

U.S. Coal Resources and Reserves Assessment Project

Assessment of Coal Resources and Reserves in the Little Snake River Coal Field and Red Desert Assessment Area, Greater Green River Basin, Wyoming

The U.S. Coal Resources and Reserves Assessment Project, as part of the U.S. Geological Survey Energy Resources Program, conducts systematic, geology-based, regional assessments of significant coal beds in major coal basins in the United States. These assessments detail the quantity, quality, location, and economic potential of the Nation's remaining coal resources and reserves and provide objective scientific information that assists in the formulation of energy strategies, environmental policies, land-use management practices, and economic projections.

Abstract

The assessment of the Little Snake River coal field and Red Desert area covers approximately 2,300 square miles in the eastern portion of the Greater Green River Basin in south-central Wyoming. Coal-bearing formations are present throughout the Eocene, Paleocene, and Cretaceous strata in the assessment area. Paleogene-age coal beds are present in the Eocene Wasatch Formation and Paleocene Fort Union Formation. Cretaceous-age coal beds are present in the Lance, Almond, and Allen Ridge Formations. Utilizing over 4,000 data points, 55 individual coal beds were identified in the assessment area. Coal resources were calculated using geologic models generated from these data points, using criteria for minimum thickness and areal extent. The geologic modeling criteria indicated that 33 of the 55 individual coal beds had sufficient thickness and areal extent to be economically significant. Calculated original coal resources within the assessment area were approximately 73.2 billion short tons (BST). After excluding coal resources lost due to land use and technical restrictions, recoverable coal resources were approximately 19.37 BST, including 2.14 BST of coal resources that could be extracted using surface mining methods and 17.23 BST of coal resources that could be extracted using underground mining methods. Due to mining costs and projected low potential sales value of the coal resources, only approximately 167 million short tons (MST) can be classified as reserves, which is less than 1 percent of the recoverable coal resources.

Introduction

The U.S. Coal Resources and Reserves Assessment Project, as part of the U.S. Geological Survey (USGS) Energy Resources Program, carries out regional-scale, geology-based assessments of significant coal beds in major U.S. coal basins. These assessments detail the quantity, quality, location, and economic potential of the Nation's remaining coal resources and reserves and provide objective scientific information that assists in the formulation of energy strategies, environmental policies, land-use management practices, and economic projections.

This fact sheet is in support of USGS Professional Paper 1836 (Scott and others, 2019).

Setting and Background Information

This assessment summarizes coal resources and reserves in the Little Snake River coal field and the Red Desert assessment area in the Greater Green River Basin in south-central Wyoming. The Little Snake River coal field and Red Desert assessment areas are contiguous and cover approximately 2,300 square miles (mi^2) of the eastern portion of the 15,400- mi^2 Greater Green River Basin (fig. 1). Highway Interstate 80 (I-80) serves as an approximate west-east dividing line between the areas, with the Red Desert assessment area lying north of I-80 and the Little Snake River coal field lying south of I-80. A stratigraphic section composed of over 11,000 feet (ft) of coal-bearing Eocene, Paleocene, and Upper Cretaceous rocks is present within the assessment area (fig. 2). Upper Cretaceous coal beds are present in coal zones within the Lance, Almond, and Allen Ridge Formations. Paleocene coal beds are present in two coal zones within the Fort Union Formation, and Eocene coal beds are present within the Wasatch Formation (Scott and others, 2019). Coal beds within the Lance and Allen Ridge Formations were not assessed for resources because the coal beds in these formations are typically thin and laterally discontinuous and did not meet the required criteria for assessment (fig. 3).

The coal resource and reserve data presented in this assessment were generated from a geologic database composed of 4,214 drill holes and measured sections (Haacke, 2018). Fifty-five individual coal beds were identified from the geologic data available (Kinney and others, 2018). Coal beds with a thickness of 3 ft or greater and having an areal extent of at least 2 mi^2 were defined as economically significant and considered for assessment. Only 33 of the 55 coal beds identified in the geologic database met these criteria (Scott and others, 2019).

