Chapter MO

SURFACE MINING AND RECLAMATION OPERATIONS FOR FORT UNION COAL

By K.I. Takahashi, T.J. Rohrbacher, and R.M. Flores

in U.S. Geological Survey Professional Paper 1625-A

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MO-49. Reclaimed lands.

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MO-54. Regraded and reseeded area.

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MO-56. Hanna Basin reclamation.

MO-57. Reclaimed lands and undisturbed native grassland in the Hanna Basin.

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MO-59. Reclaimed land on both sides of an access road in Hanna Basin.

MO-60. Reclaimed land in the Gillette coalfield.

MO-61. The dark green area in the foreground is reclaimed land in the Williston Basin. The coal truck is on a haul road surrounded by unmined land.

Surface Mining and Reclamation Operations for Fort Union Coal

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INTRODUCTION

About one-third of the coal produced in the United States comes from the northern Rocky Mountains and Great Plains region (fig. MO-1) and because of the geological setting and the quality of this resource the share is likely to increase. The purpose of this chapter is to provide an overview of the pit mining process used in much of this area through the use of photos and videos. In this way we hope to provide the lay person with an elementary understanding of some the terms used throughout this report and a general appreciation of the techniques and equipment used to extract coal resources.

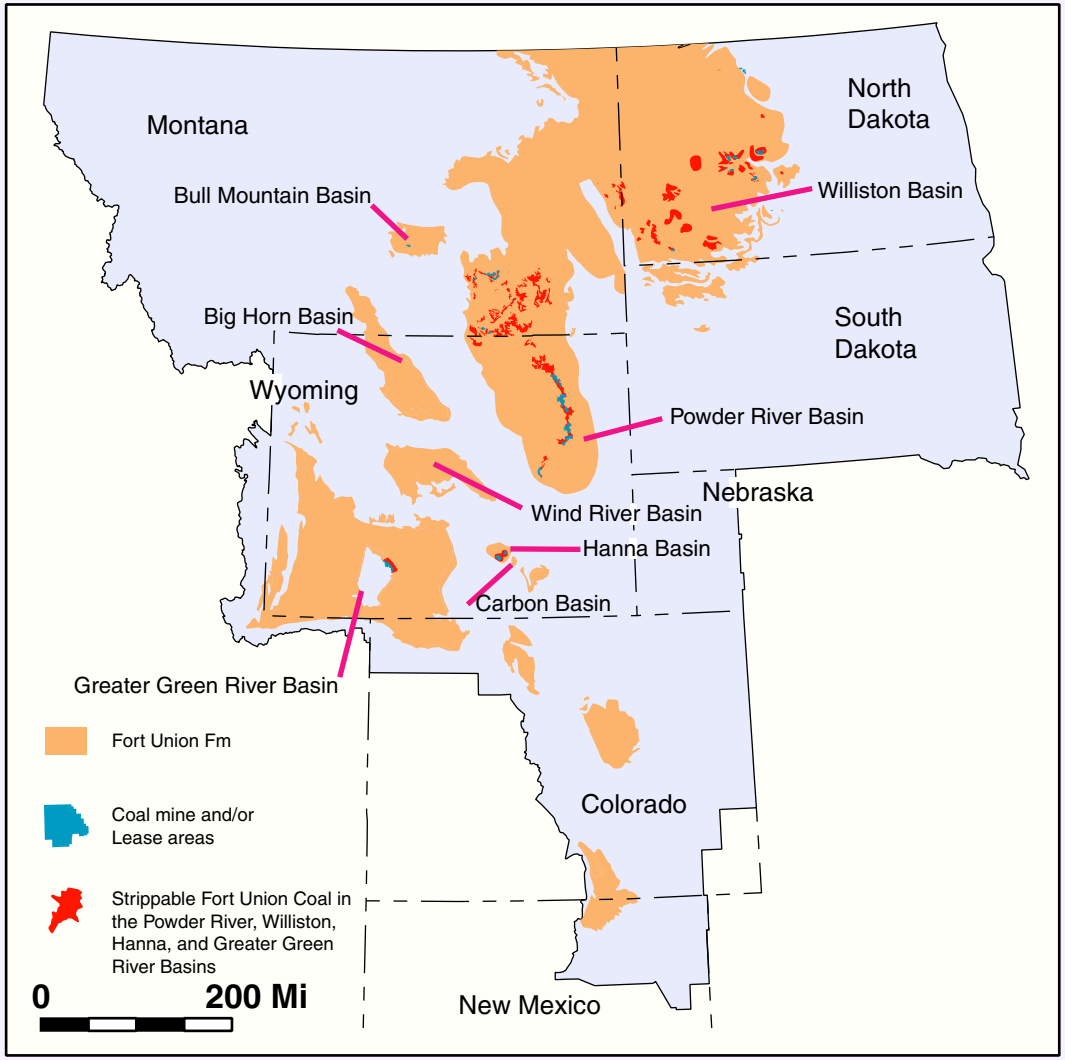

Figure MO-1. Distribution of Fort Union coal-bearing rocks and strippable Coal in the northern Rocky Mountains and Great Plains.

METHODOLOGY

The photographs were taken with a Nikon FM 35mm camera, with a Nikkor 28-70mm, f/3.5, zoom lens and an MD-12 motordrive; a Vivitar Series 1, 440PZ 35mm automatic camera with a 28-70mm f/4.5 zoom lens was also used. The photographs were then scanned on a Microtek ScanMaker E3 flat-bed scanner and a Polaroid SprintScan 35 slide scanner. Videos were taken with a Sony CCD-TR81 Hi8 camcorder and then converted to QuickTime movies, edited, and compressed on a Power Macintosh 8500 computer upgraded with a 300 MHz G3 processor.

The following software applications were used: Adobe Acrobat 4, Adobe Illustrator 8, Adobe Photoshop 5, Apple QuickTime 4, Apple Video Player 1.7.2, Avid VideoShop 3.0.2, and Microsoft Word 98.

The photos and videos used to illustrate the equipment and techniques used in pit mines in this area were taken at the following mines:

In Montana, the Big Sky mines, Decker mine, and Rosebud mine.

In North Dakota, the Beulah mine (Knife River), Falkirk mine, Freedom (Coteau) mines, and Spring Creek mines.

In Wyoming, the Belle Ayr mine, Black Butte mine, Bridger mine, Buckskin mine, Cordero Rojo mine, Cyprus-Shoshone mine, Glenrock mine, Medicine Bow mine, and the Dave Johnston mine.

SURFACE MINING

Movie 1

Surface mining operations create an open pit by first removing the topsoil and overburden; this is followed by removal of the coal. Mining usually begins at the coal bed outcrop and proceeds down-dip. The deep side of the pit is called the highwall (movie 1); it provides a cross section through the layers of overburden and coal (figs. MO-2 through MO-6). After the original pit is made, subsequent overburden is backfilled into the mined-out area and regraded to the original slope of the surface. The topsoil is replaced, and the land reclaimed to its original topography and vegetation.

Figure MO-2

Figure MO-3

Figure MO-4

Figure MO-5

Figure MO-6

Movie 2

Figure MO-7

Figure MO-8

Figure MO-9

Surface mining can be the least expensive and most productive method of extracting coal and recovers more of the coal resource (as much as 96%) than underground mining.

OVERBURDEN AND COAL REMOVAL

Extensive aerial and ground assessment, drilling, and subsequent geologic and economic analyses characterize the coal and overburden and delineate the areas to be mined. The topsoil and layers of rock over the coal are called overburden (figs. MO-7 through MO-9). In the Powder River Basin overburden thickness can be more than 200 ft and still be economically feasible (movies 2-4). Top soil is removed with large scrapers and stockpiled so that it can be reused during reclamation. To uncover the coal for mining, the overburden is drilled and blasted to break it up for easier removal.

Overburden blasting is done with ammonium nitrate and fuel oil (ANFO) packed into 3-12-inch diameter holes drilled on 10-20-ft. centers. Two different stripping methods are used to remove the overburden above the coal: dragline and truck/shovel. Large draglines are used to remove the overburden and deposit it in rows of spoil piles, usually in previously mined areas (movie 5).

Movie 3

Movie 4

Movie 5

Movie 6

EQUIPMENT

Draglines can range in size from buckets of less than 13 to more than 200 cubic yards and booms from less than 100 to more than 400 ft. (movie 6). A Bucyrus-Erie 2570 and similar draglines can have a 124 cubic yard bucket and a 340 foot boom (figs. MO-10 through MO-14).

Figure MO-10

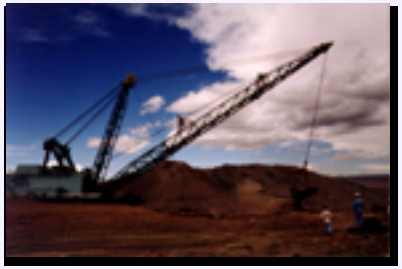

Figure MO-11

Figure MO-12

Figure MO-13

Figure MO-14

Movie 7

These draglines can be as tall as a 17 story building from the base to the tip of the boom (movie 7). They "walk" from one work site to the next on 14 by 72 foot "shoes," taking 8.5 foot "steps" at 0.1 mph, and they are powered by electric motors that produce 12,000 horsepower from a 23,000 volt power supply (figs. MO-15 through MO-20).

Figure MO-15

Figure MO-17

Figure MO-19

Figure MO-20

Figure MO-16

Figure MO-18

Movie 8

One large dragline can consume as much electrical power as a town of several thousand people (movie 8). The base of one of these draglines can be as big as the infield of a baseball diamond (figs. MO-21 through MO-24).

Figure MO-21

Figure MO-22

Figure MO-23

Figure MO-24

Movie 9

Movie 10

Electric and hydraulic shovels (movies 9-11) and end-loaders, used for removing overburden material and loading coal, have bucket capacities ranging from 12 to 54 cubic yards. Electric shovels, such as the P&H 2800 XPA, have capacities of 45 cubic yards or more, weigh 70 tons, and develop 2,760 horsepower.

Movie 11

Movie 12

Movie 13

Front-end loaders (movies 12-13), such as the Caterpillar 994 diesel, have a 23 cubic yard bucket and have 1,336 horsepower (figs. MO-25 and MO-26).

Figure MO-25

Figure MO-26

Movie 14

Movie 15

Movie 16

The large loading equipment is matched by large end-dump trucks (movies 14-16) such as the Caterpillar 789, which can carry 200 tons or 143 cubic yards, weighs 290,000 lbs empty, and is powered by an 1,800 horsepower diesel engine (figs. MO-27 through MO-33).

Figure MO-27

Figure MO-28

Figure MO-29

Figure MO-30

Figure MO-31

Figure MO-32

Figure MO-33

Movie 17

Movie 18

The coal is drilled and blasted (movies 17 and 18) using explosive mixtures such as ammonium nitrate and fuel oil (ANFO). It is then loaded onto large trucks with front-end loaders or power shovels (figs. MO-34 and MO-35) for transport to processing plants. Figures MO-36 through MO-40 show examples of the trucks, and movies 19 through 25 show the operation of trucks, front-end loaders, and shovels.

Figure MO-34

Figure MO-35

Figure MO-36

Figure MO-37

Movie 19

These trucks and truck/trailers (movies 19-21) have capacities of as much as 300 tons. The Kress CH300, which can carry 300 tons of coal, weighs 280,000 lbs empty and is powered by an 1,800 horsepower diesel engine. It is more than twice the size of a rail car. The shovels can have capacities of more than 43 cubic-yards. For example the Marion 191-M is an electrically powered, 1,650-horsepower, crawler shovel with a 27 cubic yard, 23 ton capacity.

