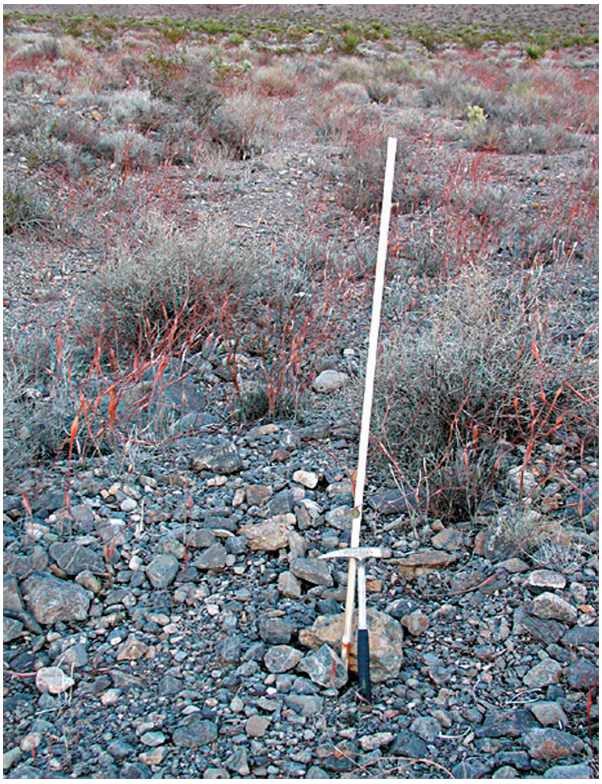

Figure 9. Possible old claim marker in the vicinity of the Moapa #1 and Micron sites, Mormon Mesa ACEC.

to Vandenberg (1937), a bed of white bentonite about 3 feet (1 m) thick is exposed for about 2 km in a bluff at the Volcanic Ash prospect (figs. 6, 10).

During field reconnaissance in this area, which is along Pahranagat Wash, we sampled a 1.1-m-thick, nearly flat lying bed of white to pale olive green expansive clay from a small prospect (fig. 11) along the south side of the wash (sample site AP-114). XRD analysis of this sample indicates the presence of smectite clay, possibly the sodium-rich clay beidellite, along with significant amounts of dolomite and minor quartz and feldspar. However, a chemical analysis of the sample (Ludington and others, 2005) suggests the presence of a magnesian smectite such as saponite, because MgO/CaO is higher than can be accounted for by dolomite contamination. In a road cut about 500 m to the west is a poor exposure of low-quality clay mixed with calcite and glassy shard tuff at about the same stratigraphic level (sample AP-115). This clay occurs in a sequence of sandstone, gypsum, and 5.6-Ma tuff capped by limestone that is probably part of the Muddy Creek Formation.

A second clay prospect, about 65 m long and 10 m wide (fig. 12), is about 6 km north-northwest of the Volcanic Ash prospect (sample site AP-038). At this prospect, a bed of pale-olive-green to pale-brown clay occurs in shallowly west dipping redbeds of the Muddy Creek Formation. On the basis of XRD analysis, this clay is considered to be of low quality because it contains large amounts of impurities, mainly calcite and quartz with minor feldspar and dolomite. The clay mineral could not be determined by XRD analysis; the clay differs considerably from the Volcanic Ash prospect clay on the basis of chemical analysis (Ludington and others, 2005).

The Fry and Jeffers prospect (fig. 6) was reportedly explored for uranium in lower Paleozoic limestone in the western part of the Mormon Mesa Tortoise ACEC (Campbell, 1987). Radioactivity at the site was about 1.6 times background, and soil samples from the area reportedly contained as much as 110 ppm U_3O_8 (Nelson, 1954). This occurrence is in shallowly northeast dipping black Paleozoic limestone with no veins or structures and no visible uranium minerals. Later reconnaissance of the area showed only weakly anomalous radioactivity, and the occurrence was judged to be of no interest (Campbell, 1987). Examination of aerial photography of the region reveals no evidence of any significant surface disturbance.

Near Meadow Valley Wash, but outside the ACEC, four other gold prospects have been reported (fig. 6): the Moapa Venture prospect, about 5 km north of the ACEC bound-

