

2021

The Law of Enhanced Weathering for Carbon Dioxide Removal: Volume 2 – Legal Issues Associated with Materials Sourcing

Romany M. Webb

Columbia University, Sabin Center for Climate Change Law, rwebb@law.columbia.edu

Follow this and additional works at: https://scholarship.law.columbia.edu/sabin_climate_change



Part of the [Environmental Law Commons](#)

Recommended Citation

Romany M. Webb, *The Law of Enhanced Weathering for Carbon Dioxide Removal: Volume 2 – Legal Issues Associated with Materials Sourcing*, Sabin Center for Climate Change Law, Columbia Law School, March 2021 (2021).

Available at: https://scholarship.law.columbia.edu/sabin_climate_change/40

This Paper is brought to you for free and open access by the Research Centers & Programs at Scholarship Archive. It has been accepted for inclusion in Sabin Center for Climate Change Law by an authorized administrator of Scholarship Archive. For more information, please contact scholarshiparchive@law.columbia.edu, rwitt@law.columbia.edu.



COLUMBIA LAW SCHOOL

SABIN CENTER FOR CLIMATE CHANGE LAW

**THE LAW OF ENHANCED
WEATHERING FOR CARBON
DIOXIDE REMOVAL**

Volume 2 – Legal Issues Associated with
Materials Sourcing

By Romany M. Webb

March 2021

© 2021 Sabin Center for Climate Change Law, Columbia Law School

The Sabin Center for Climate Change Law develops legal techniques to fight climate change, trains law students and lawyers in their use, and provides the legal profession and the public with up-to-date resources on key topics in climate law and regulation. It works closely with the scientists at Columbia University's Earth Institute and with a wide range of governmental, non-governmental and academic organizations.

Sabin Center for Climate Change Law

Columbia Law School

435 West 116th Street

New York, NY 10027

Tel: +1 (212) 854-3287

Email: columbiaclimate@gmail.com

Web: <https://climate.law.columbia.edu/>

Twitter: @ColumbiaClimate

Blog: <http://blogs.law.columbia.edu/climatechange/>

Disclaimer: This paper is the responsibility of The Sabin Center for Climate Change Law alone, and does not reflect the views of Columbia Law School or Columbia University. This paper is an academic study provided for informational purposes only and does not constitute legal advice. Transmission of the information is not intended to create, and the receipt does not constitute, an attorney-client relationship between sender and receiver. No party should act or rely on any information contained in this White Paper without first seeking the advice of an attorney.

About the author: Romany M. Webb is an Associate Research Scholar at Columbia Law School and Senior Fellow at the Sabin Center for Climate Change Law.

Acknowledgements: Preparation of this paper was generously supported by the Columbia Center on Global Energy Policy. The author would like to thank Michael Gerrard, Andrew Sabin Professor of Professional Practice at Columbia Law School and Faculty Director of the Sabin Center for Climate Change Law, and Michael Burger, Executive Director of the Sabin Center, for their advice on the drafting of this paper. Any errors are my own.

EXECUTIVE SUMMARY

Achieving the Paris Agreement’s goal of limiting the increase in global average temperatures to well below 2°C, and ideally to 1.5°C, above pre-industrial levels will likely require the removal of carbon dioxide from the atmosphere. This could be achieved in various ways, including by enhancing natural weathering processes in which carbon dioxide reacts with silicate-based rocks, eventually forming carbonate minerals (e.g., limestone). Research suggests that the amount of carbon dioxide sequestered through this natural process can be increased by grinding silicate-rich minerals (e.g., olivine) or rocks (e.g., dunite) to increase their surface area and then spreading the powder over land or ocean waters (a process known as “enhanced weathering”). Some researchers have also proposed using other silicate-based materials, including mine tailing and similar industrial wastes, in enhanced weathering.

Performing enhanced weathering at scale would require access to large amounts of silicate minerals, rocks, or other materials. This paper examines key U.S. federal and state laws governing the mining and processing of silicate-rich minerals and rocks and the sourcing of silicate-based wastes for use in enhanced weathering. Laws governing the conduct of enhanced weathering projects, both on land and in ocean waters, are analyzed in a separate paper by the author.

The development of new, or expansion of existing, mines to extract silicate minerals and rocks could raise a variety of legal and other issues. The legal framework for mining on federal, tribal, and state-owned land is especially complex, with numerous permitting and other requirements. Many of those requirements were put in place to mitigate the environmental and other risks associated with mining activities and thus should not be eliminated or weakened. However, modest changes could be made to facilitate access to silicate minerals and rocks for use in enhanced weathering, without compromising environmental or other outcomes.

Sourcing silicate-based wastes, particularly mine tailings, for use in enhanced weathering could also be challenging. There is often significant uncertainty as to who owns mine tailing and restrictions on their transfer to third parties. These issues could, again, be addressed through modest changes to existing legal frameworks.

CONTENTS

| | |
|--|-----------|
| Acronyms | 1 |
| 1. Introduction | 2 |
| 2. Mining Silicate-Rich Minerals and Rocks for Use in Enhanced Weathering | 6 |
| 2.1 Accessing Silicate-Rich Minerals and Rocks | 6 |
| 2.1.1 Federal Land | 7 |
| 2.1.2 Tribal Land | 19 |
| 2.1.3 State Land | 24 |
| 2.2 Environmental Approvals Required to Develop Silicate-Rich Minerals and Rocks | 27 |
| 2.2.1 Mining Permits | 28 |
| 2.2.2 Air Pollution Permits | 29 |
| 2.2.3 Water Pollution Permits | 33 |
| 2.2.4 Waste Management Permits | 36 |
| 3. Sourcing Artificial Silicates For Use in Enhanced Weathering | 38 |
| 3.1 Ownership of Mine Tailings | 40 |
| 3.2 Restrictions on the Transfer of Mine Tailings | 43 |
| 4. Conclusion | 44 |

ACRONYMS

| | |
|-------|--|
| ACE | U.S. Army Corps of Engineers |
| BIA | Bureau of Indian Affairs |
| BLM | Bureau of Land Management |
| BUD | Beneficial Use Determination |
| CAA | Clean Air Act |
| CVA | Common Varieties Act |
| CWA | Clean Water Act |
| DOI | Department of the Interior |
| EIS | Environmental Impact Statement |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| FIP | Federal Implementation Plan |
| FWS | Fish and Wildlife Service |
| NAAQS | National Ambient Air Quality Standards |
| NEPA | National Environmental Policy Act |
| NPDES | National Pollutant Discharge Elimination System |
| NYDEC | New York Department of Environmental Conservation |
| PM2.5 | Particulate matter consisting of particles with diameters of 2.5 microns or less |
| PM10 | Particulate matter consisting of particles with diameters of 10 microns or less |
| RCRA | Resource Conservation and Recovery Act |
| RMP | Resource Management Plan |
| SIP | State Implementation Plan |
| U.S. | United States |