The methodology for determining coal resources and reserves calculates and excludes coal resources lost due to land use and technical restrictions (fig. 3). Land-use restrictions include Federal lands that are unsuitable for leasing for mining due to the presence of threatened or endangered plant or animal

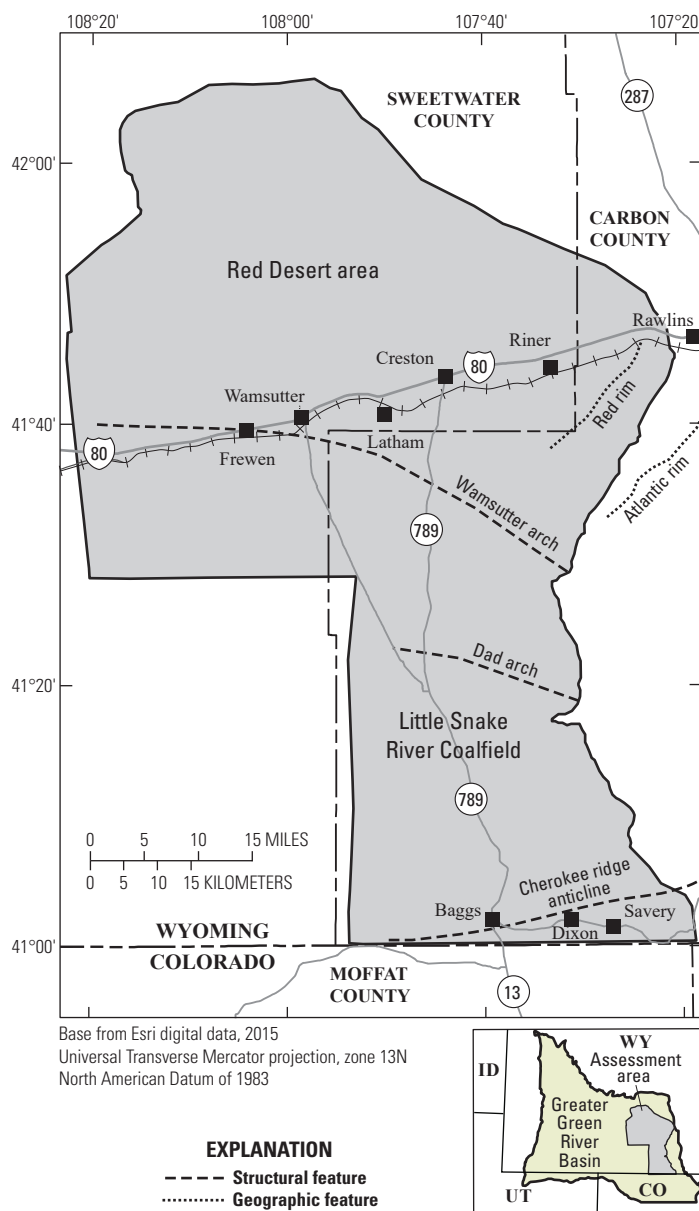


Figure 1. Location map for the Little Snake River coal field and Red Desert assessment area, Wyoming, showing the assessment study area.

species, as well as municipal watersheds, alluvial valley floors, public buildings, cemeteries, airports, archaeological areas, coalbed methane wells, oil and gas wells, pipelines, power lines, major highways, railroads, and towns. Land-use restrictions will vary with location and local land management regulations. This assessment utilizes land-use restrictions based on local practices within the Greater Green River Basin identified by Scott and others (2019).

Technical restrictions are restraints placed on mining by geologic factors or limitations on mining equipment and (or) mining technologies. These technical restrictions are considered in the assessment methodology (fig. 3). Geological factors include areas where coal beds are too thin (less than [$<$] 2.5 ft for surface mining or <8 ft for underground mining), too thick

Period	Epoch	Stratigraphic units in the Little Snake River coal field and Red Desert assessment area		Unit thickness (in feet)
		Formation	Member	
Paleogene	Eocene	Wasatch Formation	Red Desert Tongue	up to 2,100
	Paleocene	Fort Union Formation	Overland Member	up to 2,100
			Blue Gap Member	0–570
			China Butte Member	up to 2,100 unconformity
Cretaceous	Late Cretaceous	Lance Formation	Red Rim Member	up to 900
			lower member	up to 2,950
		Fox Hills Sandstone		up to 1,980
		Lewis Shale		up to 1,600
			Dad SS Member	0–600
		Almond Formation	upper member	up to 300
			lower member	up to 250
		Pine Ridge Sandstone		up to 100
		Allen Ridge Fm		up to 1,400
	Mesa Verde Group	Haystack Mts. Fm		up to 950