Movie 20

Movie 21

Movie 22

Movie 23

Movie 24

Figure MO-38

Figure MO-39

Movie 25

Figure MO-40

Movie 26

The coal is typically transported by rail to a local powerplant. Unit coal trains can be a mile or more in length usually with 100, or as many as 150 cars, each capable of carrying 100-120 tons (movie 26). Loaders fill the cars as the train is moving. A train can be filled in about 2 hours or less (figs. MO-41 through MO-43 and movies 27 and 28).

Figure MO-41

Figure MO-42

Figure MO-43

Movie 27

Movie 28

Movie 29

Long conveyor belts are often used instead of trains to move the coal directly from the mine to a "mine-mouth" power plant (fig. MO-44 and movie 29). These power plants (fig. MO-45), constructed in proximity to the mine, are an alternative to long distance transportation of coal. The electricity that is generated is carried over power lines to distant users.

Figure MO-44

Figure MO-45

Figure MO-46

Figure MO-47

Figure MO-48

Figure MO-49

RECLAMATION

After the coal has been mined, the reclamation process can begin. The reclamation process includes backfilling, recontouring, replacement of topsoil and subsequent mulching and reseeding (figs. MO-46 through MO-49). Concerted reclamation efforts were begun in response to the Wyoming Environmental Quality Act of 1973, the Surface Mine Control and Reclamation Act of 1977, and other State and Federal laws and regulations.

Figure MO-50

Figure MO-51

Figure MO-52

The original contours of the mined area are restored by refilling the mined area with the overburden from the spoil piles and then shaping to restore the terrain to its premined contours using scrapers, bulldozers, and draglines (figs. MO-50 through MO-52).

Figure MO-53

Figure MO-54

Figure MO-55

The topsoil is replaced and reseeded with pre-mined flora (figs. MO-53 through MO-55).

Figure MO-56

Figure MO-57

Figure MO-58

Figure MO-59

Figure MO-60

Figure MO-61

As the reclaimed areas mature they are difficult to distinguish from their pre-mined state (figs. MO-56 through MO-61).

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Figure MO-2. Coal removal from a dragline-stripped pit. Note the overburden spoils on the left, coal production "face" in the center, coal "fender" on the lower right and the highwall to the right.

Photograph by Ken Takahashi, 1999

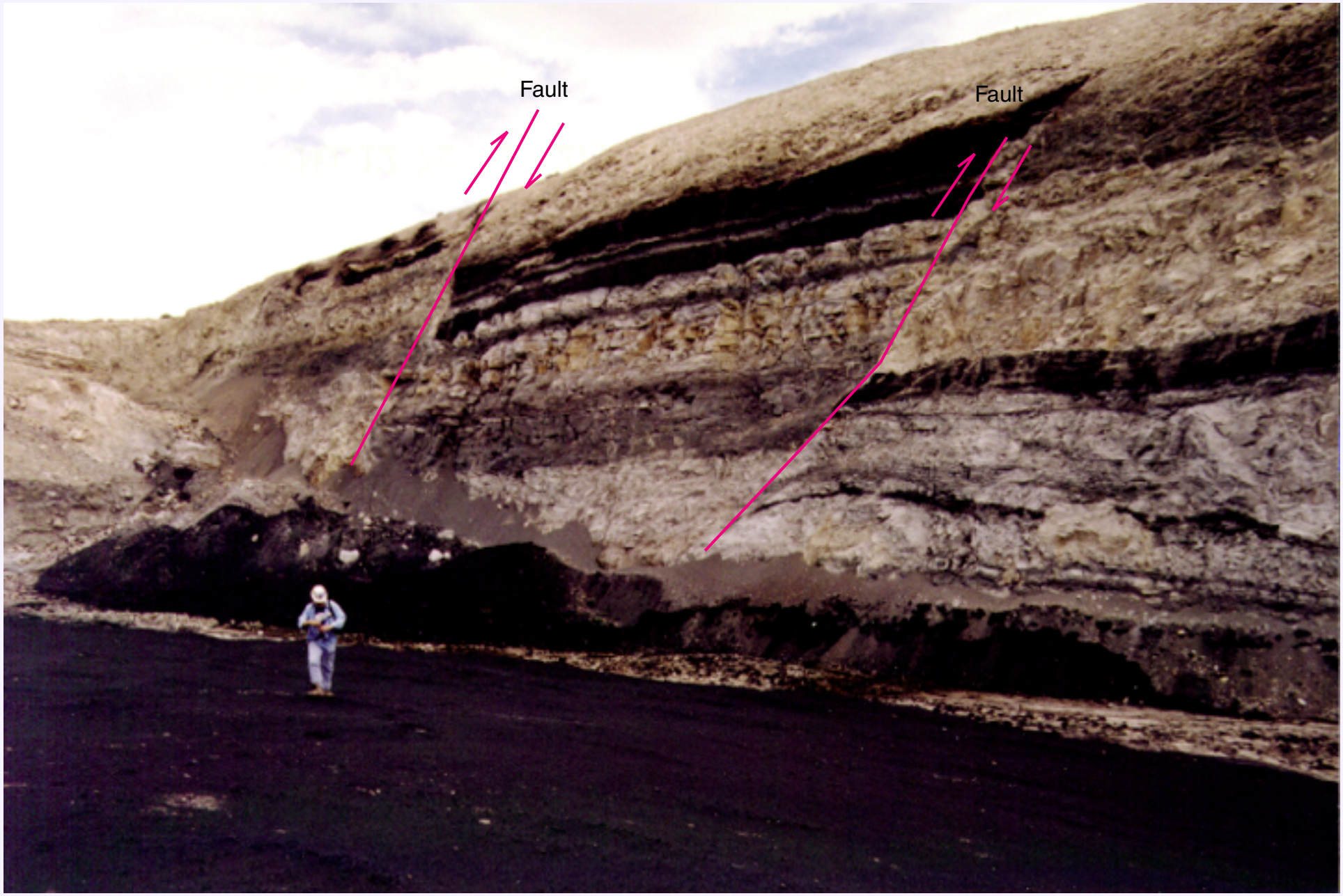

Figure MO-3. Multiple faults in the highwall of a multiple seam, dragline stripping operation. *Photograph by Ken Takahashi, 1999*

Figure MO-4. A dragline stripping operation. Note the clear distinction between the overburden and the coal bed.

Photograph by Ken Takahashi, 1999

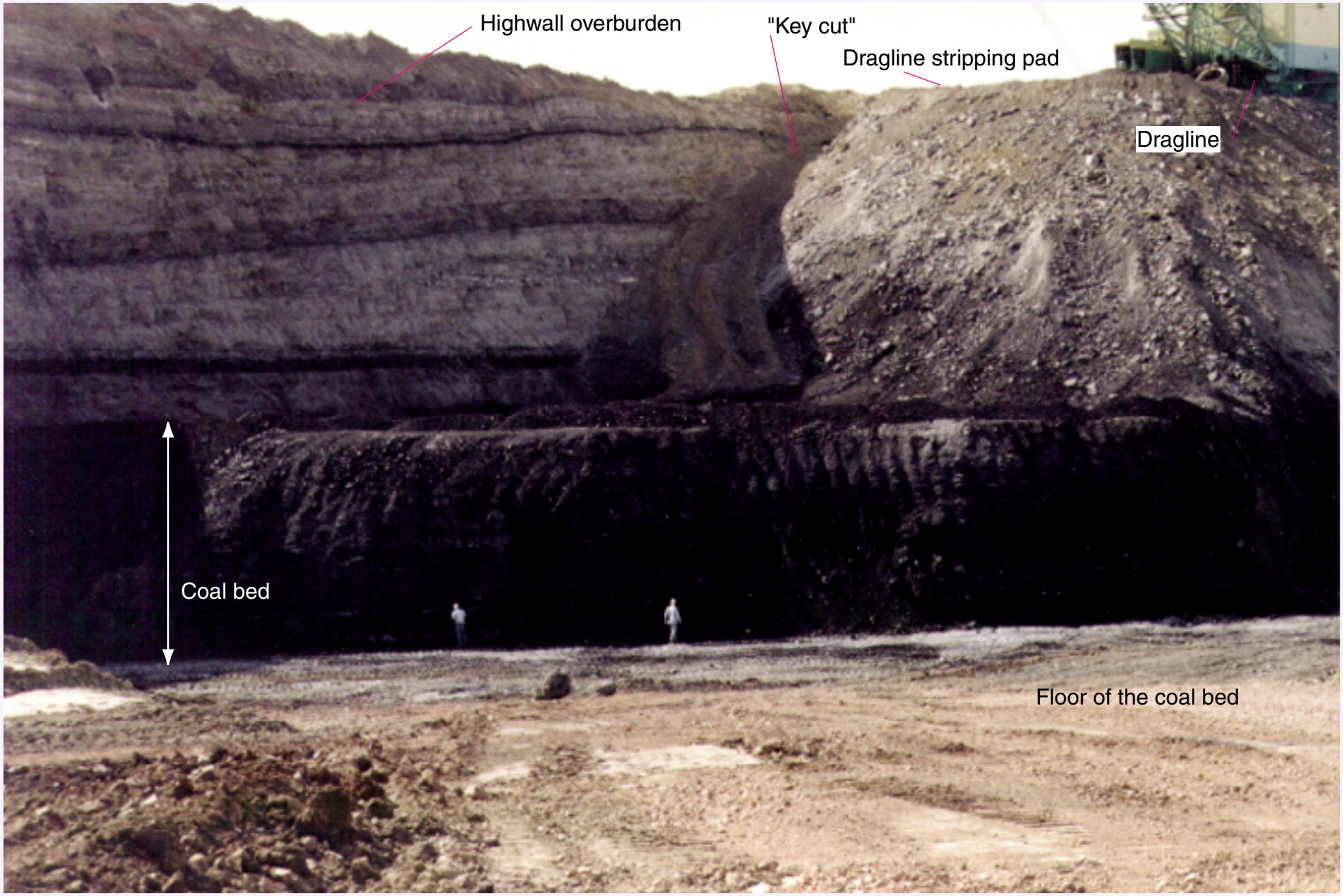

Figure MO-5. Dragline-stripped pit showing the relative overburden to coal thickness ratio. It is less than 2:1 with an estimated coal-bed thickness of more than 24 ft (if the people are 6' tall).