1. INTRODUCTION

Enhanced weathering is one of several proposed approaches for removing greenhouse gases from the Earth’s atmosphere. Scientists increasingly agree that greenhouse gas removal will be needed to limit “the increase in global average temperature to well below 2°C,” and ideally to 1.5°C, above pre-industrial levels—i.e., the goal set by the international community in the 2015 Paris Agreement.¹ Modeling by the Intergovernmental Panel on Climate Change and others indicates that, to stay within the 2°C threshold, global greenhouse gas emissions must be reduced to “net zero” by mid-century or shortly thereafter.² At that point, any residual emissions (e.g., from hard-to-eliminate sources) will need to be offset through greenhouse gas removal.³ Moreover, unless there is a rapid and dramatic increase in the rate of emissions declines in the short-term, greenhouse gas removal will also be needed in the future to compensate for past emissions.⁴

Past research on greenhouse gas removal has focused primarily on approaches for taking carbon dioxide out of the atmosphere and storing it in terrestrial biomass, underground geologic formations, or the oceans, or utilizing it in manufacturing processes (e.g., to produce fuels) or other applications.⁵ Many of the approaches, including enhanced weathering, aim to accelerate natural processes that already occur as part of the Earth’s climate cycle.

¹ Paris Agreement, Dec. 12, 2015, Art. 2(1)(a).

² Myles Allen et al., *Summary for Policymakers in GLOBAL WARMING OF 1.5°C: AN IPCC SPECIAL REPORT* (V. Masson-Delmotte et al. eds., 2018); OTTMAR EDENHOFFER ET AL., *CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE, CONTRIBUTION OF WORKING GROUP III TO THE FIFTH ASSESSMENT REPORT BY THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE* (2014), <http://perma.cc/T8J5-MBTA>. See also, e.g., UN ENV’T PROGRAM, *EMISSIONS GAP REPORT 2020* (2020), <http://perma.cc/6G97-9X68>.

³ UN Env’t Program, *supra* note 2, at 33-34.

⁴ *Id.*

⁵ See generally, ROYAL SOCIETY & ROYAL ACADEMY OF ENGINEERING, *GREENHOUSE GAS REMOVAL* 8 (2018), <http://perma.cc/NK4D-JXR4>. One commonly discussed use of carbon dioxide is in enhanced oil recovery, but the climate and other environmental impacts of that are disputed. Compare Gregory Cooney et al., *Evaluating the Climate Benefits of CO₂-Enhanced Oil Recovery Using Life Cycle Analysis*, ENVIRON. SCI. TECHNOL. 7491 (2015) (finding that, depending on the source of the carbon dioxide used, lifecycle emissions from enhanced oil recovery may be higher than those from conventionally produced oil), with Vanessa Núñez-López & Emily Moskal, *Potential for CO₂-EOR for Near-Term Decarbonization*, FRONTIERS IN CLIMATE 1:5 (2019) (finding that enhanced oil recovery using carbon dioxide produces negative emissions oil during the first several years of production).

As the name suggests, enhanced weathering aims to accelerate natural weathering processes whereby carbon dioxide reacts with silicate-based rocks, eventually forming carbonate minerals (e.g., limestone).⁶ Research suggests that the natural processes can be sped up by grinding rocks or minerals that are rich in silicate and then spreading the powder over land or ocean waters.⁷ To date, most research has focused on the possibility of using the mineral olivine, which is a fast-weathering magnesium iron silicate.⁸ Rocks, such as dunite and basalt, which contain olivine or similar silicate minerals could also be used. Additionally, some researchers have proposed using other silicate-rich substances, including industrial wastes, such as mine tailings⁹ and fly ash¹⁰ (“artificial silicates”).¹¹ In theory, artificial silicates should react with carbon dioxide in the same manner as silicate-rich rocks, and ultimately sequester the carbon dioxide in mineral form.¹² Further research is, however, needed to fully evaluate the risks associated with using artificial silicates in enhanced weathering.¹³

The international and U.S. legal frameworks governing the performance of enhanced weathering on land and in the oceans were examined in a previous paper by the author.¹⁴ The paper did not, however, discuss legal issues associated with the sourcing of materials for use in enhanced weathering. That is the subject of this paper.

⁶ The reaction releases carbonate or bicarbonate ions, which either form carbonate minerals on land or are washed into the oceans, where they eventually become carbonate sediments on the seafloor. In both cases, carbon dioxide from the atmosphere is ultimately stored in mineral form, likely for centuries or millennia. Where storage occurs in the oceans, the process also helps to counteract ocean acidification, and may lead to additional carbon dioxide being stored in the oceans. For a more detailed description of the process, see Royal Society, *supra* note 5, at 49.

⁷ See generally, Jens Hartman et al., *Enhanced Chemical Weathering as a Geoengineering Strategy to Reduce Atmospheric Carbon Dioxide, Supply Nutrients, and Mitigate Ocean Acidification*, 51 REV. GEOPHYSICS 113, 117 (2013).

⁸ See generally, Jessica Strefler et al., *Potential and Costs of Carbon Dioxide Removal by Enhanced Weathering of Rocks*, 13 ENVTL. RES. LETTERS 030401 (2018).

⁹ Mine tailings are rock-based materials generated as a by-product of hard rock mining.

¹⁰ Fly ash is the residual material left behind after the combustion of coal in electricity generating facilities.

¹¹ *Id.* at 11.

¹² *Id.*

¹³ Royal Society & Royal Academy of Engineering, *supra* note 5, at 51.

¹⁴ ROMANY M. WEBB, THE LAW OF ENHANCED WEATHERING FOR CARBON DIOXIDE REMOVAL (2020), <https://perma.cc/95FH-NKTB>.

Performing enhanced weathering at scale would require access to large amounts of reactive materials. Initial research suggests that, where silicate-based rocks are used, between one and five tons of rock are needed to sequester one ton of carbon dioxide.¹⁵ Thus, for example, up to 165 billion tons of rock would be needed to sequester just one year's-worth of global energy-related carbon dioxide emissions.¹⁶ Of course, enhanced weathering is likely to be deployed in combination with other climate mitigation strategies, and thus would not be used to offset all global energy-related emissions. However, offsetting even ten percent of those emissions using enhanced weathering would require up to 16.5 billion tons of rock, which is more than double current annual global production of coal (i.e., 7.9 billion tons).¹⁷

The mining and processing of silicate-rich rocks for use in enhanced weathering could have a range of negative environmental and other impacts. Constructing new mines typically requires land clearing, which results in carbon dioxide emissions that could partially, or in some cases entirely, offset the climate benefits of performing enhanced weathering.¹⁸ Mine construction and operation can also impair local air quality, including due to the release of silica particles (e.g., during rock grinding) which, when inhaled by humans, can cause inflammation in the lungs and eventually lead to permanent scarring and respiratory problems.¹⁹ Mining activities can similarly harm animals, including by causing habitat loss or degradation, disrupting breeding and other behaviors, and

¹⁵ Enhanced weathering can sequester 0.8 to 1.1 tons of carbon dioxide per ton of rock where dunite is used, 0.3 tons of carbon dioxide per ton of rock where basalt is used, and 0.2 tons of carbon dioxide per ton of rock where wollastonite is used. See Strefler et al., *supra* note 8, at 2. (discussing the use of dunite); Royal Society, *supra* note 5, at 49 (discussing the use of basalt and wollastonite).