Figure 2. Generalized stratigraphic column for the Little Snake River coal field and Red Desert area assessment. Units in red text are coal-bearing units assessed for coal resources and reserves. Units in blue text are coal-bearing units not assessed for coal resources and reserves. Non-coal bearing units are labeled in black. (SS, Sandstone; Fm, Formation; Mts, Mountains)

(greater than [$>$] 15 ft for underground mining), too deep ($>3,000$ ft for underground mining), too steeply dipping ($>20^\circ$), exceed stripping ratio limitations ($>10:1$ for this assessment), or are altered by oxidation, weathering, or burning along crop lines. It should be noted that technical restrictions can change over time as additional data are obtained from exploration

activities, advancements are made in mining equipment or technology, or as changes occur in mining regulations or mining economics. These changes can modify the quantity of resources and reserves calculated in assessment studies.

Assessment Criteria

In addition to meeting criteria for thickness and areal extent, as described above, coal resources are also classified as to their recoverability using surface or underground mining methods. Coal resources classified as recoverable using surface mining methods have overburden depths from 25 to 300 ft. Coal resources with overburden depths <25 ft were discarded because of the potential for the weathering or oxidation of the coal at those depths. Coal resources classified as recoverable using underground mining methods have overburden depths from 300 to 3,000 ft.

The coal resources in this assessment were classified according to geologic assurances of coal existence and data reliability, which are dependent on the density of geologic data points. The different reliability categories can be established based on the distance from a data point:

- measured ($\frac{1}{4}$ mi or less from point of measurement);
- indicated ($\frac{1}{4}$ to $\frac{3}{4}$ mi from point of measurement);
- inferred ($\frac{3}{4}$ to 3.0 mi from point of measurement); and
- hypothetical (greater than 3.0 mi from point of measurement) (Wood and others, 1983).

Coal resources are also classified by surface ownership. Three categories of surface ownership are defined: (1) Federal, (2) State, and (3) private.

Assessment Results

Coal resources were calculated using the geologic models that applied the land-use and technical restrictions and assessment criteria described above. Figure 3 shows a flow chart used by the USGS for the classification of coal resources and reserves. The calculation of the recoverable coal resources from the original coal resources for the assessment and the reliability category for those recoverable coal resources are shown in table 1 and are presented by geologic unit. Out of the 33 coal beds that met the assessment criteria, only 17 coal beds have more than 50 million short tons (MST) of recoverable surface resources or 150 MST of recoverable underground resources; these are included in table 1. These 17 coal beds, because of their greater recoverable tonnages, have the best potential for future economic development. Table 2 shows the breakdown of recoverable coal resources by mining type and coal ownership for the coal beds that meet the minimum tonnage criteria for surface and underground mines (table 1). A summary of recoverable coal resources for all 33 coal beds in the assessment study, as well as reliability category and ownership classifications are shown in table 3. A tabulation of