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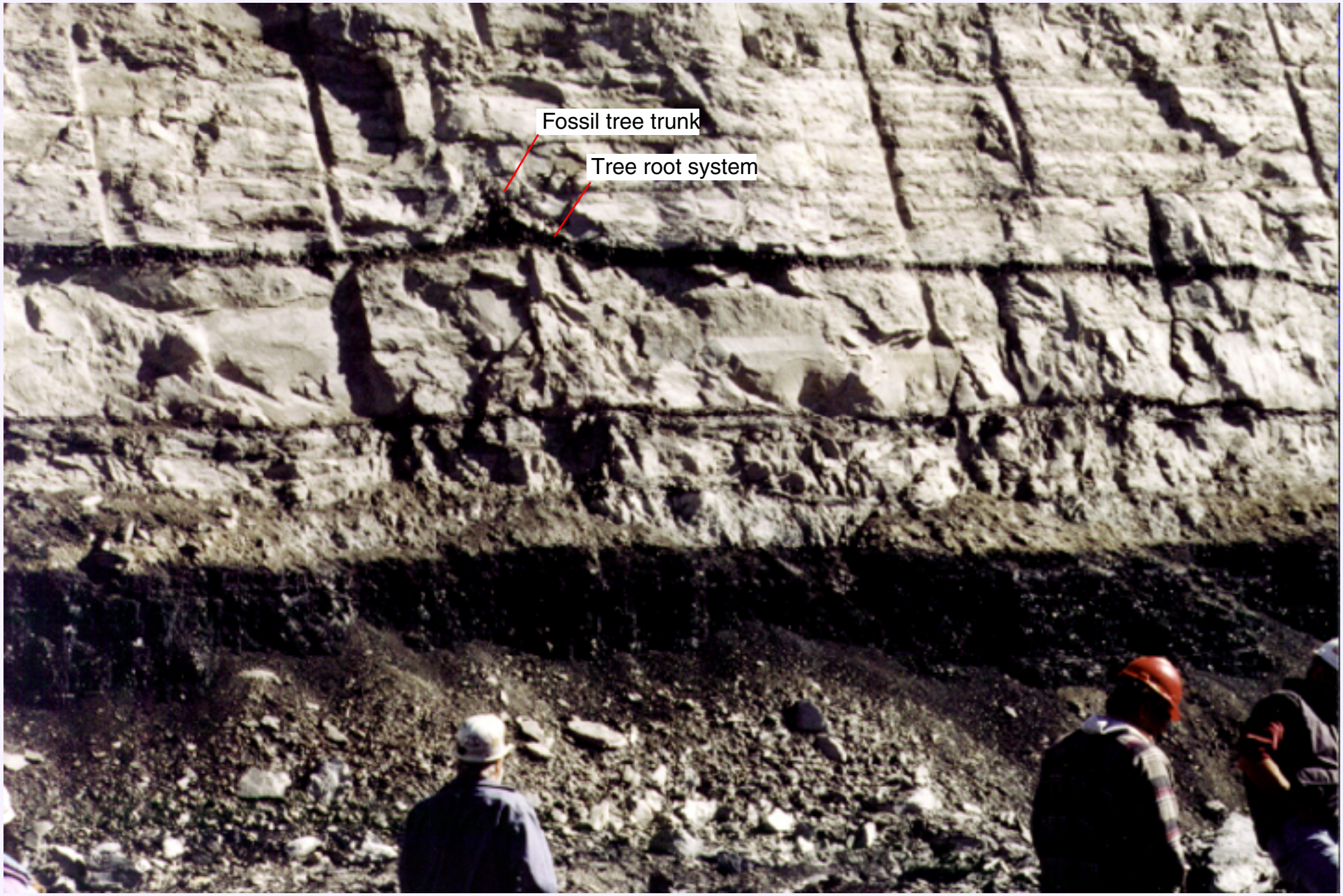

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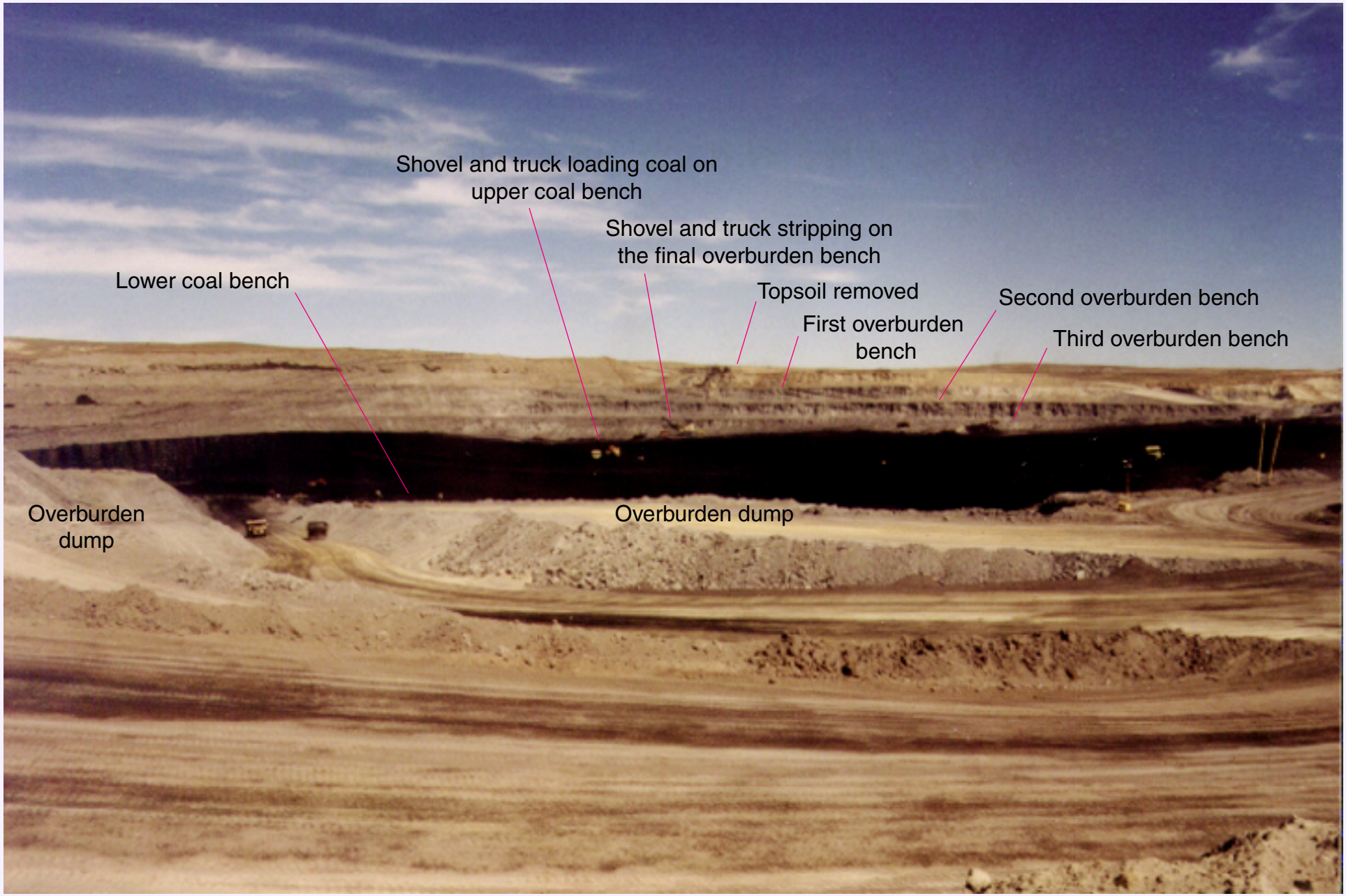
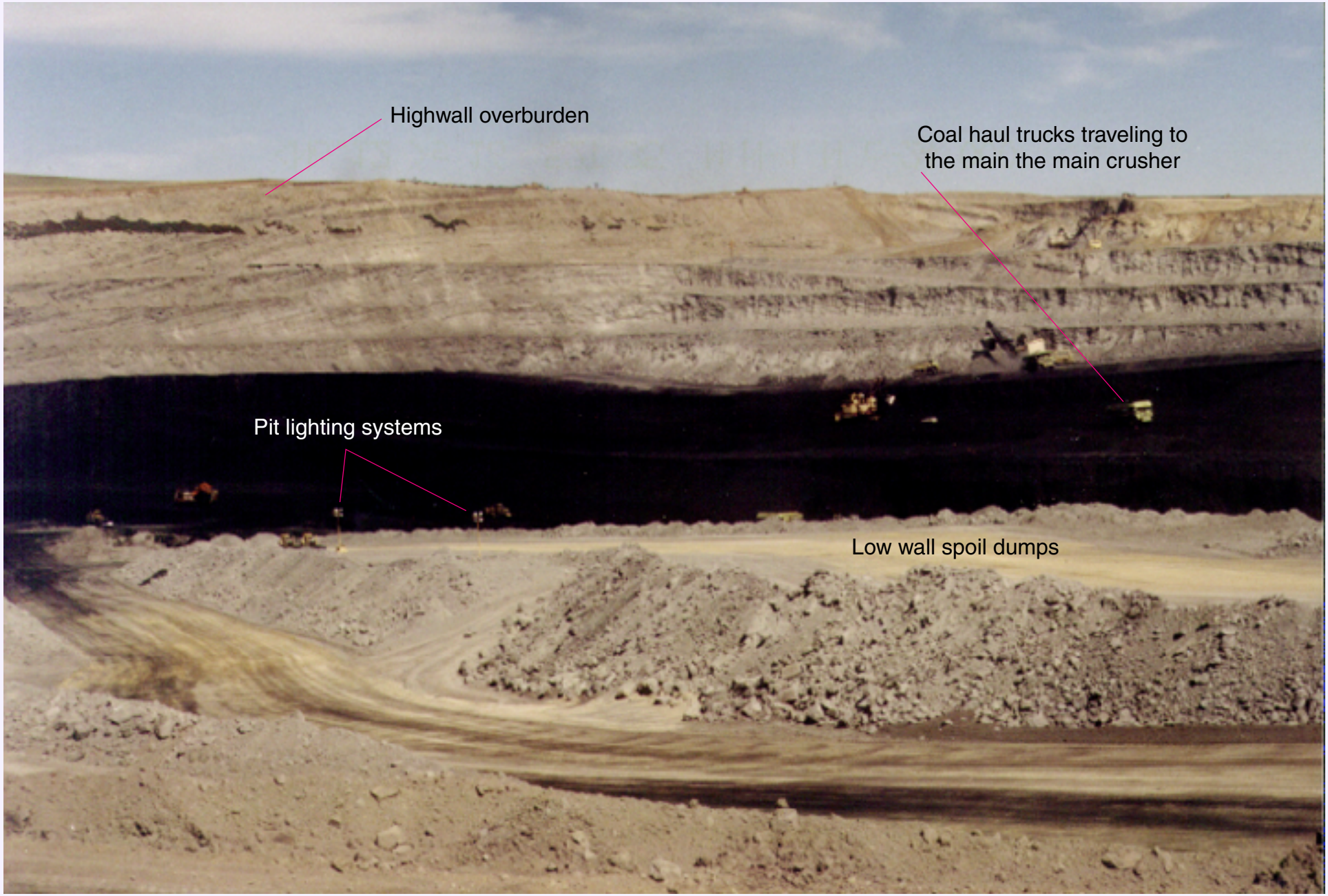


Figure MO-7. View of a multiple-bench, truck-shovel stripping operation in a large coal bed. *Photograph by Ken Takahashi, 1999*