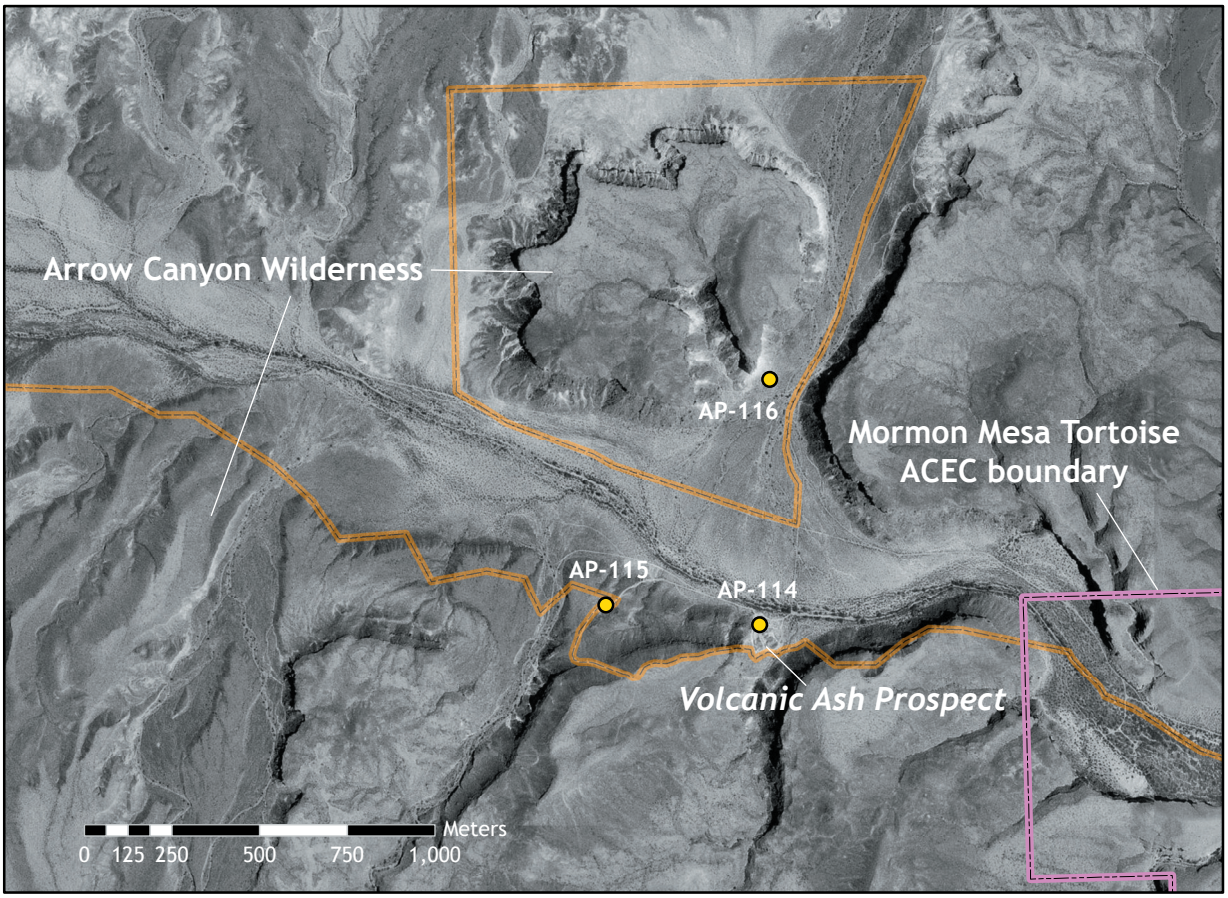

Figure 10. Aerial view of Volcanic Ash clay prospect in the Mormon Mesa ACEC, showing wilderness (orange) and ACEC (pink) boundaries, and location of samples.

ary (Nevada Department of Industrial Relations, 1983); the Great Basin prospect, about 1 km south of the ACEC boundary (Nevada Department of Industrial Relations, 1987); the Micronic Metals mine, about 2 km south of the ACEC boundary (Nevada Department of Industrial Relations, 1981); and Silverstone, about 7 km southwest of the south tip of the ACEC (Nevada Department of Industrial Relations, 1983). These sites were reportedly in operation in the 1980s, but we were unable to find any further information about these locations or locate them in the field.

The Gourd Springs mining district is in the East Mormon Mountains of Lincoln County, 12 to 15 km north of the Mormon Mesa Tortoise ACEC. Reported lode deposits are either associated with Precambrian pegmatites or consist of manganese enrichments in Cambrian limestone (Tschanz and Pampeyan, 1970). Manganese ore was reportedly produced in 1929 from this district, but Tingley (1984) was unable to locate these workings.

The Mormon Mountains district contains the Whitmore Mine, which is about 10 km north of the ACEC. It consists of several adits, shallow shafts, and prospect pits along a moderately northwest-dipping detachment fault. Unmineralized Paleozoic limestone is in the hanging wall, and altered and veined granitic rock is in the footwall. Quartz, pyrite, chalcopyrite, and bornite occur in the veins, and a select vein sample contains more than 2 percent copper and 50 ppm silver (Tingley, 1989). In 1908, 19 short tons of ore were produced containing 4 troy ounces of silver and 2,621 pounds of copper.

Near the town of Mesquite, about 10 km east of the ACEC, three small mills reportedly operated intermittently in the 1980s (fig. 6): Envirochem (Nevada Department of Industrial Relations, 1982); White Park R.D (Nevada Department of Industrial Relations, 1991); and Aggandize Mining Co. (Nevada Department of Industrial Relations, 1991). None of these is known to be operating at present.

The White Star bedded gypsum deposit is located about 7 km southwest of the south tip of the ACEC, near the town of Glendale, Nevada (figs 1, 6). The deposit, a flat-lying gypsite bed about 7 m thick in the Muddy Creek Formation, was mined by the White Star Plaster Co. from 1919 to 1920 to supply a nearby mill (Papke, 1987). The White Star No. 2 deposit, about 4 km to the southeast, was mined underground from 1921 to 1923 to feed the same mill. The latter deposit consists of a shallowly west dipping gypsum unit about 8 m thick in the Kaibab Formation (Papke, 1987).

Federated Commercial Industries Co. is currently exploring a large area of gypsum in the upper part of the Muddy Creek Formation in Lincoln County, about 4 km north of the Mormon Mesa ACEC. Published information on gypsum in this area describes the Snowhite deposit as flat-lying, near-surface gypsite about 2 m thick in an area of about 7 km^2 (Papke, 1987). The current exploration personnel of Federal Commercial Industries report that it covers a much larger area (G. W. Hansen, written commun., 2005).

Arrow Canyon ACEC

No mineral deposits are known in or near the Arrow Canyon ACEC. However, several wells were drilled to explore for geothermal energy in the Muddy Springs area about 1 to 6 km east of the east end of the Arrow Canyon ACEC.

Coyote Springs Tortoise ACEC

The Lead King mine, in the Dike mining district, exploited a polymetallic deposit in a shear zone in upper Paleozoic carbonate rocks. It is less than 2 km south of the south tip of the Coyote Springs Tortoise ACEC (fig. 6). It reportedly produced 2 carloads of lead ore sometime before the 1950s (Longwell and others, 1965). This deposit may be a Mississippi-Valley-type deposit of Paleozoic age.

Small quantities of ore have been produced from mines in the Gass Peak mining district, which is about 10 to 15 km west of the south end of the Coyote Springs Tortoise ACEC (fig. 6). The bedrock in this district is Monte Cristo Limestone that

Figure 11. White to pale-olive-green clay in a small prospect on the south side of Pahranagat Wash. Sample site AP-114.

Figure 12. Clay bed in redbeds of the Muddy Creek Formation. Unnamed clay prospect, sample site AP-038.

has been replaced with lead and zinc minerals (now oxidized) adjacent to shear zones. The June Bug Mine produced about 1,000 short tons of ore in 1916-1917 (Longwell and others, 1965). The Sampson claim has no recorded production. Some of the deposits in the Gass Peak district may be Mississippi-Valley-type replacement deposits.

A once-active quarry in the Ordovician Eureka Quartzite is in the central part of the Coyote Springs Tortoise ACEC (fig. 6). This quarry is about 150 m long, 30 m wide, and 20 m deep (fig. 13). It is visible from Highway 93 near the western base of the Arrow Canyon Range. The quartzite is white, very hard, firmly cemented, and partially recrystallized. It may have been mined as a source of stone rather than of silica. A chip sample of quartzite that represents about 10 m of bedded thickness (sample AP-036; Ludington and others, 2005) contains more than 99 percent SiO_2. Except for slightly elevated Fe_2O_3, it is suitable for the production of container glass (table 1). The thickness of the Eureka Quartzite in the area is given at 40 to 50 m (Page, 1998). Reserves available at economic mining costs may be low because the bedding dips shallowly westward under increasingly thick cover. Mapping by Page (1992, 1998) shows that the Eureka Quartzite crops out extensively in the Arrow Canyon Range. In the Coyote Springs ACEC it is mainly high on the steep western face of the range and within the Arrow Canyon Wilderness Area.

Figure 13. Quartzite quarry on the Coyote Springs Tortoise ACEC at the west base of the Arrow Canyon Range. Sample site AP-036.