¹⁶ Int'l Energy Agency, *Global CO2 Emissions in 2019*, <https://perma.cc/NTL5-TJWZ> (last updated Feb. 11, 2020) (reporting that global energy-related carbon dioxide emissions totaled approximately 33 gigatons in 2019).

¹⁷ Int'l Energy Agency, COAL INFORMATION: OVERVIEW (2020), <https://perma.cc/TBE6-LUBF>.

¹⁸ Webb, *supra* note 14, at 10.

¹⁹ U.S. Dep't of Labor, *Silica Crystalline*, SAFETY AND HEALTH TOPICS, <https://perma.cc/MQ9E-D8Z7> (last visited Mar. 3, 2021).

altering predator-prey dynamics.²⁰ They have, in the past, also been a major source of soil and water contamination.²¹

The adverse effects of mining are often disproportionately felt by low-income and minority communities. For example, in the Appalachia region where most U.S. coal mining historically occurred, both poverty and mortality rates are significantly higher in mining counties compared to non-mining counties.²² Mining for coal, uranium, and certain other materials historically often occurred on Native American land, much of which has not been fully remediated, leaving the residents exposed to a range of health risks.²³ Those same communities could be affected by mining undertaken in connection with enhanced weathering projects. Indeed, one of the world's largest known deposits of olivine—i.e., the material considered most suitable for use in enhanced weathering—is found in the Twin Sisters Mountain in Washington state, which is in close proximity to the Nooksack Indian Reservation.²⁴

This paper examines the key U.S. federal and state laws governing the mining and processing of silicate-rich minerals and rocks for use in enhanced weathering. It also discusses legal issues associated with sourcing artificial silicates. The primary focus is on issues relating to the sourcing of mining waste, which is the artificial silicate most commonly proposed for use in enhanced weathering.

The remainder of this paper is structured as follows: Part 2 begins by analyzing the requirements for obtaining rights to minerals underlying federal, state, tribal, and private land. It also discusses other permits and approvals commonly required for mineral extraction and processing. Part 3 then examines key issues associated with sourcing artificial silicates, particularly

²⁰ Laura J. Sonter et al., *Mining and Biodiversity: Key Issues and Research Needs in Conservation Science*, 285 PROC. ROYAL SOC. (2018).

²¹ Matthew Ross, *Mining Powers Modern Life, But Can Leave Scarred Lands and Polluted Waters Behind*, THE CONVERSATION (Oct. 3, 2019), <https://perma.cc/WTN5-THL5>.

²² Michael Hendryx, *Poverty and Mortality Disparities in Central Appalachia: Mountaintop Mining and Environmental Justice*, 4 J. HEALTH DISPARITIES RES. & PRAC. 44, 48-49 (2011).

²³ Doug Brugge & Rob Goble, *The History of Uranium Mining and the Navajo People*, 92 AM. J. PUB. HEALTH 1410 (2002).

²⁴ The shortest distance between the Twin Sisters Mountain and the Nooksack Indian Reservation (i.e., “as the crow flies”) is approximately 13 miles. See Env'tl. Prot. Agency, *EJSCREEN: Environmental Justice Screening and Mapping Tool* (Version 2020), <https://ejscreen.epa.gov/mapper/>.

mining waste, including how to determine the ownership of such waste and restrictions on its transfer to third parties. Part 4 concludes.

2. MINING SILICATE-RICH MINERALS AND ROCKS FOR USE IN ENHANCED WEATHERING

Initial research suggests that enhanced weathering may be most effective when performed using the mineral olivine because it is a particularly fast-weathering magnesium-iron silicate.²⁵ One of the world's largest known olivine deposits, estimated at approximately 200 gigatons, is located in the Twin Sisters Mountain in Washington state.²⁶ A second significant olivine deposit, estimated at 200 megatons, extends in a belt from northeast Georgia into western North Carolina.²⁷ In both locations, the olivine deposits are found in dunite rock, which could be used directly in enhanced weathering (i.e., after grinding), or processed to extract the olivine for use by itself. Enhanced weathering could also be performed using other silicate-containing rocks, such as basalt, which is found throughout the western U.S. and in parts of the mid-west and east.²⁸ This part discusses key laws applicable to the mining and processing of olivine, dunite, basalt, and similar materials for use in enhanced weathering. It also suggests reforms that could increase access to such materials, without comprising environmental and other protections.

2.1 Accessing Silicate-Rich Minerals and Rocks

Any person wanting to extract silicate materials from land must hold an interest in those materials.²⁹ Before any interest can be obtained, the owner of the materials must first be identified. The minerals underlying land are often owned by the party that owns the surface estate. In some

²⁵ Jessica Strefler et al., *Potential and Costs of Carbon Dioxide Removal by Enhanced Weathering of Rocks*, 13 ENVTL. RES. LETTERS 030410, 2 (2018).

²⁶ S.C. KREAVOR ET AL., MAPPING THE MINERAL RESOURCE BASE FOR MINERAL CARBON-DIOXIDE SEQUESTRATION IN THE CONTERMINOUS UNITED STATES 10 (2009), <https://perma.cc/U8FB-KMBX>

²⁷ *Id.* See also Olivine and Dunite, ONEMINE.ORG, <https://perma.cc/TCY6-H5X6> (last updated Jan. 1, 1994).

²⁸ For a list of areas containing basalt, see USGS, *Geologic Units Containing Basalt*, MINERAL RESOURCES, <https://perma.cc/7VUJ-HCEL> (last visited Jan. 29, 2021).

²⁹ Depending on where the materials are located and methods of extraction and processing, the miner may also require various environmental and other permits. See *infra* part 2.2.

cases, however, the surface estate may have been severed from the mineral estate and transferred separately. This results in a so-called “split estate,” where the surface is owned by one party, and the minerals by another.

Privately-owned minerals can be purchased or leased from the owner via contract. This is a standard property transaction, which raises few novel legal issues. There is, however, added legal complexity where the minerals are under federal, state, or tribal ownership.

2.1.1 Federal Land

The federal government owns approximately 640 million acres of land, as well as 700 million acres of sub-surface mineral estate, some of which may contain silicate-based minerals suitable for use in enhanced weathering.³⁰ The entire federally-owned mineral estate is managed by the Department of the Interior (“DOI”) through its Bureau of Land Management (“BLM”).³¹ BLM also manages the surface of approximately 245 million acres of federally-owned land (“public land”).³² Most of the remaining federally-owned mineral estate underlies land where the surface is managed by another federal entity, such as the U.S. Forest Service (193 million acres), Fish and Wildlife Service (“FWS”) (89.2 million acres), or National Park Service (79.9 million acres).³³ However, some of the federal mineral estate is located on split-estate lands, where the surface is owned by a state or local government or private party. This part discusses key legal issues associated with silicate mining in areas where both the surface and mineral estates are under federal ownership.