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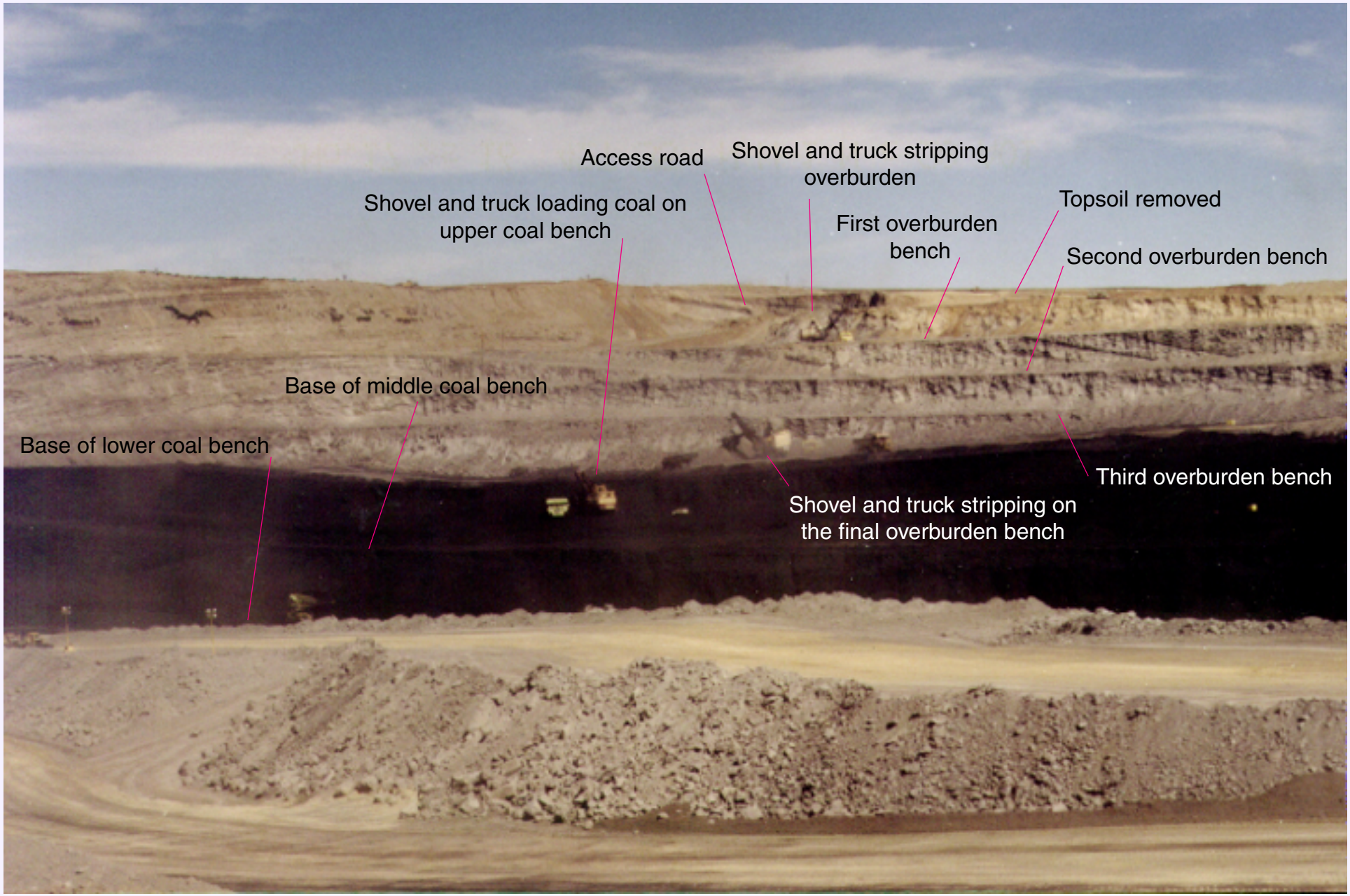

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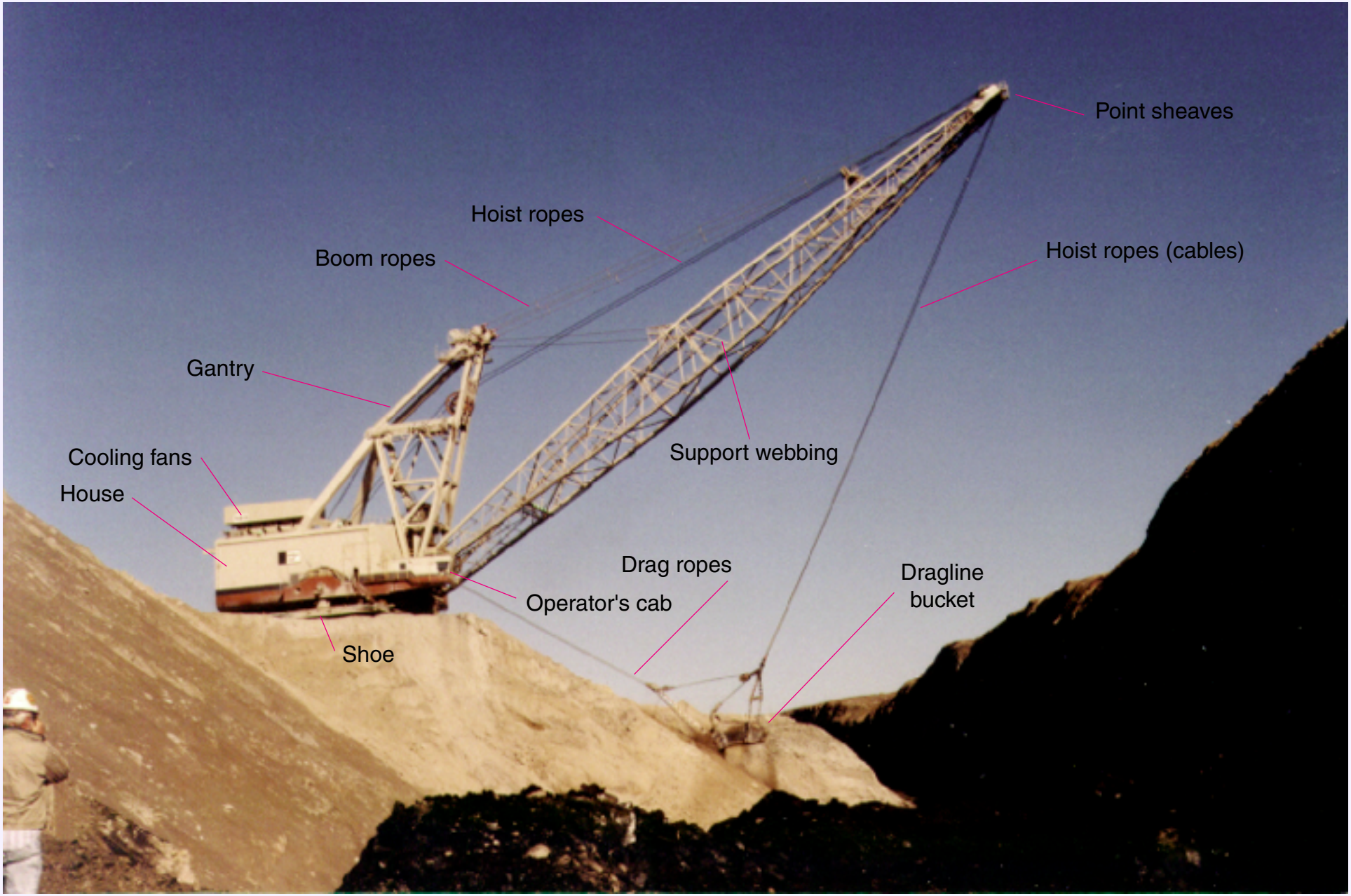

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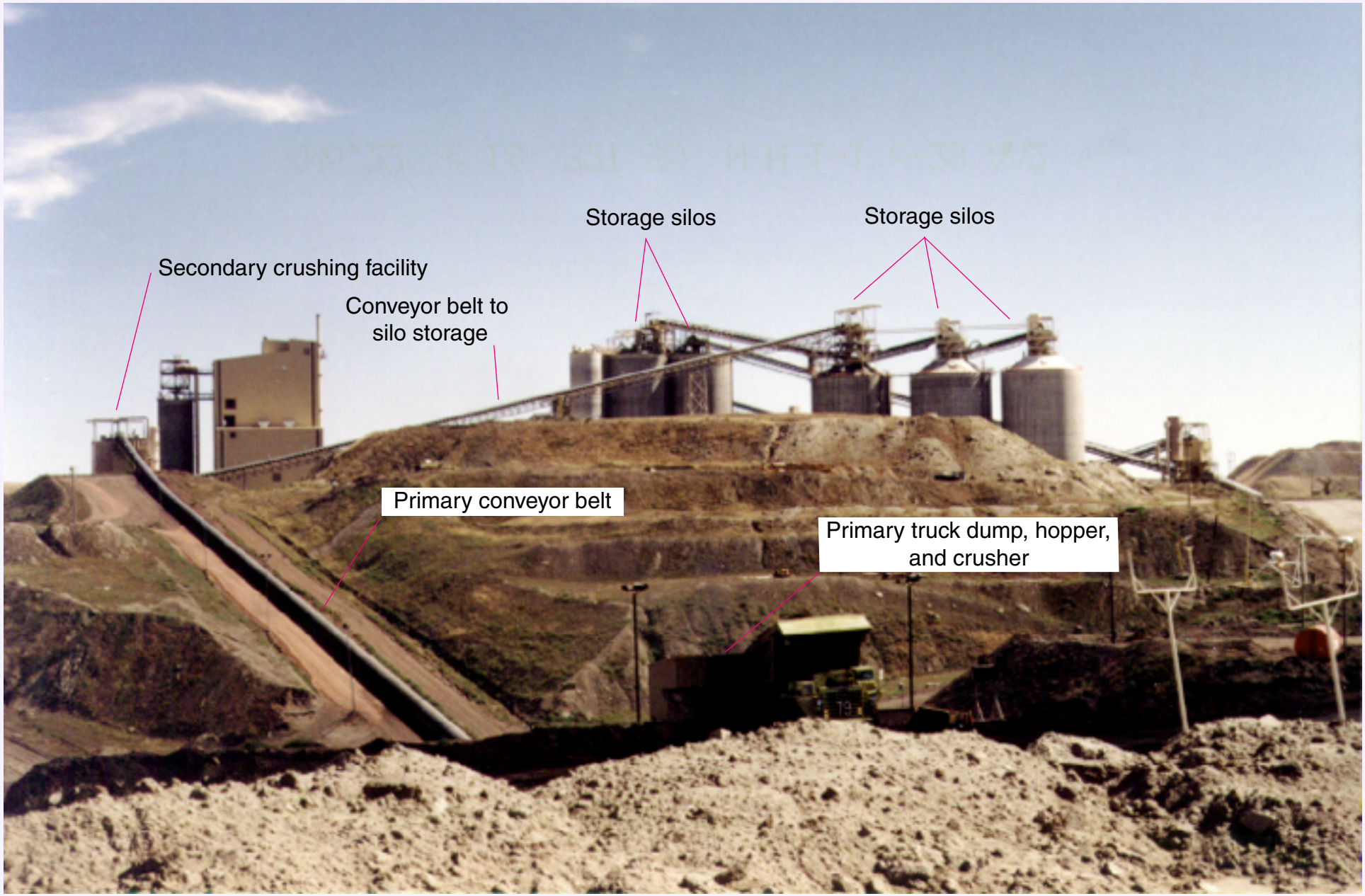