The quarry described above is west of the Arrow Canyon Range mining district as defined by Tingley (1992). This district reportedly contains several deposits of silica and building stone within about 10 km of the east boundary of the Coyote Springs Tortoise ACEC. The locations of some of these are in doubt because of discrepancies among published sources (Murphy, 1954; Tingley, 1989; Hess, 2001). The Tiffany Minerals Co. quarry is the only other mined deposit located by us or by Tingley (1989) with certainty. The Eureka Quartzite was mined at a rate of about 2,000 short tons per year from this site (Murphy, 1954), which is about 1 km east of the Coyote Springs Tortoise ACEC. The quarry is about 75 m long, 40 m wide, and 12 m deep in a dip slope on beds that dip at a low angle to the east (Tingley, 1989). On the basis of an analysis reported in Murphy (1954), the chemistry of Tiffany mine quartzite has very high SiO_2 and is similar to that of our sample AP-036. We have no information about reserves at the Tiffany deposit.

The Chemical Lime Corporation mines high-calcium limestone from the Crystal Pass Limestone Member of the Devonian Sultan Formation at Apex about 5 km east of the south end of the ACEC (fig. 6). In addition, the company mines dolomite from the Bullion Dolomite Member of the Monte Cristo Formation in the same area. Both rocks are used to make lime in an adjacent plant. Relatively minor amounts of magnesium are considered to be deleterious in high-calcium lime, and kiln feed that contains more than 1 percent $MgCO_3$ (about 0.5 percent MgO) is unsuitable (S. Krukowski, personal commun., 2006). In addition, kiln feed with more than 1 percent SiO_2 is generally considered unacceptable. In southern Nevada, Cambrian through Middle Devonian rocks, which are predominantly dolomite and dolomitic limestone, generally

Table 1. Comparison of major element composition of Nevada silica deposits.

[AP-036 = quartzite quarry, Coyote Springs ACEC; AP-117 = American Cement and Aggregate Corp. plant, Mercury, Nevada; AP-006C = Arden Quarries, Nevada. Tiffany Mine and Simplot Silica data are from Murphy (1954); container glass specification data are from Zdunczyk and Linkous (1994). na = data not available.]

Element	AP-036	AP-117	AP-006C	Tiffany Mine	Simplot Silica ore	Simplot Silica product	Container glass specification
SiO_2	99.42	98.53	95.56	99.52	97.25	98.93	98.5 min
Al_2O_3	0.17	0.33	0.77	0.27	1.38	0.65	0.5 max
Fe_2O_3	0.16	0.25	0.4	0.01	0.19	0.03	0.035 max
MgO + CaO	0.07	0.06	1.22	0.02	0.27	0.05	0.2 max
TiO_2	0.01	0.02	0.02	0.01	0.08	0.03	0.03 max
Cr_2O_3	0.036	0.04	0.031	na	0.00	na	0.001 max

Table 2. Comparison of some major element analyses of 3-m chip sample AP-324 and 25-m chip sample AP-328 from the Coyote Springs Tortoise ACEC with a grab sample from the Apex quarry, with Portland cement specifications, and with high-Ca lime specifications.

[$CaCO_3$ % calculated using CaO x 1.78; $MgCO_3$ % calculated using MgO x 2.09. Apex Limestone Quarry data from Tingley and others (1992). Portland cement specifications from Ames and others (1994). High-Ca lime ore specification from Stanley T. Krukowski (oral commun., 2005).]

Element	AP-324	AP-328	Apex Limestone Quarry	Portland cement ore specification	High-Ca lime ore specification
SiO_2	1.86	2.00	0.80		<1
Al_2O_3	0.20	0.16	0.16		
Fe_2O_3	0.11	0.08	0.12		
MgO	0.54	0.26	0.34		<0.5
CaO	54.32	56.23	54.94	ca. 50	
Na_2O+K_2O	0.12	0.08	0.05	<0.4	
P_2O_5	0.08	0.01	0.04		
LOI	42.8	41.10	43.20		
$CaCO_3$	96.69	100.09	97.79		>95
$MgCO_3$	1.13	0.54	0.71		
Total carbonate	97.82	100.63	98.50		

contain too much MgO and (or) other impurities (such as silica in the form of chert) to meet specifications. However, some Upper Devonian and Mississippian limestone units in southern Nevada generally have sufficiently low MgO contents for lime production. The Crystal Pass Limestone at Apex is chemically suitable (table 2), and it is especially attractive because its very fine grain size is desirable for the production of high-quality lump lime. More coarsely crystalline limestone decrepitates during calcination, producing fine-grained lime.

Mineral Exploration and Development

There are a number of current placer claims in and adjacent to the Mormon Mesa Tortoise ACEC. American Gold Corp. holds four current association placer claims on the surface of Mormon Mesa, along the south boundary of the Mormon Mesa Tortoise ACEC, near its east end. These are part of the same block of claims described in the Virgin River ACEC report (Chapter G of this report). A group of eight individuals hold five association placer claims in the central part of the Mormon Mesa Tortoise ACEC, near the northern boundary, along Meadow Valley Wash. These claims include the Roaring Springs Ranch prospect mentioned above. A different group of eight people holds two other placer claims further south along Meadow Valley Wash, just within the Mormon Mesa Tortoise ACEC. The Fire Corporation holds seven association placer claims along the south boundary of the ACEC, about 3 to 8 km west of Meadow Valley Wash, and a third group of eight people holds two claims in that same vicinity. John P. Simons holds five placer claims in the western part of the ACEC, just south of the Fry and Jeffers uranium prospect.

American Cement and Aggregate Corp. holds eight claims near the center of the Coyote Springs Tortoise ACEC in the vicinity of the quartzite quarry described above. The company produces silica sand from the Eureka Quartzite near Mercury, Nevada. Nevada Aggregates Holding LLC holds a single claim near the south tip of the Coyote Springs Tortoise ACEC.

None of the claims listed above shows any signs of current exploration activity. We are not aware of any other current exploration activity in the three ACECs.

Geothermal Sites and Exploration

Wells drilled near the Mormon Mesa Tortoise and Arrow Canyon ACECs intersected thermal water (fig. 6). Warm springs and wells in the Muddy Springs area are within 1 km of the Arrow Canyon ACEC and 2 km of the Mormon Mesa Tortoise ACEC. On the basis of data in Garside (1994) and Shevenell and Garside (2005), well CSV-3, which is near U.S. Highway 93 along the west border of the Coyote Springs Tortoise ACEC, intersected hot water (41°C), and other wells and springs in the area produce warm water (31-36°C). Warm Spring, which is in the Muddy Springs geothermal area, produces one of the highest flows of thermal water in Nevada (Garside, 1994).

Despite the presence of thermal wells and springs in the area, the likelihood for a geothermal system with sufficiently high temperature (150°C) for electrical generation in the area

is considered to fall in the "permissive" to "marginally favorable" classes in most of the three ACECs (Coolbaugh and others, 2005). These classes constitute the two lowest geothermal favorability classifications for the Great Basin. Relatively small areas in the central and northern part of the Coyote Springs Tortoise ACEC and the northwestern part of the Mormon Mesa Tortoise ACEC are shown by Coolbaugh and others as "favorable," which is equivalent to only moderate potential in their classification scheme. However, potential for direct use applications, such as residential or aquacultural heating, is high in the Muddy Springs area.