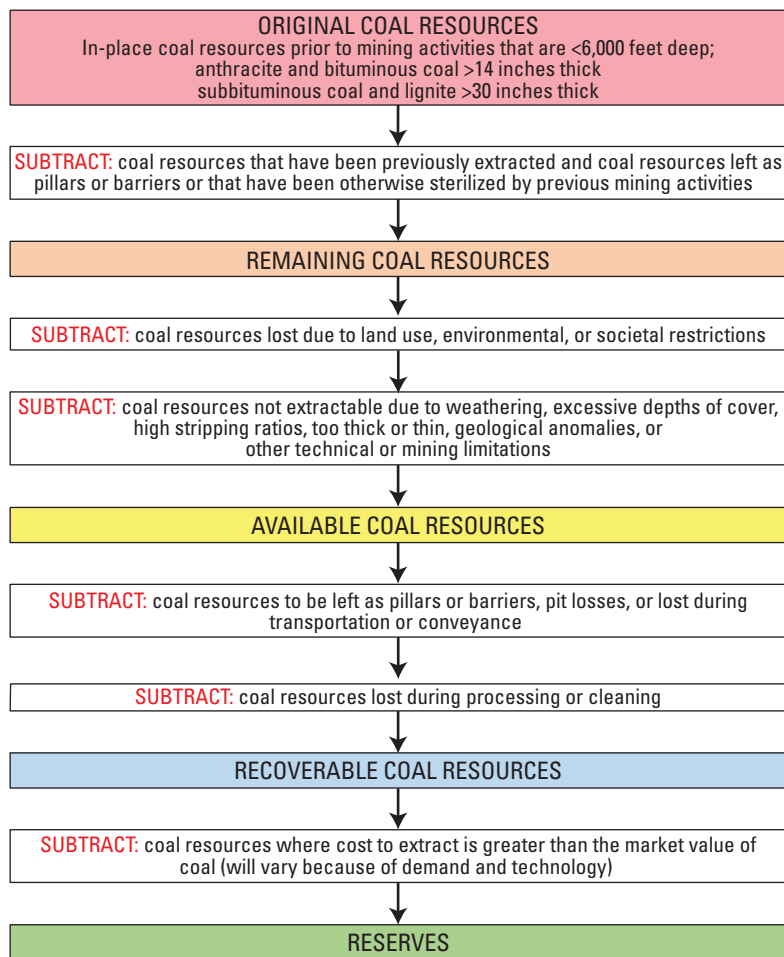


Figure 3. Flow chart for the classification of coal resources and reserves used by the U.S. Geological Survey for coal assessment studies (Luppens and others, 2009). (<, less than; >, greater than)

recoverable resources, reliability category, and coal ownership for all 33 assessed coal beds can be found in Scott and others (2019).

Conclusions

Approximately 19.3 billion short tons (BST) of recoverable coal resources have been calculated for the Little Snake River coal field and Red Desert assessment area in the Greater Green River Basin, Wyoming. Over 2.1 BST of the recoverable resources may be extracted using surface mining methods. The remaining 17.2 BST of recoverable coal resources may be extracted using underground mining methods. Because of the density of drill hole data within the assessment area (Scott and others, 2019), approximately 71 percent of the recoverable coal resources have a reliability category classification of measured or indicated. Approximately 55 percent of recoverable coal resources are located on Federal lands (Scott and others, 2019). When projected mining costs and current spot market prices (as of June 10, 2019) are applied through economic modeling, approximately 167 MST can be classified as reserves, which represents less than 1 percent of the recoverable coal resources. All the tonnage classified as reserves may be extracted through surface mining methods.

Table 1. Original resources, recoverable resources, and reliability classification for coal beds having more than 50 million short tons (MST) of recoverable surface resources or 150 MST of underground recoverable resources in the Little Snake River coal field and Red Desert assessment area, Wyoming. Coal resources (in MST) lost to land-use and technical restrictions are also shown. Values are reported in MST. Mbr, Member; Fm, Formation; Gp, Group.