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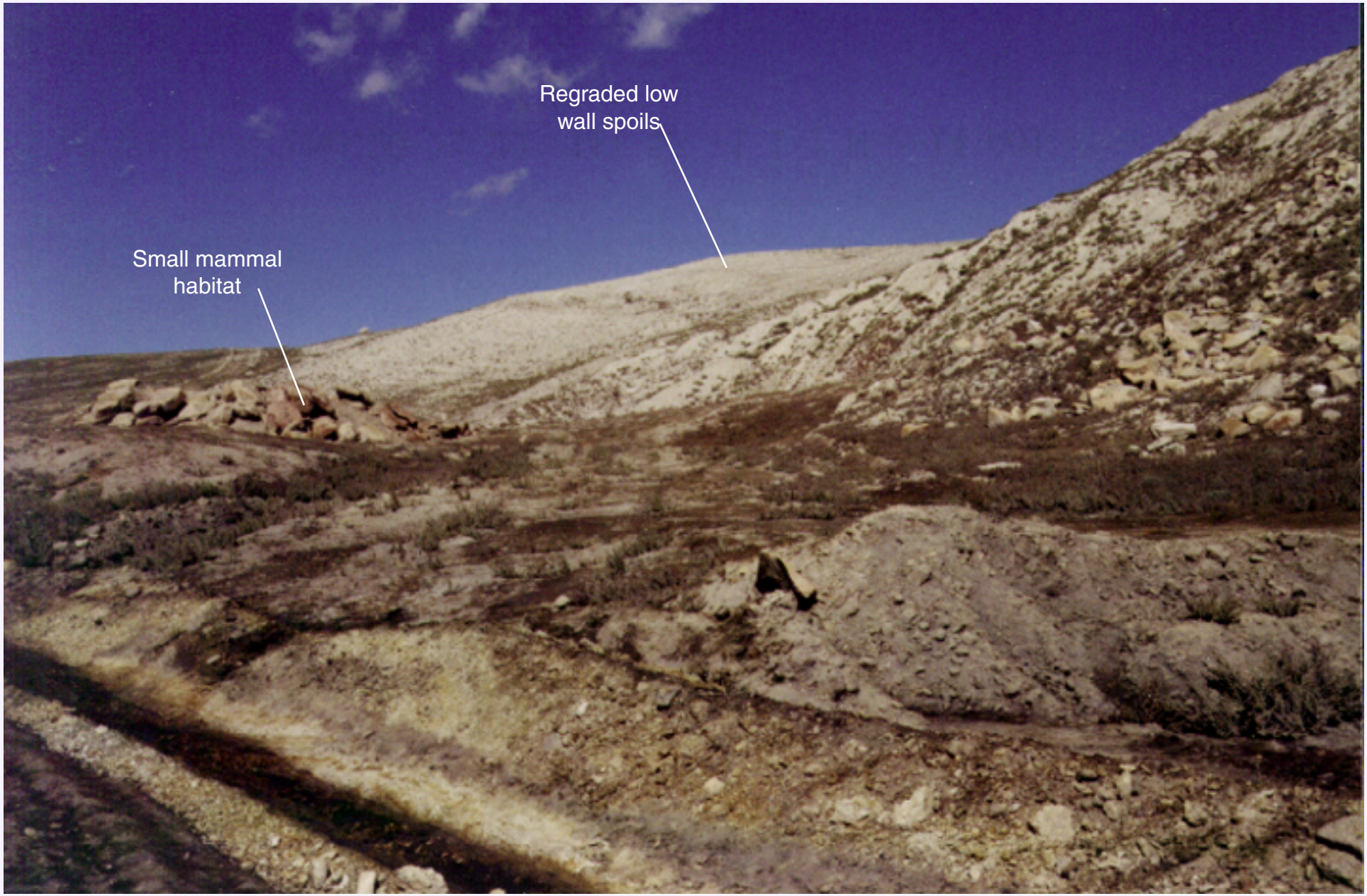


Figure MO-46. Regraded low wall spoils. The vegetation has not been re-established to pre-mining conditions yet. Note the rocks placed to form dens for small animals.

Photograph by Ken Takahashi, 1999

Figure MO-47. Regraded and revegetated low wall spoils.

Photograph by Ken Takahashi, 1999

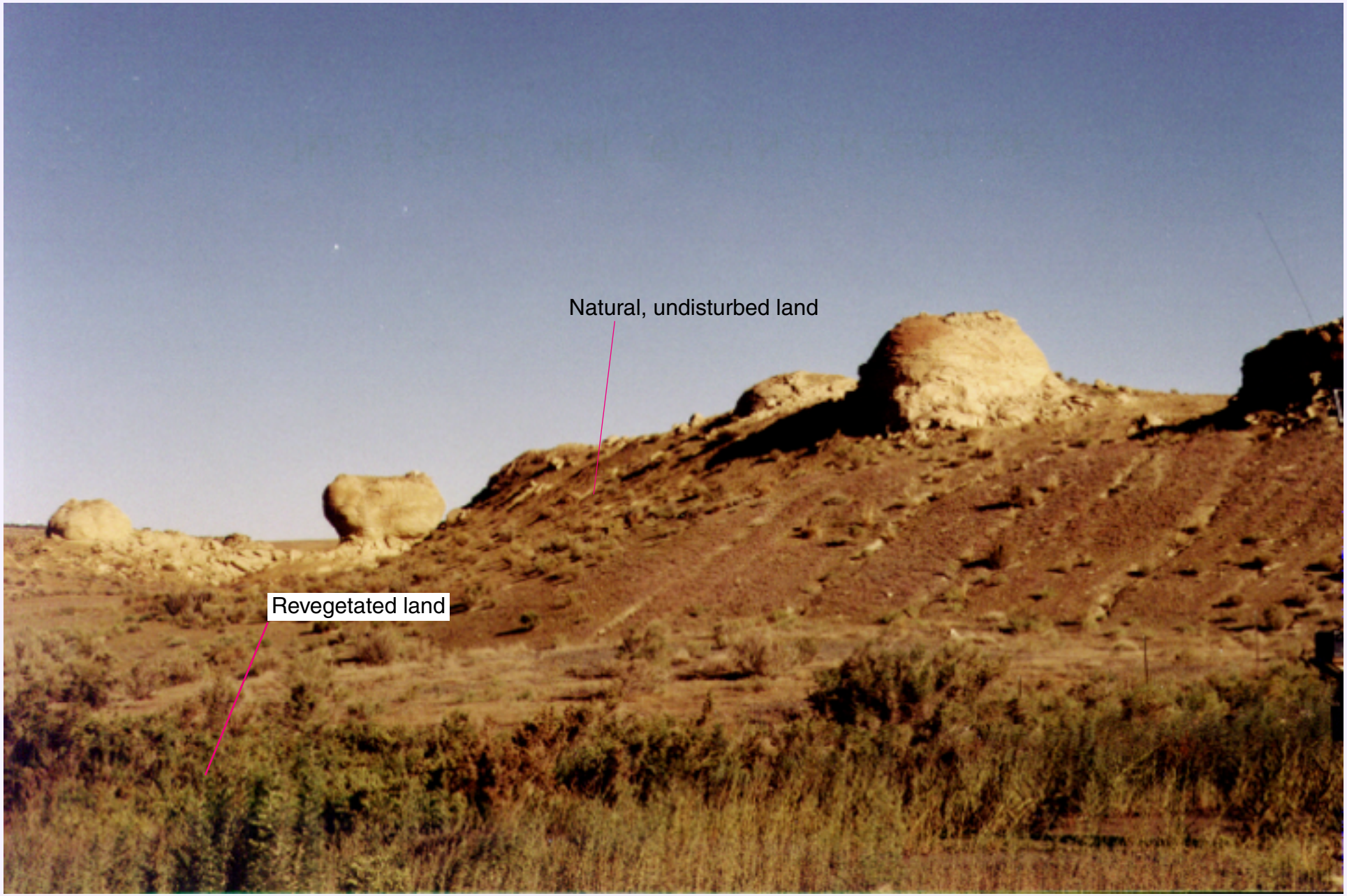


Figure MO-48. Revegetated land is shown in the foreground with natural, undisturbed land in the background.

Photograph by Ken Takahashi, 1999

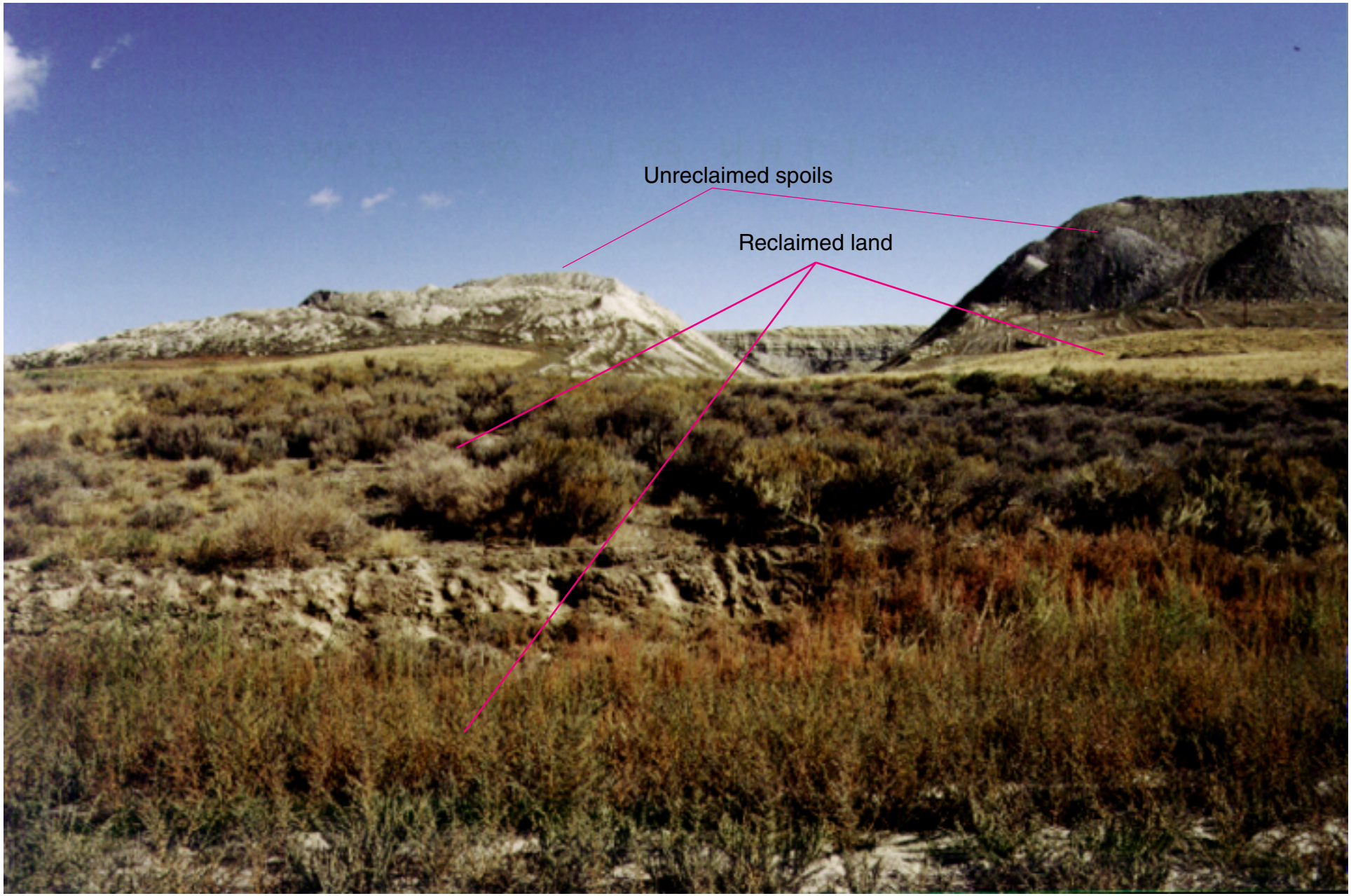


Figure MO-49. Reclaimed lands.

Photograph by Ken Takahashi, 1999

Figure MO-50. Topsoil replacement using Caterpillar scrapers.