Mineral Resource Potential

Locatable Minerals in Mormon Mesa Tortoise ACEC

Precious and Base Metals.—Although there are hydrothermal precious- and base-metal deposits in nearby areas, the geologic environments that host these deposits do not occur inside this ACEC, and the potential for their presence is low.

Uranium.—The Fry and Jeffers uranium prospect is not in an area that exhibits significant or widespread effects of mineralizing processes, and radioactivity in the area is not much above background levels. On the basis of this and the regional geology, we do not consider the ACEC to have potential for uranium deposits.

Clay. —There are clay occurrences within this ACEC, but the clay is of poor quality and unlikely to be present in large amounts. The potential for clay deposits is low.

Stone and Silica.—At least two deposits have produced silica and/or stone near this ACEC. However, there are no continuous outcrops of Eureka quartzite within the ACEC, and the mineral resource potential is low.

Limestone.—At Apex (fig. 6), high-calcium limestone is mined from the Crystal Pass Member, the uppermost unit in the Devonian Sultan Limestone, and this unit is known to contain high-calcium limestone elsewhere in southern Nevada. An equivalent limestone unit is included in the upper part of the Guilmette Formation, which crops out in the western part of the Mormon Mesa Tortoise ACEC (Page, 1992, 1998). Although we have demonstrated that the Sultan (or upper Guilmette) contains high-calcium limestone at one site in the Coyote Springs Tortoise ACEC, the potential for economic deposits cannot be demonstrated at the highest certainty level without more careful sampling. Two large areas mapped as Sultan Formation (Longwell and others, 1965) and upper Guilmette Formation (Page, 1992, 1998) are considered to have high potential, with moderate certainty, for limestone deposits (tract MMT01, fig. 14).

Gypsum.—There are two abandoned gypsum mines near the south tip of this ACEC, but the appropriate depositional environments are not found inside the ACEC, and the potential for gypsum deposits there is low.

Leasable Minerals in Mormon Mesa Tortoise ACEC

The entire Mormon Mesa Tortoise ACEC is within the region considered by the BLM to be moderately favorable for oil and gas (Smith and Gere, 1983). There is no indication of potential for brine or evaporite deposits of sodium or potassium. The Mormon Mesa Tortoise ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is low.

Salable Minerals in Mormon Mesa Tortoise ACEC

Crushed Stone.—The highest potential areas for crushed-stone aggregate are located in the western part of this ACEC, where Paleozoic carbonate rocks form north-trending ridges. The highest quality lithologies are found in the Highland Peak Formation, the Nopah Formation, Eureka Quartzite, Laketown Dolomite, Simonson Dolomite, the Guilmette Formation, the Crystal Pass Limestone, Battleship Wash Formation, and various members of the Bird Springs Formation. Geologic mapping by Page (1992) indicates that the carbonate rocks in these units are limestone, dolomitic limestone, and dolomite and are relatively chert-free compared to other Paleozoic carbonate units. Areas underlain by these rocks constitute tract AMAC03 (fig. 15), and have high potential for crushed-stone aggregate, with a high degree of certainty. High-potential areas in the tract are also present in the south-central part of the ACEC along the southern extension of the Mormon Mountains.

Siliceous beds in other carbonate units are composed of discontinuous chert layers that can be in intervals of as much as 7 m thick. Units that have shale interbeds and/or significant chert content were designated to have moderate potential for crushed-stone aggregate, with a moderate level of certainty (tract AMAC08, fig. 15).

Low potential units include the Muddy Creek Formation, which is a friable sandstone-shale sequence with conglomeratic units. The distribution of Muddy Creek Formation was used to designate tract AMAC05 (fig. 15), which has low potential for crushed-stone aggregate, with a high level of certainty. Some areas of Muddy Creek Formation are covered with varying thicknesses of Quaternary alluvial deposits; these areas were evaluated for sand and gravel aggregate deposits.

Sand and Gravel.—Extensive sand and gravel units occur across Mormon Mesa. These deposits are characterized by carbonate clasts from the Arrow Canyon Range and the Mormon Mountains. They constitute good-quality aggregate and are assigned a high potential for sand and gravel aggregate deposits, with a high level of certainty (tract AMAC10, fig. 15). On the mesa itself, alluvial fan deposits lie atop the Mormon Mesa caliche horizon, which in turn is underlain by the Muddy Creek Formation. In areas south of the Mormon Mountains, the alluvial deposits are thinner and expose the caliche horizon and the underlying Muddy Creek Formation.