Geologic Unit	Coal bed	Mining method	Original resources	Land-use restrictions	Technical restriction	Recoverable resources	Recoverable resources by reliability classification			
							Measured	Indicated	Inferred	Hypothetical
Wasatch Fm	Monument	Surface	882	0	422	460	167	257	36	0
		Underground	118	0	47	71	0	8	63	0
		TOTAL	1,000	0	469	531	167	265	99	0
Wasatch Fm	Lower Sourdough	Surface	551	0	436	115	40	73	2	0
		Underground	80	0	15	65	5	26	34	0
		TOTAL	631	0	451	180	45	99	36	0
Wasatch Fm	Creston	Surface	1,131	2	639	490	399	90	1	0
		Underground	733	0	316	417	90	249	78	0
		TOTAL	1,864	2	955	907	489	339	79	0
Wasatch Fm	Latham	Surface	444	15	362	67	44	21	2	0
		Underground	1,124	0	630	494	176	224	94	0
		TOTAL	1,568	15	992	561	220	245	96	0
Wasatch Fm	Unnamed #2	Surface	24	0	24	0	0	0	0	0
		Underground	762	0	344	418	13	84	299	22
		TOTAL	786	0	368	418	13	84	299	22
Overland Mbr Fort Union Fm	Upper Cherokee	Surface	220	50	122	48	38	10	0	0
		Underground	3,174	203	2,290	681	126	327	228	0
		TOTAL	3,394	253	2,412	729	164	337	228	0
Overland Mbr Fort Union Fm	Cherokee	Surface	543	56	91	396	302	94	0	0
		Underground	6,057	531	3,413	2,113	318	1,219	576	0
		TOTAL	6,600	587	3,504	2,509	620	1,313	576	0
Overland Mbr Fort Union Fm	Lower Cherokee	Surface	68	10	56	2	2	0	0	0
		Underground	3,715	252	2,901	562	89	355	118	0
		TOTAL	3,783	262	2,957	564	91	355	118	0
Overland Mbr Fort Union Fm	Cow Butte	Surface	175	5	124	46	34	11	1	0
		Underground	788	30	267	491	179	307	5	0
		TOTAL	963	35	391	537	213	318	6	0
Overland Mbr Fort Union Fm	Horse Butte	Surface	170	1	126	43	26	17	0	0
		Underground	8,116	565	3,517	4,034	454	2,035	1,545	0
		TOTAL	8,286	566	3,643	4,077	480	2,052	1,545	0
China Butte Mbr Fort Union Fm	Fillmore Ranch/ Baggs	Surface	213	4	73	136	106	30	0	0
		Underground	9,454	265	6,802	2,387	353	1,396	637	1
		TOTAL	9,667	269	6,875	2,523	459	1,426	637	1
China Butte Mbr Fort Union Fm	Muddy Creek/ Five Mile Point	Surface	78	1	69	8	8	0	0	0
		Underground	3,841	409	2,846	586	119	361	107	0
		TOTAL	3,919	410	2,915	594	127	361	107	0
China Butte Mbr Fort Union Fm	Wild Cow	Surface	14	0	12	2	2	0	0	0
		Underground	569	0	357	212	12	68	132	0
		TOTAL	583	0	369	214	14	68	132	0
China Butte Mbr Fort Union Fm	Olson Draw	Surface	134	14	76	44	39	4	0	0
		Underground	4,605	187	2,401	2,017	318	896	776	27
		TOTAL	4,739	201	2,477	2,061	357	900	776	27
China Butte Mbr Fort Union Fm	Red Rim	Surface	76	3	55	18	16	2	0	0
		Underground	3,443	298	2,684	461	55	211	195	0
		TOTAL	3,519	301	2,739	479	71	213	195	0
Almond Fm Mesaverde Gp	Cow Creek Butte	Surface	477	0	383	94	33	44	16	0
		Underground	2,683	0	1,583	1,100	264	524	312	0
		TOTAL	3,160	0	1,966	1,194	297	568	328	0
Almond Fm Mesaverde Gp	Robertson	Surface	272	0	217	55	18	31	6	0
		Underground	1,277	0	811	466	95	255	116	0
		TOTAL	1,549	0	1,028	521	113	286	122	0

Table 2. Recoverable coal resources for the Little Snake River coal field and Red Desert assessment area, Wyoming, reported by mining extraction method and coal ownership for coal beds having more than 50 million short tons (MST) of recoverable surface resources or 150 MST of underground recoverable resources. Values are reported in MST. Mbr, Member; Fm, Formation; Gp, Group.