Photograph by Ken Takahashi, 1999

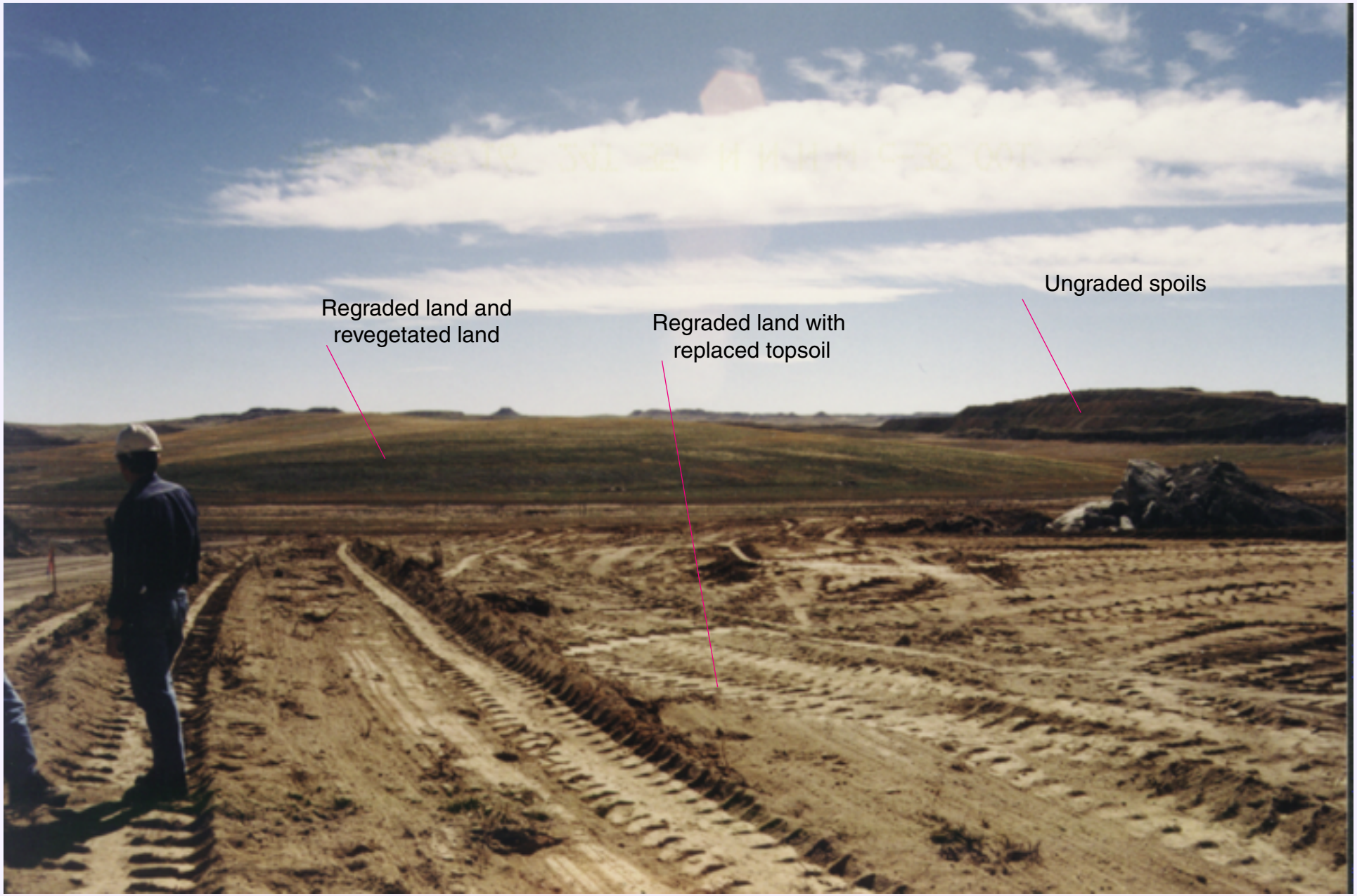


Figure MO-51. Reclamation in different stages: land in the foreground has been regraded and the topsoil (root medium material) has been replaced. Land in the background has been regraded and revegetated.

Photograph by Ken Takahashi, 1999

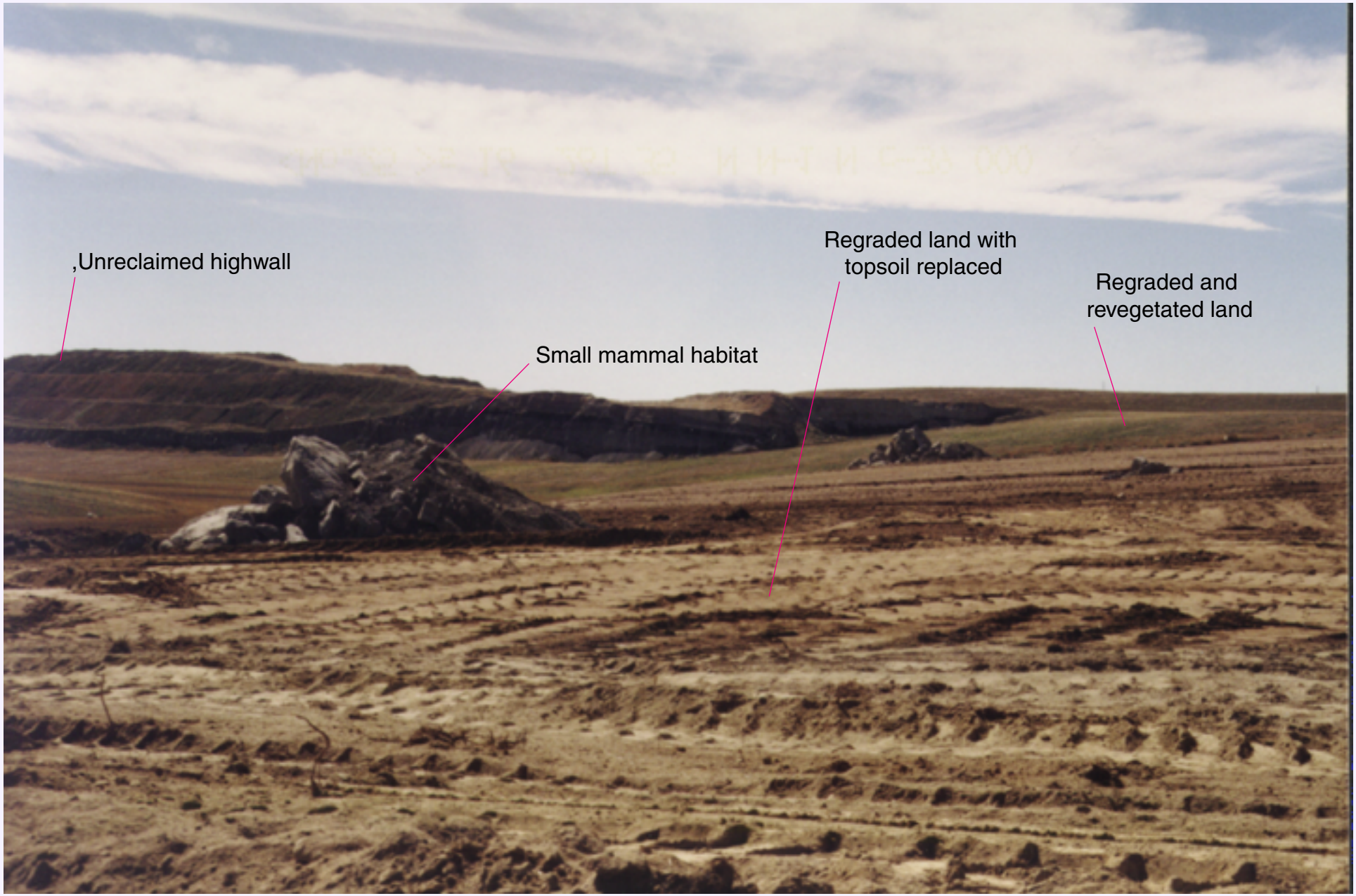


Figure MO-52. Early stages of reclamation: regraded land; regraded land with topsoil replaced; regraded land with topsoil replaced and revegetated.

Photograph by Ken Takahashi, 1999

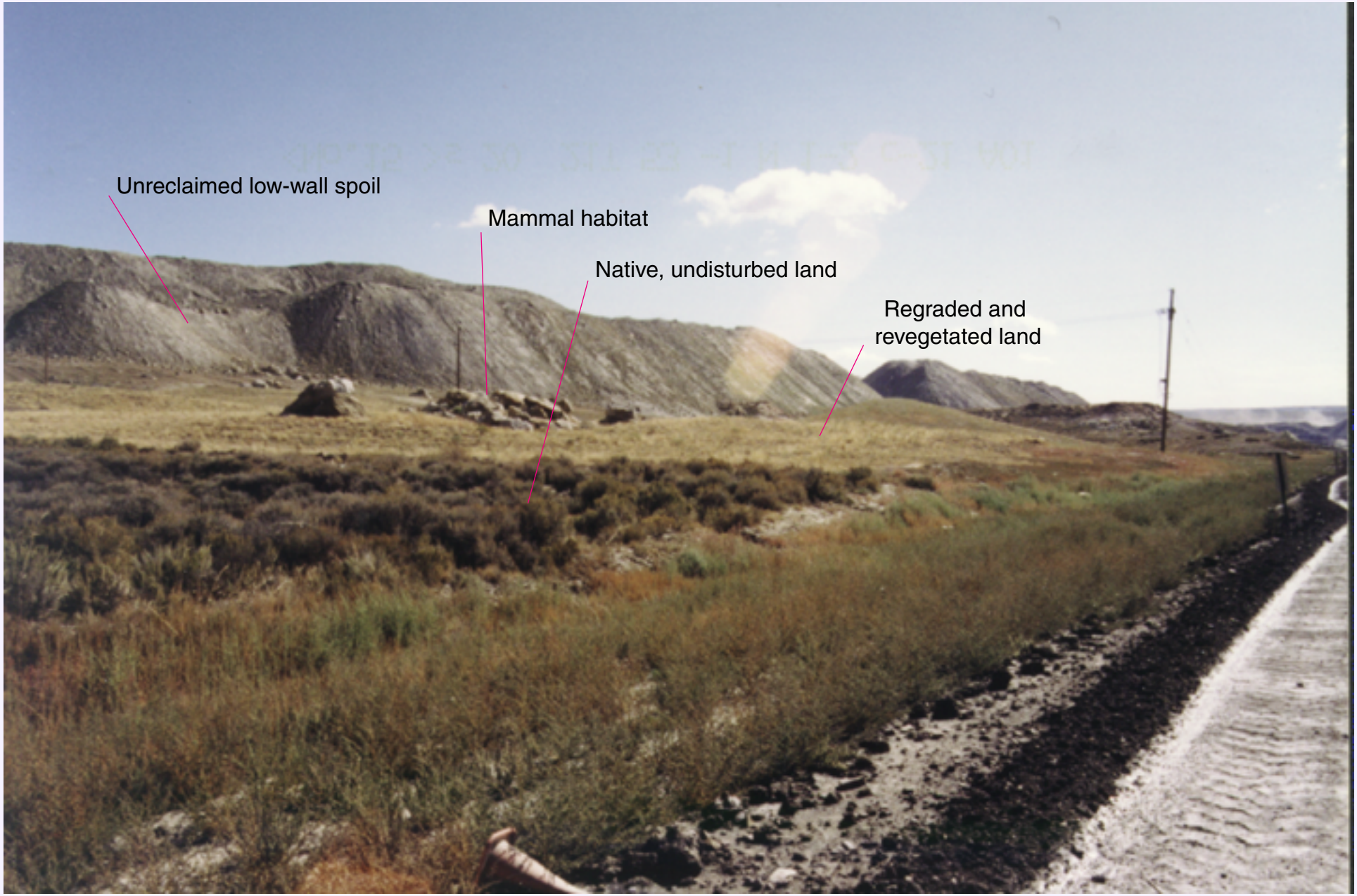


Figure MO-53. Low wall, out of pit regrading and revegetation adjacent to a major haul road.

Photograph by Ken Takahashi, 1999

Figure MO-54. Regraded and reseeded area.