Mining is prohibited on some federally-owned land, including in national parks and monuments.³⁴ It is, however, generally permissible on public land managed by BLM and in national

³⁰ CONGRESSIONAL RESEARCH SERVICE, FEDERAL LAND OWNERSHIP: OVERVIEW AND DATA 1 & 4 (2020), <https://perma.cc/38RJ-TYWQ>.

³¹ *Id.* at 4.

³² *Id.*

³³ *Id.* at 1.

³⁴ 16 U.S.C. § 3811.2-2.

forests managed by the Forest Service (“federal forest land”).³⁵ Together, those areas cover approximately 438 million acres, or nearly seventy percent of all federally-owned land.³⁶

Most mining on public and federal forest land is governed by the General Mining Act of 1872 (“Mining Act”).³⁷ Enacted to “foster and encourage private enterprise in . . . the development of economically sound and stable domestic mining,”³⁸ the Mining Act confers broad rights on U.S. citizens and certain others to explore for and extract “valuable mineral deposits in lands belonging to the United States.”³⁹ The scope of the Mining Act was, however, curtailed in 1995 in the Multiple Surface Use Act (also known as the Common Varieties Act (“CVA”). The CVA excluded “common varieties of sand, stone, gravel, pumice, pumicite, [] cinders and . . . petrified wood” (“common materials”) from the scope of the Mining Act.⁴⁰ The mining of common materials is regulated under the Materials Act of 1947.⁴¹

Basalt and dunite rock extracted for use in enhanced weathering may, in some circumstances, qualify as “common varieties of . . . stone” within the terms of the CVA. While the term “stone” is not defined in the CVA, it has been interpreted broadly to include rock of “igneous, sedimentary, or metamorphic origin,” regardless of its mineral composition.⁴² BLM has previously identified basalt as a type of stone for the purposes of the CVA⁴³ and would likely treat dunite similarly. Dunite, like basalt, is a type of igneous rock which BLM has previously held constitutes

³⁵ Some public and federal forest lands have been withdrawn from mining by statute or Presidential declaration. The Secretary of the Interior can also temporarily withdraw land from mining under the Federal Land Policy and Management Act. *See generally*, CAROL HARDY VINCENT & ERIN H. WARD, CONGRESSIONAL RESEARCH SERVICE, WITHDRAWAL OF FEDERAL LANDS: ANALYSIS OF A COMMON LEGISLATED WITHDRAWAL PROVISION (2021), <https://perma.cc/639E-MMN2>.

³⁶ Congressional Research Service, *supra* note 30, at 1.

³⁷ 30 U.S.C. § 21 et seq.

³⁸ *Id.* § 21a.

³⁹ *Id.* § 22. *See also* 43 C.F.R. § 3830.12 (defining “mineral” to mean a substance “recognized as a mineal by the scientific community”).

⁴⁰ 30 U.S.C. § 611.

⁴¹ The Materials Act authorizes the Secretaries of Interior and Agriculture to “dispose of mineral materials . . . on public lands of the United States . . . if the disposal of such mineral . . . materials (1) is not otherwise expressly authorized by law . . . (2) is not expressly prohibited by laws of the United States, and (3) would not be detriment to the public interest.” *See* 30 U.S.C. § 601.

⁴² *U.S. v. Harold Ladd Pierce*, 75 Interior Dec. 270 (DOI ALJ 1968). *See also*, *McGlinchy v. State*, 354 P.3d 1025 (Alaska 2015) (discussing DOI’s definition).

⁴³ *Id.*

“stone” for the purposes of the CVA. To remove any uncertainty, BLM could issue a guidance document or similar statement, identifying dunite as a stone covered by the CVA.

A case-by-case assessment would be needed to determine whether a particular basalt or dunite rock deposit is of a common variety. The CVA provides that “common varieties . . . of stone” do not include “deposits which are valuable because” they have “some property giving [them] distinct and special value.”⁴⁴ That is, a deposit is not common if it has some unique characteristic that enables it to be sold at a higher market price than other deposits of the same type, or that makes it cheaper and thus more profitable to extract.⁴⁵ BLM regulations require an assessment of:

- the nature of the deposit in question as compared to other deposits of the same stone;
- whether the deposit in question has some “unique physical property” that gives it “a distinct and special value” as compared to other deposits of the same stone;
- if the special value is for a use to which common varieties of the stone are also put, whether the deposit in question has “some distinct and special value for such use;” and
- whether the distinct and special value of the deposit in question is reflected in a “higher price . . . in the market place.”⁴⁶

Some basalt, dunite, or other rock deposits may have high silicate contents, which could make them more valuable for use in enhanced weathering or other applications. Where that is the case, the rock deposit may be treated as an uncommon variety of stone under the CVA. The mining of such uncommon deposits would be governed by the Mining Act, while the Materials Act would apply to the mining of common deposits (subject to the limitation discussed below).

⁴⁴ 30 U.S.C. § 611.

⁴⁵ U.S. v. Pope, 27 IBLA 133, 134 (IBLA 1976) (finding that, “[t]o support a finding of distinct and special value, the evidence must show that the unique property would command a market price higher than that for common materials used for the same purpose or that the unique property would reduce overhead production costs and thus provide for greater profits”). *See also* U.S. v. Bolinder, 83 Interior Dec. 609 (IBLA 1976) (holding that, “[i]n order for a variety of [stone] to be classified as “uncommon,” . . . it must meet two criteria: (1) the deposit must have a unique property, and (3) the unique property must give the deposit a distinct and special value”).

⁴⁶ 43 C.F.R. § 3830.12(b).

Importantly, as explained above, the Materials Act only applies to common varieties of stone and other materials listed in the CVA.⁴⁷ In the past, when applying the CVA, BLM has drawn a distinction between the listed materials and their constituent elements. According to BLM, “in determining whether a particular material falls within the purview of the [CVA], it is necessary to determine whether the material as a totality has value or whether only a constituent element of the material has value.”⁴⁸ To make that determination, BLM looks at how the material is used. BLM takes the view that, where “the whole rock is simply ground and . . . applied,” it is “used as a stone” and thus falls within the terms of the CVA.⁴⁹ In contrast, where a mineral within the rock is “extracted or separated from the matrix in which it occurs” and used by itself, it “cannot properly be considered to be a stone” and thus falls outside the CVA.⁵⁰ Under this approach, common varieties of basalt and dunite would fall under the CVA if they were ground and used as is, without extraction of the olivine or other minerals they contain. However, if the minerals were extracted and used separately, they would not be covered by the CVA.

It is unclear which approach would be taken in enhanced weathering projects. Some enhanced weathering studies have proposed using ground basalt or dunite rock as is, while others have suggested extracting olivine and using it separately.⁵¹ The latter approach could increase the total cost of enhanced weathering projects as additional expense would be incurred in extracting and processing the olivine. However, because olivine has a higher silicate content than basalt and

⁴⁷ 30 U.S.C. § 611. *See also* U.S. v. Pierce, 75 interior Dec. 270, 279 (DOI ALJ 1968) (noting that the CVA “does not apply to common varieties of all minerals but only to common varieties of those enumerated, namely sand, stone, gravel, pumice, pumicite, or cinders”).