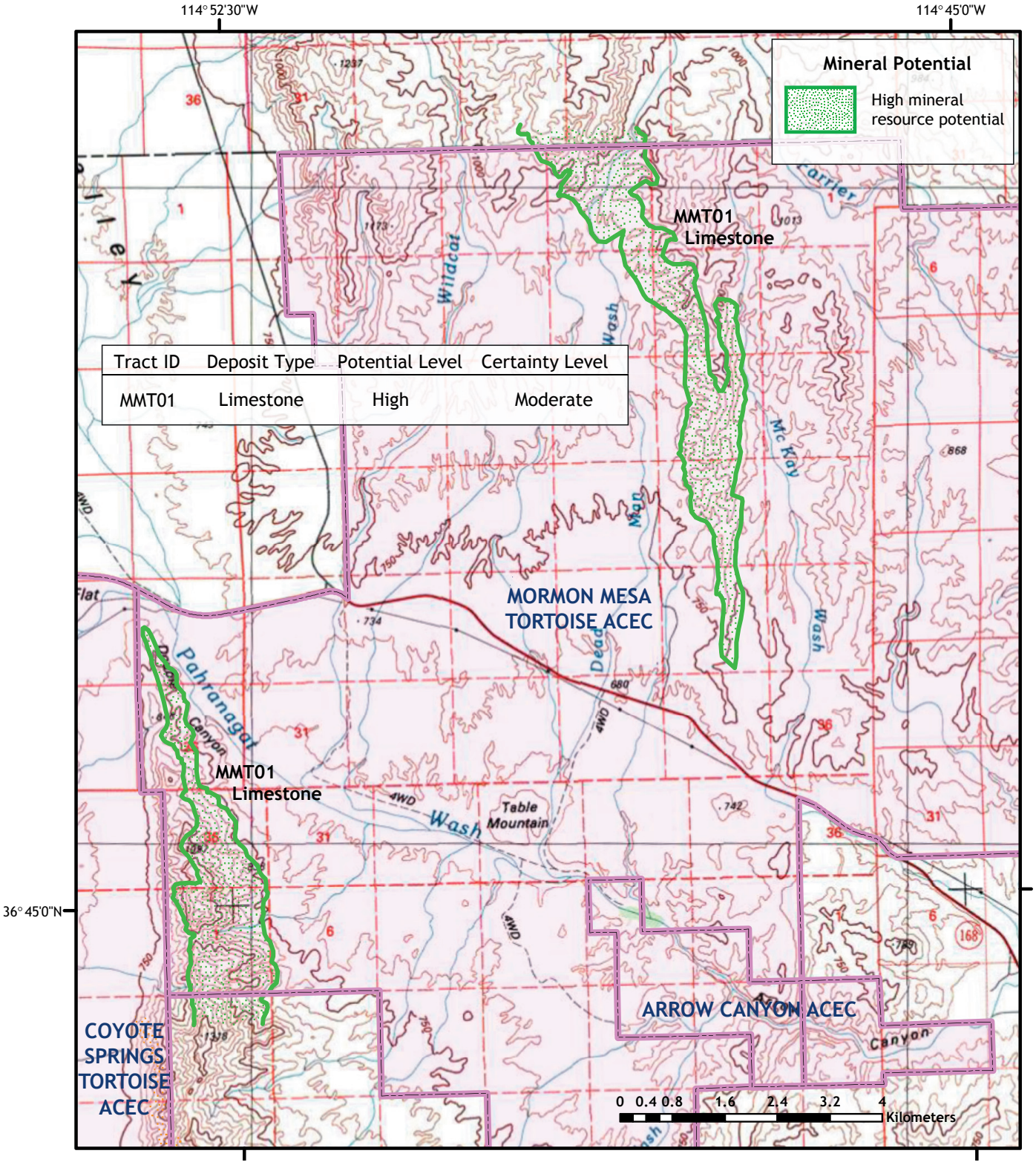

Figure 14. Mineral resource potential tracts for limestone deposits in the Mormon Mesa Tortoise Area of Critical Environmental Concern (ACEC).

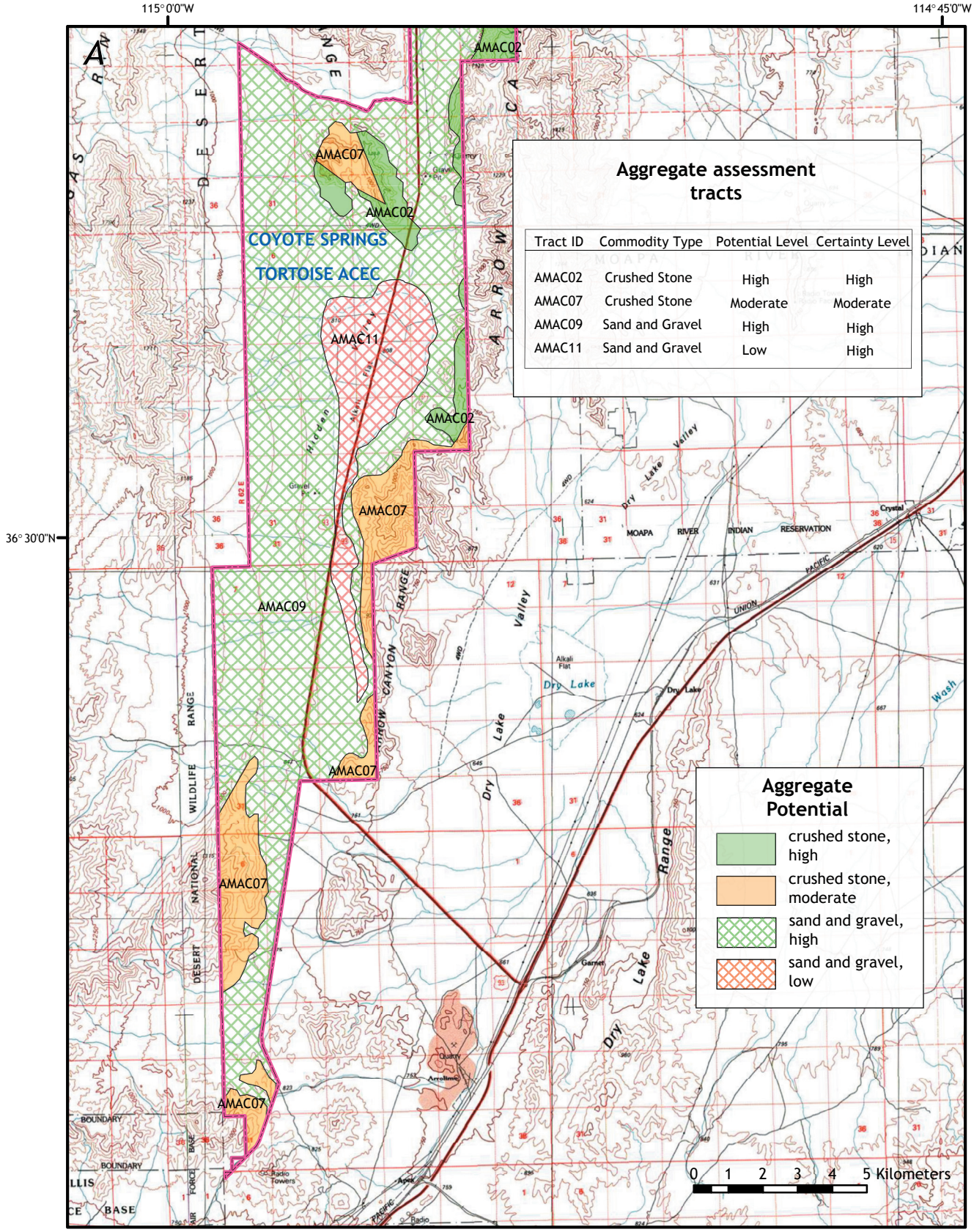

Figure 15. Mineral resource potential tracts for aggregate resources in the Mormon Mesa Tortoise (*B, C, D*), Arrow Canyon (*B*), and Coyote Springs Tortoise (*A, B*) Areas of Critical Environmental Concern (ACEC).