Photograph by Ken Takahashi, 1999

Figure MO-55. Reclaimed land in foreground and unreclaimed low-wall spoils in background. *Photograph by Ken Takahashi 1999*

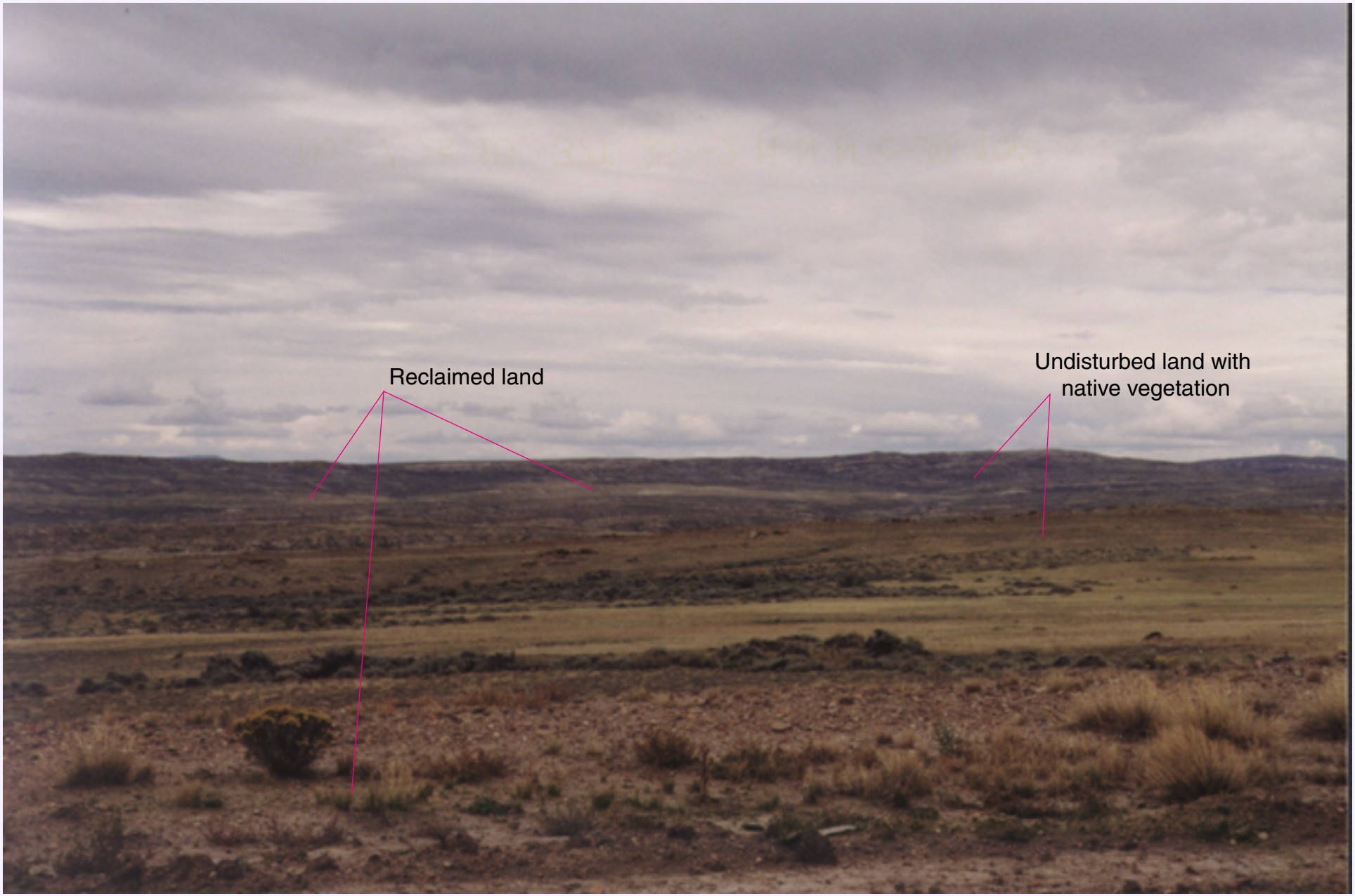


Figure MO-56. Hanna Basin reclamation.

Photograph by Ken Takahashi, 1999

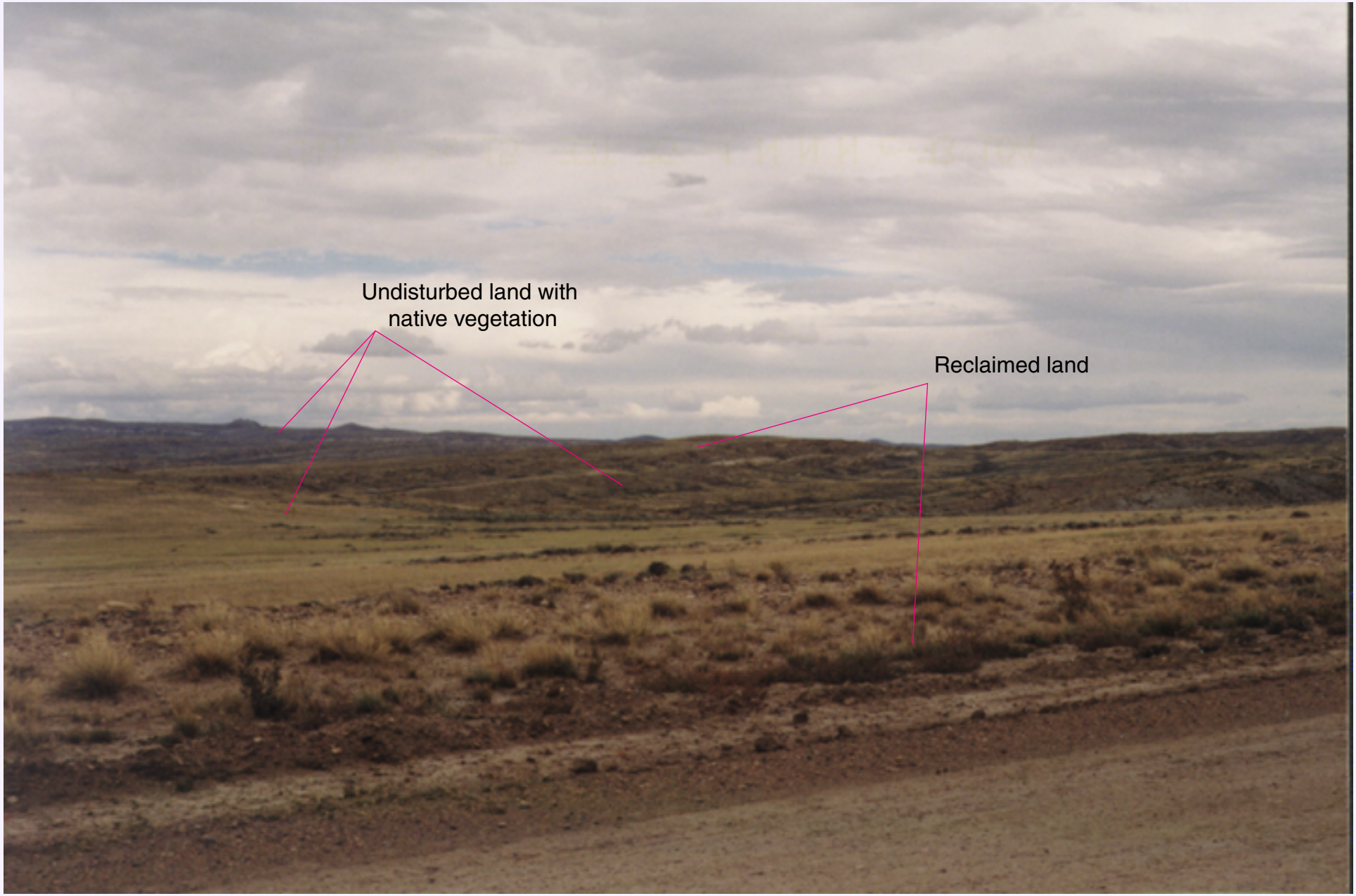


Figure MO-57. Reclaimed lands and undisturbed native grassland in the Hanna Basin.

Photograph by Ken Takahashi, 1999

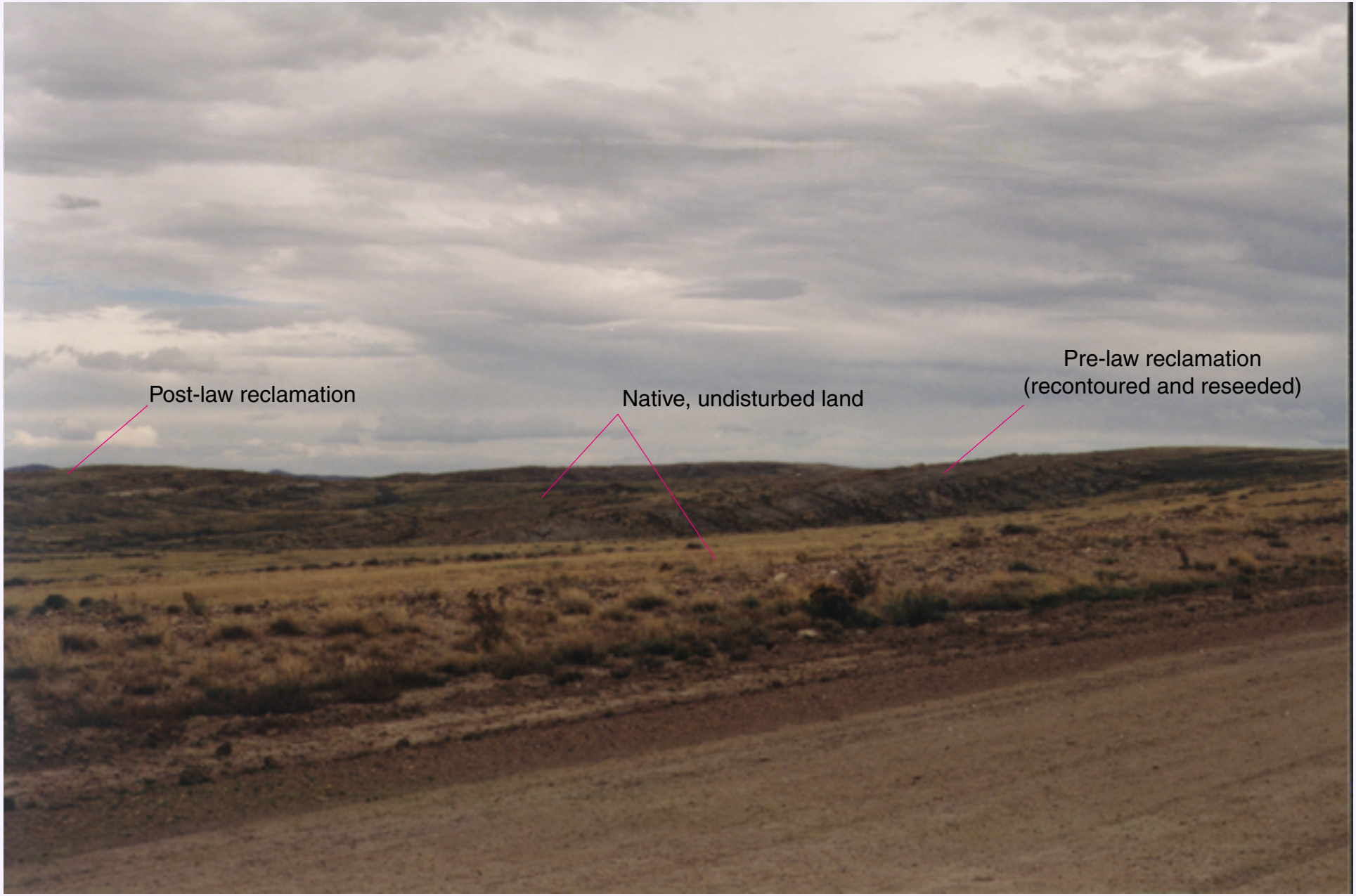


Figure MO-58. It is difficult to distinguish between reclaimed lands and undisturbed land on this Hanna Basin access road. Pre-law reclamation areas were regraded to a 3:1 slope and reseeded.