⁴⁸ Pierce, 75 Interior Dec. at 279. *See also* U.S. v. Beal, 23 IBLA 378 (IBLA 1976) (applying the test articulated in Pierce).

⁴⁹ Pierce, 75 Interior Dec. at 280.

⁵⁰ *Id.* at 281. It should be noted that, while BLM considers how materials will be used to determine whether they qualify for sale under the Materials Act, BLM does not ultimately control the end use of the materials. *See generally*, BUREAU OF LAND MGMT., INSTRUCTION MEMORANDUM 2017-101: MINERAL MATERIALS SALES FOR USE IN FEDERAL-AID HIGHWAY PROJECTS (2017), <https://perma.cc/8JX3-X9H7> (providing that “[w]hen BLM sells mineral materials under the Materials Act, the mineral materials become the property of the purchaser after the materials have been excavated, paid for, and removed from Federal lands . . . Subsequent use or re-sale of the mineral materials is at the discretion of the purchasers”).

⁵¹ *See e.g.*, Royal Society, *supra* note 5, at 49; Strefler et al., *supra* note 8, at 2.

dunite, its use could increase the total amount of carbon dioxide stored through enhanced weathering (i.e., relative to the volume of materials used).

Where basalt or dunite rock is used in enhanced weathering as is, the Materials Act would apply to its extraction. In contrast, the Mining Act would apply where olivine is extracted from the rock and used separately.

(A) Requirements imposed by the Materials Act

The Materials Act authorizes the sale of “mineral materials,” including “common varieties of . . . stone,” such as basalt and dunite, on public and federal forest land.⁵² The Secretary of the Interior (through BLM) oversees sales of common varieties of stone on public land, while sales on federal forest land are overseen by the Secretary of the Agriculture (through the Forest Service).⁵³ Both BLM and the Forest Service follow broadly the same process when making sales.

Under the Materials Act, BLM and the Forest Service can only sell common varieties of basalt, dunite, and other stone if the sale “would not be detrimental to the public interest.”⁵⁴ BLM considers sales to be detrimental to the public interest, and thus prohibited, where the “aggregate damage to public land and resources” from mining the stone exceeds the “public benefits that BLM expects from the” sale.⁵⁵ When assessing the “public benefits” of mining silicate materials for use in enhanced weathering projects, BLM could take into account the downstream benefits of such projects, including their potential to mitigate climate change by removing carbon dioxide from the atmosphere.⁵⁶ Those benefits could be quantified using tools such as the social cost of carbon, which reflects cost of damage caused by each ton of carbon dioxide released into the atmosphere, and conversely the value of the benefits obtained by removing carbon dioxide from the atmosphere.⁵⁷

⁵² 30 U.S.C. § 601.

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ 43 C.F.R. § 3601.11.

⁵⁶ This is similar to the approach taken by BLM in decisions regarding oil and gas leasing on public lands. In some past decisions, BLM has considered the downstream greenhouse gas emissions associated with the use of oil and gas extracted on federal lands. *See generally*, Michael Burger and Jessica Wentz, *Downstream and Upstream Greenhouse Gas Emissions: The Proper Scope of NEPA Review*, 41 HARV. ENVTL. L. REV. 109, 134 (2017).

⁵⁷ ENVTL. PROT. AGENCY, FACT SHEET: SOCIAL COST OF CARBON (2016), <https://perma.cc/8VV8-T6QU>.

The Forest Service also considers the impact of mining on land and resources in determining whether to make sales. Under Forest Service regulations, no sale can occur unless reasonable measures have been put in place to protect, or mitigate any adverse effects of mineral development on, other resources.⁵⁸

BLM and the Forest Service cannot sell stone in areas that have been identified as inappropriate for mining in an applicable Resource Management Plan (“RMP”).⁵⁹ BLM and the Forest Service use RMPs to guide land management decisions. Each RMP identifies resource goals for a designated area of federal land and specifies management practices and land uses that are consistent with the achievement of those goals.⁶⁰ Where an RMP designates land as inappropriate for mining, it would need to be amended before BLM or the Forest Service could sell stone thereon for use in enhanced weathering or other activities.

The process for amending RMPs is complex and lengthy, often taking several months or years to complete. As an illustration, before amending any of its RMPs, BLM must publish notice of the proposed amendment(s) in the Federal Register and appropriate local media and invite comments from the public.⁶¹ BLM must also consult with the Governor of the state in which the relevant land is located to ensure the amended RMP will be consistent with any applicable state and local plans, policies, and programs.⁶² Additionally, BLM must comply with the National Environmental Policy Agency (“NEPA”) ⁶³ which requires federal agencies to prepare an environmental impact statement (“EIS”) for any action they undertake, authorize, or fund that “significantly affect[s] the quality of the human environment.”⁶⁴ The EIS must include an assessment of the likely effect of the action and alternatives on natural, economic, social, and cultural resources.⁶⁵

⁵⁸ 36 C.F.R. § 228.43(a) & (c).

⁵⁹ 43 C.F.R. § 3601.12(c) (“BLM will not dispose of mineral materials from areas identified in land use plans as not appropriate for mineral materials disposal”); 36 C.F.R. § 228.43(a)(4) (Forest Service “[d]ecisions to authorize the disposal of mineral materials must conform to approve land and resource management plans”).

⁶⁰ See generally, Bureau of Land Mgmt., *Planning 101*, PLANNING AND NEPA, <https://perma.cc/4P8V-BT5K> (last visited Mar. 10, 2021).

⁶¹ 43 C.F.R. § 1610.2 & 1601.5-5.

⁶² *Id.* §§ 1610.3-2 & 1601.5-5.

⁶³ 42 U.S.C. § 4321 et seq.

⁶⁴ *Id.* § 4332(2)(C).

⁶⁵ *Id.*

In developing the EIS, BLM must invite comments from the public and consult with other government agencies with relevant authority or expertise. Consultation may also be required under other statutes, such as the Endangered Species Act (“ESA”), which directs federal agencies to consult with FWS before undertaking, authorizing, or funding any action that could “jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of [its] habitat.”⁶⁶ A similar process must be followed by the Forest Service when amending its RMPs.

In areas where mining is permitted under the applicable RMP BLM and the Forest Service can sell common varieties of basalt, dunite, and other stone on public and federal forest land, respectively.⁶⁷ Sales generally occur through a competitive auction process in which parties submit sealed written or oral bids.⁶⁸ The highest bidder is awarded a contract for sale if his/her bid is equal to or above the fair market value of the stone, as determined through appraisal, and he/she is able to meet any obligations imposed by BLM or the Forest Service.⁶⁹ BLM and the Forest Service can also enter into non-competitive contracts for sale (i.e., without holding an auction) in some circumstances, including where it is “impracticable to obtain competition” or there is insufficient time to invite competitive bids because of “an emergency situation affecting public health, safety, or property.”⁷⁰ Before entering into any contract, BLM and the Forest Service must conduct an

⁶⁶ 16 U.S.C. § 1536(a)(1). An “endangered species” is one that “is in danger of extinction throughout all or a significant portion of its range.” A “threatened species” is one that “is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” *See id.* § 1532(6) & (20).