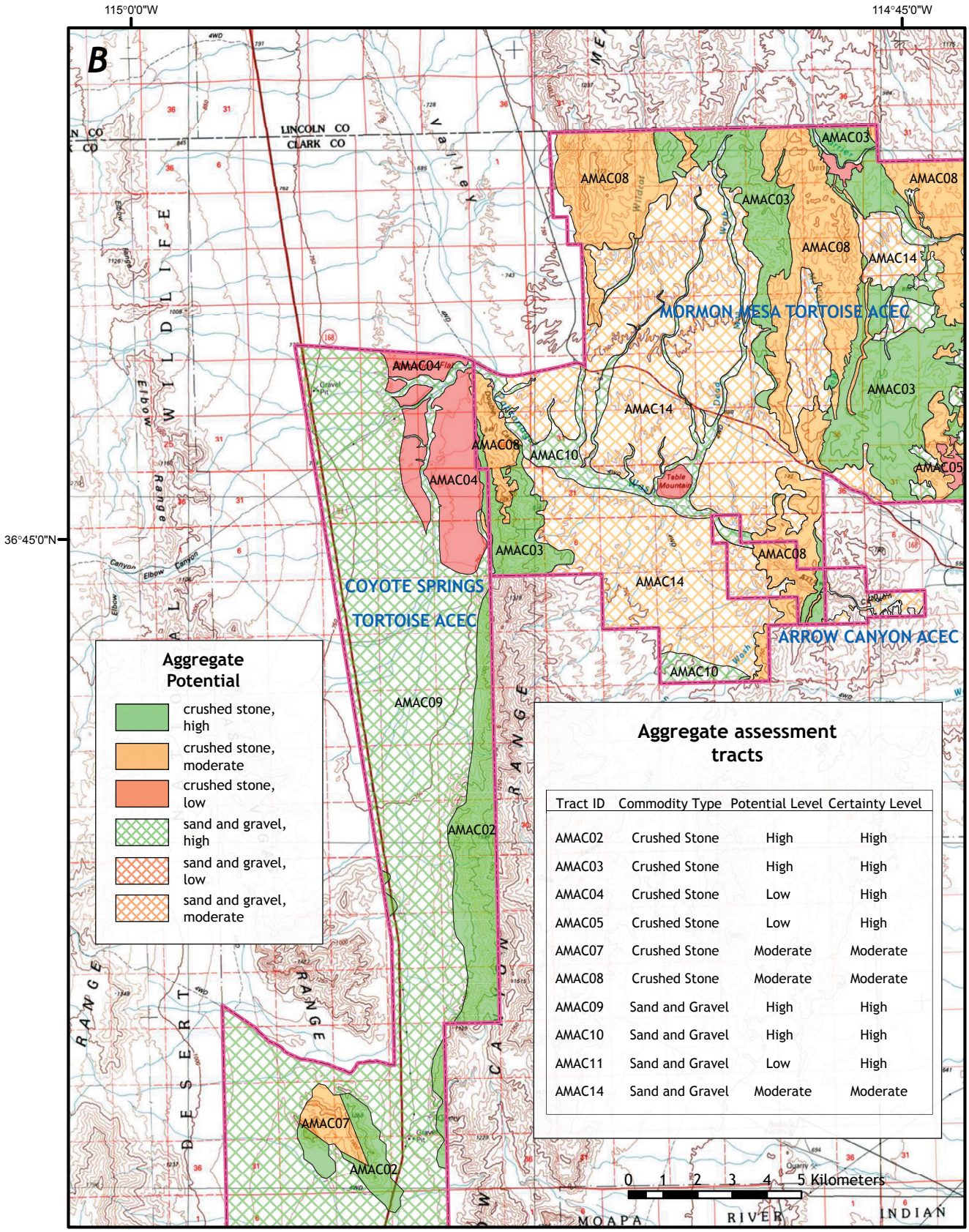

Figure 15.—Continued.

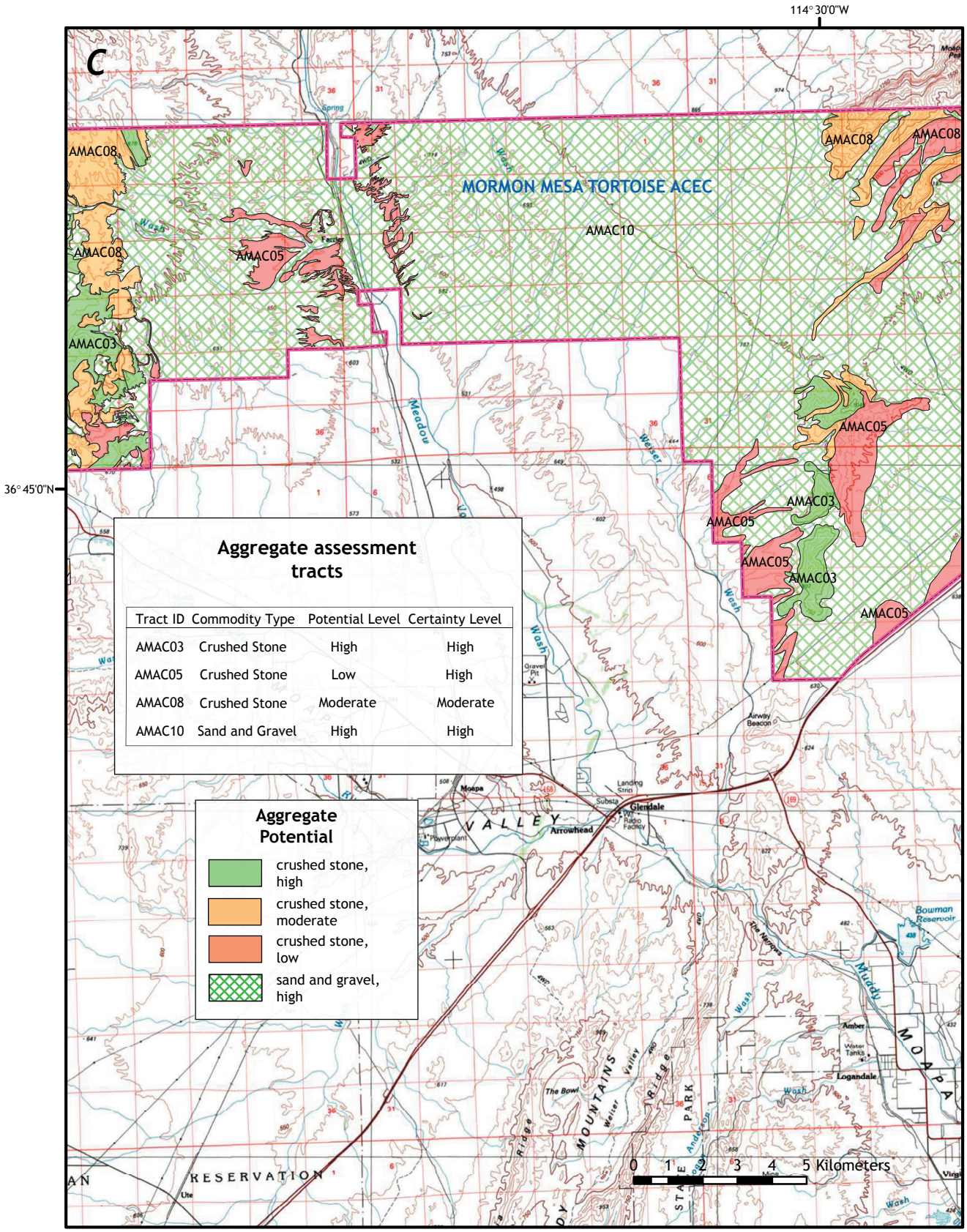

Figure 15.—Continued.