Geologic Unit	Coal bed	Mining method	Recoverable resources	Recoverable resources by coal ownership		
				Federal	State	Private
Wasatch Fm	Monument	Surface	460	276	15	169
		Underground	71	57	14	0
		TOTAL	531	333	29	169
Wasatch Fm	Lower Sourdough	Surface	115	54	0	61
		Underground	65	55	10	0
		TOTAL	180	109	10	61
Wasatch Fm	Creston	Surface	490	310	1	179
		Underground	417	216	0	201
		TOTAL	907	526	1	380
Wasatch Fm	Latham	Surface	67	28	1	38
		Underground	494	312	0	182
		TOTAL	561	340	1	220
Wasatch Fm	Unnamed #2	Surface	0	0	0	0
		Underground	418	261	1	156
		TOTAL	418	261	1	156
Overland Mbr Fort Union Fm	Upper Cherokee	Surface	48	27	1	20
		Underground	681	404	1	276
		TOTAL	729	431	2	296
Overland Mbr Fort Union Fm	Cherokee	Surface	396	207	2	187
		Underground	2,113	1,144	18	951
		TOTAL	2,509	1,351	20	1,138
Overland Mbr Fort Union Fm	Lower Cherokee	Surface	2	1	0	1
		Underground	562	289	12	261
		TOTAL	564	290	12	262
Overland Mbr Fort Union Fm	Cow Butte	Surface	46	23	1	22
		Underground	491	252	0	239
		TOTAL	537	275	1	261
Overland Mbr Fort Union Fm	Horse Butte	Surface	43	16	6	21
		Underground	4,034	2,197	40	1,797
		TOTAL	4,077	2,213	46	1,818
China Butte Mbr Fort Union Fm	Fillmore Ranch/ Baggs	Surface	136	72	0	64
		Underground	2,388	1,288	77	1,023
		TOTAL	2,524	1,360	77	1,087
China Butte Mbr Fort Union Fm	Muddy Creek/ Five Mile Point	Surface	8	5	0	3
		Underground	586	251	41	294
		TOTAL	594	256	41	297
China Butte Mbr Fort Union Fm	Wild Cow	Surface	2	0	0	2
		Underground	212	104	2	106
		TOTAL	214	104	2	108
China Butte Mbr Fort Union Fm	Olson Draw	Surface	44	30	1	13
		Underground	2,017	945	102	970
		TOTAL	2,061	975	103	983
China Butte Mbr Fort Union Fm	Red Rim	Surface	18	8	2	8
		Underground	461	199	26	236
		TOTAL	479	207	28	244
Almond Fm Mesaverde Gp	Cow Creek Butte	Surface	93	63	17	13
		Underground	1,100	784	42	274
		TOTAL	1,193	847	59	287
Almond Fm Mesaverde Gp	Robertson	Surface	55	47	4	4
		Underground	466	315	37	114
		TOTAL	521	362	41	118

Table 3. Tabulation of coal resources for all 33 coal beds assessed in the Little Snake River coal field and Red Desert assessment area, Wyoming (Scott and others, 2019) by geologic unit and mining extraction method. Values are reported in millions of short tons (MST).

Geologic unit	Mining method	Original resources	Land-use restrictions	Technical restrictions	Recoverable resources	Recoverable resources by reliability classification				Recoverable resources by surface ownership		
						Measured	Indicated	Inferred	Hypothetical	Federal	State	Private
Wasatch Formation	Surface	3,607	20	2,431	1,156	662	452	42	0	680	17	459
	Underground	3,224	0	1,743	1,481	290	601	568	22	909	25	547
Overland Member	Surface	1,176	122	519	535	402	132	1	0	274	10	251
Fort Union Formation	Underground	21,850	1,581	12,388	7,881	1,166	4,243	2,472	0	4,286	71	3,524
China Butte Member	Surface	669	24	417	228	190	37	0	0	128	3	97
Fort Union Formation	Underground	35,590	2,298	27,203	6,089	1,016	3,131	1,915	28	2,996	267	2,827
Almond Formation	Surface	1,408	0	1,189	219	82	107	30	0	168	22	28
Mesaverde Group	Underground	5,684	0	3,905	1,779	421	871	487	0	1,272	88	419
Total	Surface	6,860	166	4,556	2,138	1,336	728	73	0	1,250	52	835
Total	Underground	66,348	3,879	45,239	17,230	2,893	8,846	5,442	50	9,463	451	7,317
	Grand total	73,208	4,045	49,795	19,368	4,229	9,574	5,515	50	10,713	503	8,152
	Percent of total					21.8%	49.4%	28.5%	0.3%	55.3%	2.6%	42.1%

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For More Information

Coal assessment results also are available at the USGS Energy Resources Program website at <https://energy.usgs.gov/>.

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Contact information for the U.S. Coal Resources and Reserves Assessment Project is available at the USGS Energy Resources Program Website at <https://energy.usgs.gov>.