⁶⁷ BLM and the Forest Service cannot sell materials on land forming part of a national park, national monument, or Indian reservation under the Materials Act. *See* 30 U.S.C. § 601.

⁶⁸ 43 C.F.R. §§ 3602.41 & 3602.43 (rules for public land); 36 C.F.R. §§ 228.57 & 228.58 (rules for federal forest land). *See also* 30 U.S.C. § 601 (requiring mineral materials to be sold “to the highest responsible qualified bidder after formal advertising and such other public notice as . . . [may be] deem[ed] appropriate”).

⁶⁹ 43 C.F.R. § 3602.45 (rules for public land); 36 C.F.R. § 228.58(d) (rules for federal forest land). *See also* 43 U.S.C. § 3602.13 (providing that “BLM will not sell mineral materials at less than fair market value. BLM determines fair market value by appraisal”); 36 C.F.R. § 228.48 (requiring “[a]ll mineral materials for sale [on federal forest land to] be appraised to determine fair market value”).

⁷⁰ 43 C.F.R. § 3602.31 (rules for public land); 36 C.F.R. § 228.59 (rules for federal forest land).

Volume limits may apply to non-competitive sales in some circumstances. For example, where the Forest Service decides to sell materials on a non-competitive basis because it is “impracticable to

environmental review under NEPA⁷¹ and comply with other applicable requirements, for example under the ESA.⁷²

Although the Materials Act generally requires common varieties of stone to be sold at “fair market value,” BLM and the Forest Service can, in limited circumstances, permit their extraction free of charge. Under the Materials Act, BLM and the Forest Service can issue free use permits to government and non-profit entities, authorizing them “to take and remove, without charge, materials . . . for use other than for commercial or industrial purposes or resale.”⁷³ The Materials Act does not define what constitutes a “commercial or industrial” use of materials and no guidance on that issue is provided in regulations issued by BLM or the Forest Service. The U.S. Court of Appeals for the D.C. Circuit has interpreted “commercial or industrial” use to mean any use that generates a profit.⁷⁴ Thus, according to the court, free use permits may be issued to government or non-profit entities that intend to use the materials to construct facilities of a “public, non-commercial, nature” (e.g., roads) or for other activities unrelated to any “profit-making enterprise.”⁷⁵ Again, before issuing free use permits, BLM and the Forest Service must complete any required environmental and other reviews (e.g., under NEPA and the ESA).⁷⁶

Congress could amend the Materials Act to allow free use permits to be issued for any extraction of materials in connection with an enhanced weathering project (i.e., regardless of whether the extractor is a government or non-profit entity or the enhanced weathering project is

obtain competition,” no more than 100,000 cubic yards in volume or the weight equivalent can be sold in any one sale and no more than 200,000 cubic yards or the weight equivalent can be sold in any one state in any twelve-month period. *See id.* § 228.59(a).

⁷¹ 42 U.S.C. § 4321 et seq. *See also* BUREAU OF LAND MGMT., NATIONAL ENVIRONMENTAL POLICY ACT HANDBOOK H-1790-1, 16 (2008), <https://perma.cc/GY2R-RJ3A>; FOREST SERV., NATIONAL ENVIRONMENTAL POLICY ACT HANDBOOK FSH 1909, Ch. 20 (2011), <https://perma.cc/ZV2K-94WB>.

⁷² 16 U.S.C. § 1531 et seq. Under the ESA, federal agencies must consult with FWS before undertaking or authorizing any activity that may affect terrestrial species, which have been listed as endangered or threatened. BLM and the Forest Service may be required to undertake additional consultations and reviews under other federal statutes, including but not limited to the National Historic Preservation Act and American Indian Religious Freedom Act. *See* 16 U.S.C. § 470 et seq; 42 U.S.C. § 1996 et seq.

⁷³ 30 U.S.C. § 601.

⁷⁴ *Wilderness Society v. Morton*, 479 F.2d 842, 884 (D.C. Cir. 1973).

⁷⁵ *Id.*

⁷⁶ *See supra* notes 71 & 72.

commercial in nature). That would reduce the cost of obtaining materials for use in enhanced weathering projects and thus effectively subsidize project development.

Unless and until the Materials Act is amended, BLM and the Forest Service could only issue free use permits to government and non-profit entities extracting materials for use in enhanced weathering in select cases. Applying the test established by the D.C. Circuit, where a government or non-profit entity proposes to use materials in enhanced weathering projects that are not “profit-making,” the entity may qualify for a free-use permit. Enhanced weathering projects that do not generate any revenue, for example through the sale of carbon credits or similar instruments, would likely qualify as non-profit-making. This could include projects that are not used to generate carbon credits, as well as projects that do generate such credits, but do not sell them (e.g., where the credits are retained by a government or non-profit entity to establish compliance with a net-zero emissions commitment). Some revenue-generating projects may similarly qualify as non-profit-making, for example where the revenues are insufficient to cover the costs of the project (i.e., such that it does not generate a profit). This is less certain, however. To increase certainty for project developers, BLM and the Forest Service could issue a guidance document or similar statement, outlining the circumstances in which it will issue free use permits in connection with enhanced weathering projects.

BLM and the Forest Service could also waive current limits on the amount of materials that can be taken by non-profit entities under free use permits. Currently, under BLM and Forest Service regulations, free use permits issued to non-profit entities have a maximum term of one year and can only be extended once for no more than one additional year.⁷⁷ The permit holder cannot take more than 5,000 cubic yards of stone in any year.⁷⁸ The limits on permit duration and renewal and stone volumes are not mandated by statute. As such, BLM and the Forest Service could amend their regulations to increase the duration of free use permits issued in connection with enhanced weathering projects, as well as the amount of stone that can be taken under such permits.

⁷⁷ 43 C.F.R. § 3604.21 (rules for public land); 36 C.F.R. §§ 228.53 & 228.62(b) (rules for federal forest land).

⁷⁸ 43 C.F.R. § 3604.12(b) (rules for public land); 36 C.F.R. § 228.62(d)(2) (rules for federal forest land).