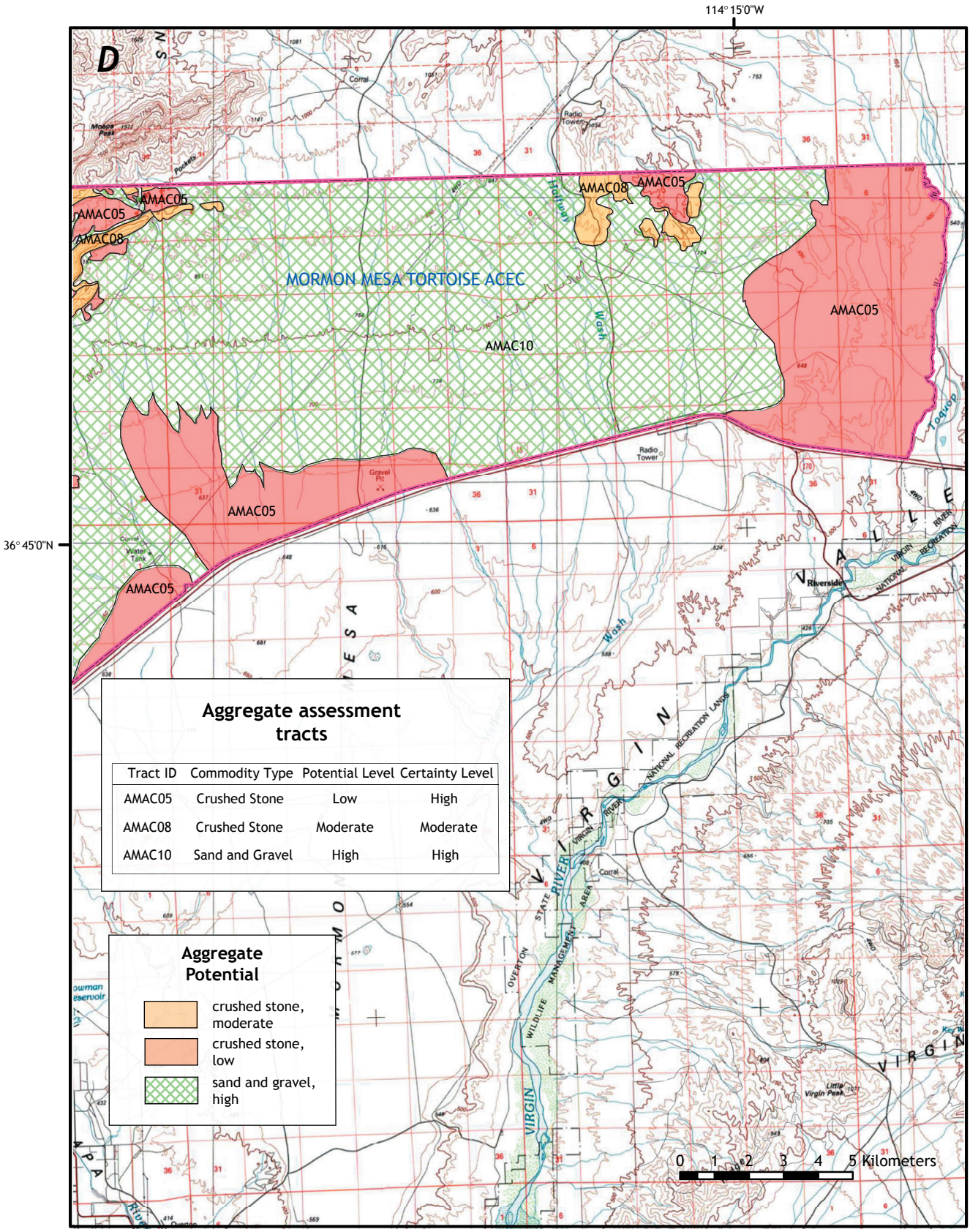

Figure 15.—Continued.

Farther west, a thin veneer of alluvial deposits overlies the Muddy Creek Formation, making separating the two difficult. Together, the Muddy Creek Formation and these alluvial deposits were used to delineate a tract (tract AMAC14, fig. 15) that has moderate potential for sand and gravel aggregate deposits, with a moderate level of certainty. Three small areas (tract AMAC12, fig. 15) have low sand and gravel potential, with a low certainty level.

Locatable Minerals in Arrow Canyon ACEC

Clay.—There are clay occurrences near the Arrow Canyon ACEC, but the clay is of poor quality and unlikely to be present inside the ACEC. The potential for clay deposits is low.

Stone and Silica.—At least two deposits have produced stone and (or) silica near this ACEC. However, there are no outcrops of the Eureka Quartzite inside the ACEC, and there is no potential for the occurrence of sand and (or) silica deposits.

The Arrow Canyon ACEC contains no known deposits of other locatable minerals.

Leasable Minerals in Arrow Canyon ACEC

The entire Arrow Canyon ACEC is within the region considered by the BLM to be moderately favorable for oil and gas (Smith and Gere, 1983). There is no indication of potential for brine or evaporite deposits of sodium or potassium. The Arrow Canyon ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is low.

Salable Minerals in Arrow Canyon ACEC

Crushed Stone.—High quality stone in Paleozoic carbonate rocks was used to define tract AMAC01 (fig. 15) in the eastern part of the Arrow Canyon ACEC. This tract has high potential for crushed-stone aggregate with a high certainty level. The western part of the ACEC is characterized by the lower quality stone in tract AMAC06 (fig. 15), which has moderate potential for crushed-stone aggregate deposits, with a moderate level of certainty.

Sand and Gravel.—Alluvial deposits and the Muddy Creek Formation constitute tract AMAC13, in the southwest and easternmost parts of this ACEC, which has moderate potential for sand and gravel aggregate deposits, with a moderate certainty level (fig. 15). The area of Pahranagat Wash that is upstream from Arrow Canyon gorge is alluvial gravels and has high potential for sand and gravel aggregate deposits, with a high certainty level (tract AMAC10, fig. 15).

Locatable Minerals in Coyote Springs Tortoise ACEC

Precious and Base Metals.—Although there are hydrothermal precious- and base-metal deposits in nearby areas, the geologic environments that host these deposits do not occur inside this ACEC, and the potential for their presence is low.

Silica and Stone.—At least two mines produced silica-rich quartzite in and near this ACEC. Both metallurgical-grade silica and stone were probably produced. Small tracts that include outcrop areas of the Eureka Quartzite have been designated to have moderate potential for silica deposits with a high level of certainty. The potential for commercial silica deposits is not high in these tracts because the Eureka Quartzite dips shallowly west under large thicknesses of carbonate rock; therefore, development of these deposits appears unlikely. The potential for production of building stone from such deposits is considered to be low because the stone is neither unique nor particularly attractive. These areas (tract CST01, fig. 16) are all near the eastern boundary of the ACEC and near the western base of the Arrow Canyon Range. Part of one of the areas is in the Arrow Canyon Wilderness and thus closed to mineral entry.