Photograph by Ken Takahashi, 1999

Figure MO-59. Reclaimed land on both sides of an access road in Hanna Basin.

Photograph by Ken Takahashi, 1999

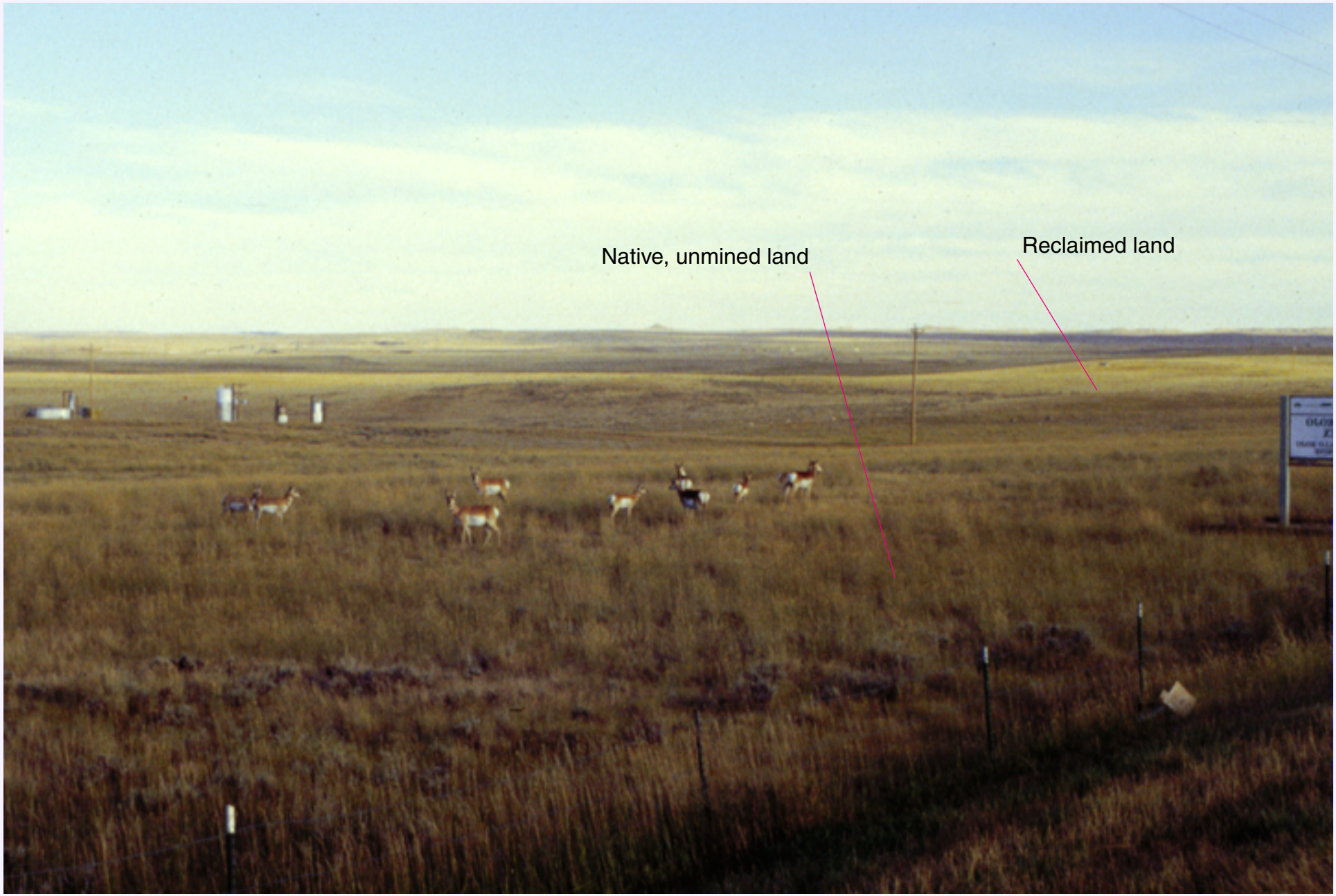


Figure MO-60. Reclaimed land in the Gillette coalfield.

Photograph by Ken Takahashi, 1999

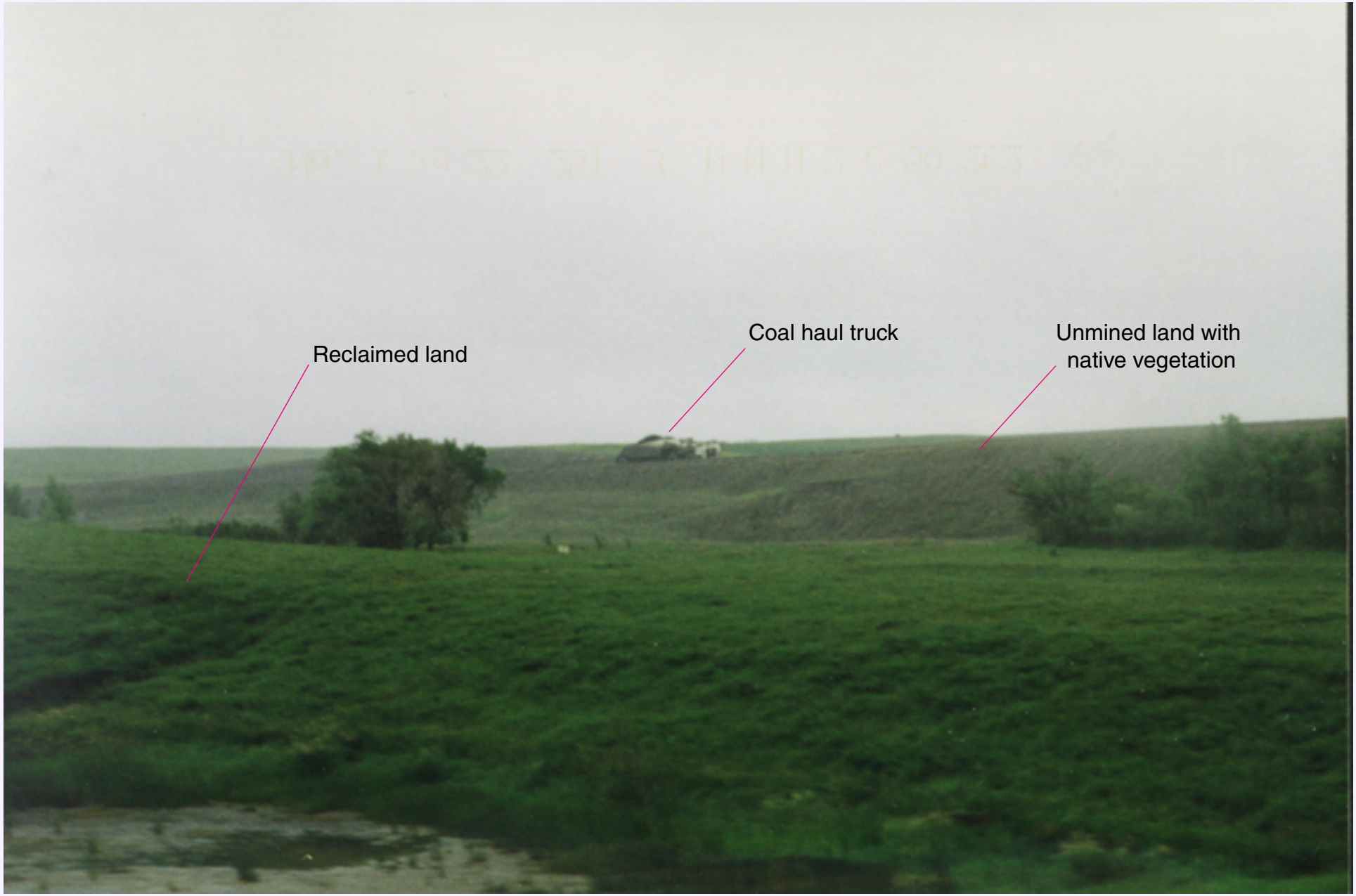
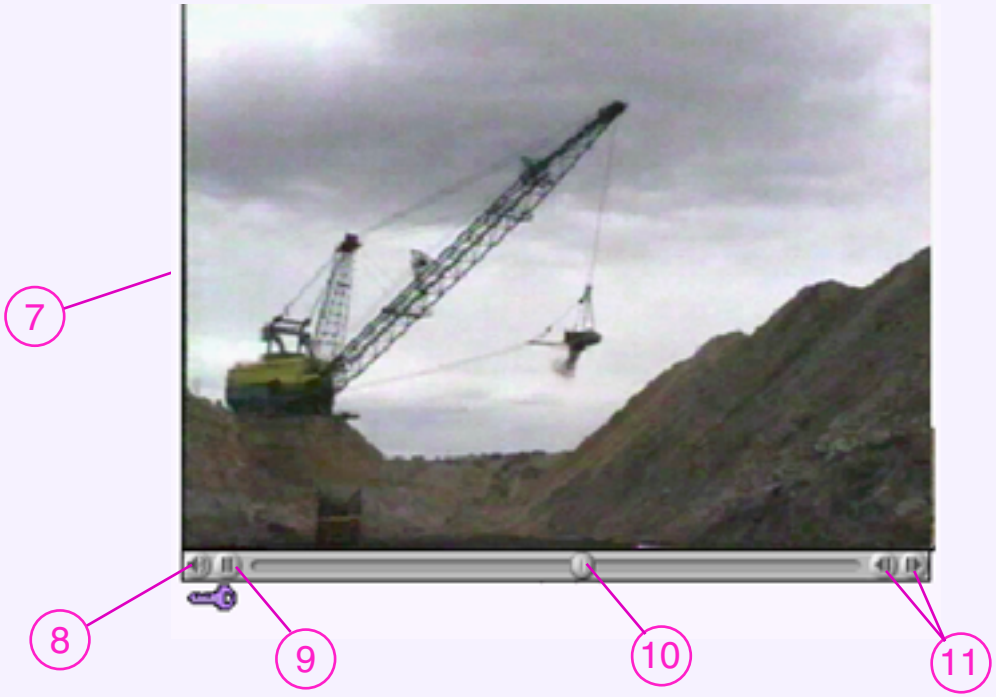


Figure MO-61. The dark green area in the foreground is reclaimed land in the Williston Basin. The coal truck is on a haul road surrounded by unmined land.

Photograph by Ken Takahashi, 1999



Instructions (continued)

7. Clicking on the large images plays the movies and provides additional controls.

8. Sound volume control. Clicking on this button will display a sliding volume control which can be dragged up or down to raise or lower the volume.

9. This is the start and stop button. Click on this button to start and stop the video.

10. This button indicates the progress of the movie. It can be dragged to the left or right to move to a different part of the video.

11. These buttons go to the beginning and end of the video.

Instructions

In addition to the normal Acrobat Reader tools, this chapter contains several additional buttons to facilitate navigation:

1. The left and right pointing red triangles advance the reader to previous and next page in the chapter.

2. The curved left pointing button will take you to the page from which you made your last menu selection.

3. Click on the small photos to view the full-size version.

4. Click on the "thumbnail" images to go directly to that page.

5. Click on the large images to view short video clips of the equipment or procedures.

6. Double-click on the key to get information about the movie.