(B) Requirements Imposed by the Mining Act

Not all minerals found on public and federal forest land are subject to sale under the Materials Act. For example, as noted above, the Materials Act does not apply to uncommon varieties of basalt, dunite, and other stone or to olivine and similar minerals that are extracted from the stone. The mining of such materials is, instead, governed by the Mining Act.⁷⁹ Under the Mining Act, U.S. citizens and others who have applied for citizenship (“eligible individuals”) can acquire rights to mineral deposits on federal lands in nineteen states⁸⁰ through a process known as “location,” which is based on historic claim-staking practices.⁸¹

Under the location system, eligible individuals can enter public and federal forest land to search for minerals and, while actively searching, are deemed to hold “pedis possessio” rights to the land entitling them to exclude others who do not have better title.⁸² On discovery of a valuable mineral deposit, the eligible individual can claim the land and minerals by marking the boundaries of the claimed area, posting a location notice on the area, and recording the notice with BLM and relevant state and local government agencies.⁸³ On location, the individual acquires an “unpatented” claim to the land and the mineral deposit, which gives him/her exclusive rights to possession and the ability to exclude others, including the federal government itself.⁸⁴ Historically, individuals holding unpatented claims could apply to BLM to have them patented, at which time the individual

⁷⁹ 30 U.S.C. § 21 et seq.

⁸⁰ Mining claims can be located on federal land in Alaska, Arizona, Arkansas, California, Colorado, Florida, Idaho, Louisiana, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming. See 43 CFR § 3811.2-1(a).

⁸¹ 30 U.S.C. § 22 (declaring all “all valuable mineral deposits in lands belonging to the United States” to be “free and open to exploration and purchase, and the lands in which they are found to occupation and purchase, by citizens of the United States and those who have declared their intention to become such”). Business entities organized under state law are considered citizens and may locate mining claims. See 43 C.F.R. § 3830.3 (providing that mining claims may be located by (a) U.S. citizens, (b) legal immigrants who have filed an application for citizenship, (c) business entities organized under the laws of a state, and (d) duly constituted and appointed agents acting on behalf of those listed above).

⁸² See generally, Karol L. Kahalley, *Prediscovery Rights Under the Doctrine of Pedis Possessio*, in *AMERICAN LAW OF MINING* (2nd Ed) (Cheryl Outerbridge et al. eds., 2020).

⁸³ 43 C.F.R. §§ 3832.1-3832.12. See also BUREAU OF LAND MGMT., ADMINISTRATION OF MINING CLAIMS, MILL SITES, AND TUNNEL SITES HANDBOOK H-3830-1 (2015), <https://perma.cc/Z63B-XTQ2>.

⁸⁴ See generally, Robert D. Comer, *Ownership Interests in Valid Unpatented Mining Claims*, in *AMERICAN LAW OF MINING* (2nd Ed) (Cheryl Outerbridge et al. eds., 2020).

would acquire full title to the land.⁸⁵ However, since 1994, Congress has used annual appropriations acts to prohibit BLM from accepting new patent applications.⁸⁶ Thus, federally-owned land that has been claimed for mineral development can no longer be transferred to private ownership, but the claimant still has full rights to develop minerals in the land.

As noted above, mining claims are located by marking the boundaries of the claimed site, posting a notice on the site, and recording that notice with various government agencies. Federal regulations impose few requirements with respect to site marking, merely providing that the corners of the site must be staked or monumented so as to clearly establish the exterior lines of the claimed site.⁸⁷ A notice of location, including the name(s) and address(es) of the locator(s), the date of location, and a description of the claimed site, must be posted “in a conspicuous place” on the site.⁸⁸ The notice must also be filed with the relevant BLM state office and relevant state and local government agencies.⁸⁹ BLM requires all steps to be completed within ninety days of discovery of the valuable mineral deposit.⁹⁰ However, some states have adopted their own regulations, which require location notices to be filed within thirty or sixty days.⁹¹

At the time of filing the location notice, the locator must pay a location fee (\$40 at the time of writing) and maintenance fee (\$165 at the time of writing) to BLM.⁹² Additional maintenance fees must be paid annually thereafter.⁹³ BLM can waive the requirement for annual maintenance payments in certain circumstances, including where the locator has ten or fewer mining claims

⁸⁵ The federal government would convey title to the land to the individual, effectively removing it from government ownership and making it private land. *See generally*, BLM, MINING CLAIMS AND SITES ON FEDERAL LAND 27 – 28 (2011), <https://www.blm.gov/sites/blm.gov/files/MiningClaims.pdf>.

⁸⁶ *See e.g.*, Consolidated Appropriations Act 2019, Pub. L. No. 116-6, § 404 (2019).

⁸⁷ 43 C.F.R. § 3832.11(c)(2).

⁸⁸ *Id.* § 3832.11(c).

⁸⁹ *Id.*

⁹⁰ *Id.* § 3832.11(a).

⁹¹ BUREAU OF LAND MGMT., MINING CLAIMS AND SITES ON FEDERAL LANDS 15 (2019), <https://perma.cc/9YFV-QB3P>.

⁹² 30 U.S.C. § 28g; 43 C.F.R. §§ 3830.11(c) & 3830.21.

⁹³ 30 U.S.C. § 28f; 43 C.F.R. § 3834.11.

nationwide.⁹⁴ However, where a waiver is granted, the locator must perform at least \$100 worth of work on the site each year, and file proof of the work with BLM.⁹⁵

Where the mining claim is located on public lands, before performing any work that will result in more than negligible disturbance to land or resources, the locator must generally have a plan of operations approved by BLM.⁹⁶ On receiving the plan, BLM must make it available for public review and comment.⁹⁷ BLM must also conduct an environmental review under NEPA and, where activities could harm endangered or threatened species, consult with FWS under the ESA.⁹⁸ BLM may approve the plan if it determines that the work proposed therein will not result in “unnecessary or undue degradation of public lands.”⁹⁹ To meet that requirement, the person conducting the work must comply with various performance standards. Specifically, the person must:

- comply with the RMP applicable to the land on which the work will occur;
- comply with all applicable environmental and other laws;
- take appropriate steps to prevent adverse impacts to threatened or endangered species or their habitat;
- avoid activities that could damage or destroy important cultural, historical, or paleontological resources;
- maintain all structures, equipment, and other facilities in a safe and orderly manner; and

⁹⁴ 30 U.S.C. § 28f(d); 43 C.F.R. § 3835.1.

⁹⁵ 43 C.F.R. §§ 3835.12 & 3835.31-33.

⁹⁶ *Id.* § 3809.11(a) (requiring operators to “submit a plan of operations and obtain BLM’s approval before beginning operations greater than casual use”). *See also id.* §§ 3809.5 (defining “casual use” to mean “activities ordinarily resulting in no or negligible disturbance of the public lands or resources”) & 3809.412 (providing that work may not begin “until BLM approves [the] plan of operations”). A plan of operations is not required to perform exploration work, if that work would disturb no more than 5 acres of land. However, before performing such work, the claimant must submit a notice of operations to BLM. The notice of operations does not have to be formally approved by BLM. The claimant can begin work 15 calendar days after submitting the notice, unless BLM notifies him/her/it that it must delay, for example because BLM needs additional time to complete its review or the notice of operations requires amendments. *See id.* §§ 3809.21, 3809.301, 3809.311, 3809.312, & 3809.313. The miner may also require various permits from EPA and other agencies. *See infra* Part 2.2.

⁹⁷ *Id.* § 3809.411.