Limestone.—Three small areas of Devonian limestone in the Coyote Springs Tortoise ACEC have been designated as high potential, with moderate certainty, for commercial high-calcium limestone. This designation is supported by a sample of high-calcium limestone in one of these areas, although our sample of this rock has unacceptably high SiO_2 (table 2). Further sampling and analysis would be required to raise the certainty level. These areas (tract CST02, fig. 16) are along the eastern boundary of the ACEC in the Arrow Canyon Range and along the western boundary in the Las Vegas Range.

Leasable Minerals in Coyote Springs Tortoise ACEC

The entire Coyote Springs Tortoise ACEC is within the region considered by the BLM to be moderately favorable for oil and gas (Smith and Gere, 1983). There is no indication of potential for brine or evaporite deposits of sodium or potassium. The Coyote Springs Tortoise ACEC contains no known deposits of other leasable minerals, and the potential for their occurrence is low.

Salable Minerals in Coyote Springs Tortoise ACEC

Crushed Stone.—The areas with the highest potential for crushed-stone aggregate in the Coyote Springs Tortoise ACEC are in the northern half of the ACEC, at the base of the Arrow Canyon Range. Here, the rocks include the Nopah Formation, Ordovician dolomites and quartzites, and the Silurian Laketown Dolomite. Monte Cristo Limestone is found in the southern part of the ACEC in the Las Vegas Range. These rock units were used to delineate tract AMAC02 (fig. 15), which has high potential for crushed-stone aggregate, with a high certainty level.

The presence of significant amounts of chert in some parts of the Bird Springs Formation leads to designation of

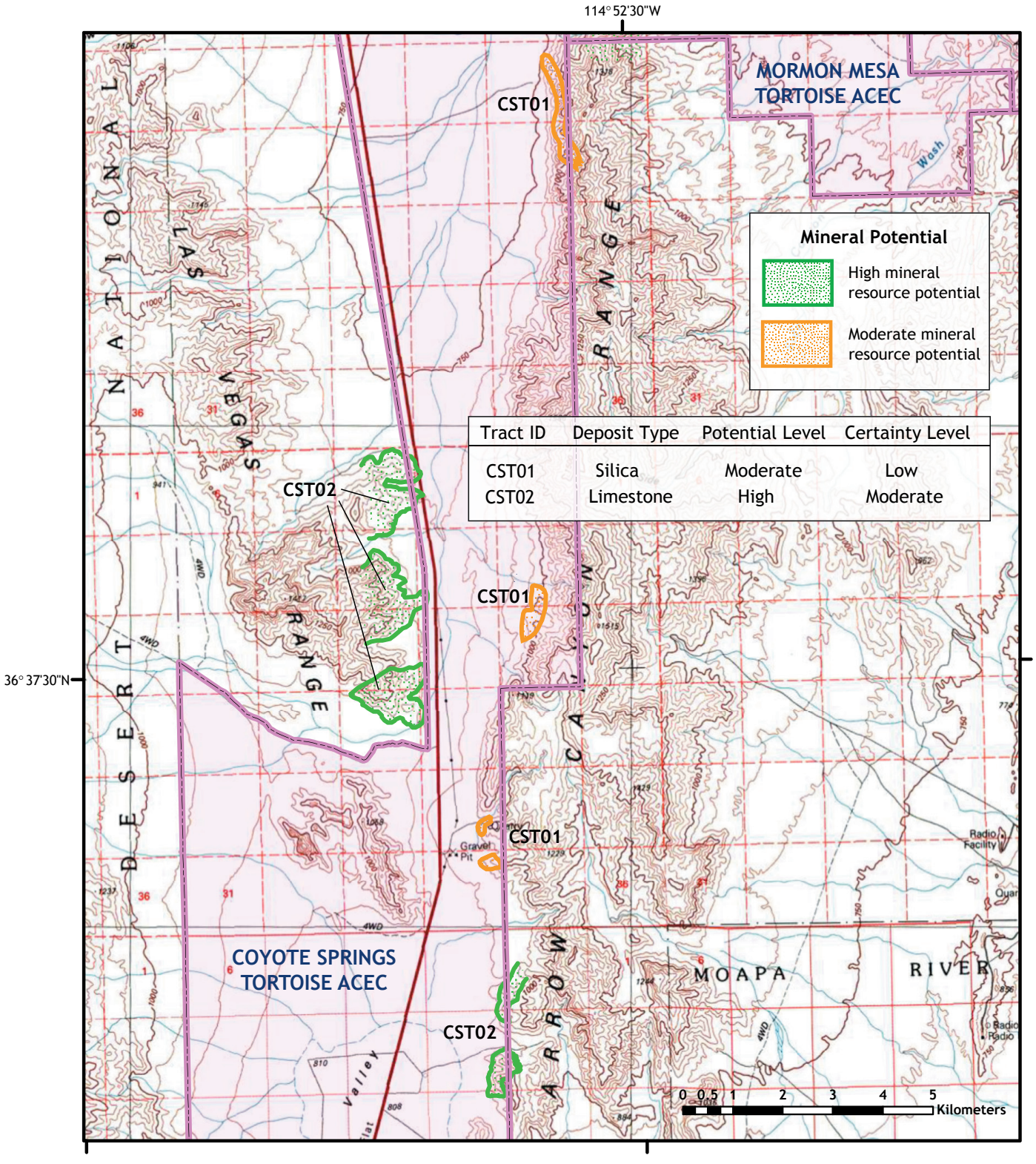

Figure 16. Mineral resource potential tracts for silica and limestone deposits in the Coyote Springs Tortoise Area of Critical Environmental Concern (ACEC).

the areas underlain by this rock unit to have only moderate potential for crushed-stone aggregate, with a moderate level of certainty. This tract (AMAC07, fig. 15) is mostly in the southern part of the ACEC.

In the far northeastern part of the ACEC, just west of the Arrow Canyon Range, some areas of Muddy Creek Formation that are moderately well lithified constitute tract AMAC04 (fig. 15), which has low potential for crushed-stone aggregate, with a high level of certainty.

Sand and Gravel.—Most of Coyote Springs Valley is underlain by alluvial deposits containing primarily clasts of carbonate rocks from the Las Vegas and Arrow Canyon Ranges. These areas constitute tract AMAC09 (fig. 15), which has high potential for sand and gravel aggregate deposits, with a high level of certainty.

In the southern part of this ACEC, playa deposits extend some 11 km along the axis of the valley. The playa deposits are fine-grained silt and clay, and they constitute tract AMAC11 (fig. 15), which has low potential for sand and gravel aggregate deposits, with a high level of certainty.

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