⁹⁸ *Id.*

⁹⁹ *Id.*

- reclaim the area where the work occurs, including by removing all structures and equipment, closing any underground works, reapplying soils, revegetating the land, and restoring wildlife and fisheries habitats,¹⁰⁰

The miner must also provide BLM with a financial guarantee that is at least sufficient to cover the cost of reclaiming the area disturbed by the work.¹⁰¹

The above requirement for BLM approval of a plan of operations does not apply where mining work is conducted on federal forest land. While BLM is responsible for managing the mineral estate underlying federal forest land, surface resources on that land are managed by the Forest Service. It is, therefore, the Forest Service that oversees surface disturbing activities and reclamation associated with mining on federal forest land. Under Forest Service regulations, persons performing mining work must generally submit a plan of operations to the Forest Service for approval if the work “will likely cause significant disturbance of surface resources.”¹⁰² Before approving the plan, the Forest Service must complete any required environmental reviews or other consultations (e.g., under NEPA and the ESA).¹⁰³ Mining activities conducted under an approved plan must meet the same “performance standards” as those imposed on activities on public lands.¹⁰⁴ There is also an additional requirement that, as far as practicable, work must be “harmonize[d] . . . with scenic values through such measures as . . . vegetative screening, and construction of structures and improvements which blend with the landscape.”¹⁰⁵

2.1.2 Tribal Land

The federal government also plays a central role in overseeing mineral development on tribal land, which is held by American Indian tribes in trust for their members, and on allotted land, which is held by the U.S. in trust for individual American Indians. Together, tribal and allotted land cover approximately 56 million acres, primarily in the western U.S.¹⁰⁶ Notably, there are several areas of

¹⁰⁰ *Id.* § 3809.420. *See also id.* § 3809.5 (defining “reclamation”).

¹⁰¹ *Id.* §§ 3809.412 & 3809.551

¹⁰² 36 C.F.R. § 228.4(a)(3). The miner may also require various permits from EPA and other agencies. *See infra* Part 2.2.

¹⁰³ *Id.* § 228.4(f).

¹⁰⁴ *Id.* § 228.8.

¹⁰⁵ *Id.* § 228.8(d).

¹⁰⁶ Dep’t of Interior, Bureau of Indian Affairs, *Frequently Asked Questions*, <https://perma.cc/TV5C-X832> (last visited Mar. 2, 2021).

tribal land in north-western Washington state, in close proximity to the Twin Sisters Mountain, which contains one of the world's largest known olivine deposits.¹⁰⁷ That and other tribal and allotted land may similarly contain olivine or other silicate-rich minerals or rocks suitable for use in enhanced weathering. This part discusses how third parties can obtain rights to develop minerals on tribal and allotted land.

Many American Indian tribes were granted land by the federal government under treaties. The Supreme Court has held that, where a treaty is ambiguous as to whether the grant included resources on the land, it should be construed in favor of the relevant Indian tribe.¹⁰⁸ Thus, American Indian tribes are considered to own the minerals underlying land granted by treaty, unless the treaty specifically excluded mineral rights from the grant.¹⁰⁹ However, like tribal lands, the minerals underlying them are held by the American Indian tribe in trust for its members and can only be developed with the approval of the federal government.

The Indian Mineral Leasing Act of 1938¹¹⁰ authorizes most American Indian tribes¹¹¹ to lease tribal land “for mineral purposes.”¹¹² Additionally, under the Indian Mineral Development Act of 1982,¹¹³ American Indian tribes are authorized to enter into other agreements, including joint venture and production sharing agreements, for the development of mineral resources on tribal land (“mineral agreements”).¹¹⁴ Individual American Indians who have been allotted land can, with the consent of the relevant tribe and the mineral developer, have it included in a mineral agreement¹¹⁵ or enter into separate mineral leases for their allotted land under the Allotted Lands Leasing Act of

¹⁰⁷ See *supra* Part 1.

¹⁰⁸ *U.S. v. Shoshone Tribe of Indians*, 304 U.S. 111, 117 (1938) (holding that “doubts, if there were any, as to ownership of lands, minerals or timber would be resolved in favor of the tribe”).

¹⁰⁹ *Id.*

¹¹⁰ 25 U.S.C. § 396a et seq.

¹¹¹ The Indian Mineral Leasing does not authorize the issuance of mineral leases on land within the Crow Reservation in Montana or the Osage Reservation in Oklahoma, the ceded lands of the Shoshone Reservation in Wyoming, or the coal and asphalt lands of the Choctaw and Chickasaw Tribes in Oklahoma. *Id.* § 396f.

¹¹² *Id.* § 396a.

¹¹³ *Id.* § 2101 et seq.

¹¹⁴ *Id.* § 2102(a).

¹¹⁵ *Id.* § 2102(b).

1909.¹¹⁶ All mineral leases and agreements must be approved by the Secretary of the Interior¹¹⁷ who, in practice, acts through DOI's Bureau of Indian Affairs ("BIA").¹¹⁸ When approving mineral leases and agreements, BIA must conduct any required environmental and other reviews, including under NEPA.¹¹⁹

BIA regulations include detailed provisions governing the execution of mineral leases (i.e., under the Indian Mineral Leasing Act) and mineral agreements (i.e., under the Indian Mineral Development Act).¹²⁰ Under the regulations, American Indian tribes have significantly more flexibility when entering into mineral agreements, as compared with mineral leases. Whereas mineral agreements can be negotiated between the relevant tribe and developer,¹²¹ mineral leases must generally be issued via competitive auction.¹²² Auctions may be conducted under sealed or oral bid and the lease awarded to the bidder offering the highest bonus.¹²³ In addition to paying the offered bonus, the lessee must also pay annual rents based on the size of the leased area and royalties on the extracted materials, in amounts determined by the Secretary of the Interior.¹²⁴

¹¹⁶ *Id.* § 396.

¹¹⁷ *Id.* §§ 396, 396a, & 2102.

¹¹⁸ See generally, Dep't of Interior, *Bureau of Indian Affairs*, <https://perma.cc/285S-M5GI> (last visited Mar. 3, 2021).

¹¹⁹ 25 C.F.R. §§ 211.7 (requiring BIA to comply with NEPA when approving leases on tribal land) & 212.7 (requiring BIA to comply with NEPA when approving leases on allotted land). See also BUREAU OF INDIAN AFFAIRS, NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) GUIDEBOOK (2012), <https://perma.cc/K2BK-PVZP>.

¹²⁰ Only leases can be executed under the Indian Mineral Leasing Act. In contrast, mineral agreements executed under the Indian Mineral Development Act can be structured in a variety of ways, including as joint venture agreements, production sharing agreements, and service agreements.

¹²¹ 25 C.F.R. § 225.21.

¹²² *Id.* §§ 211.20 (outlining the procedures for leasing tribal land) & 212.20 (outlining the procedures for leasing allotted land). The Secretary of the Interior may authorize tribes to negotiate mineral leases on tribal land. See *id.* § 211.20(a). The Secretary may also negotiate leases on allotted land, on behalf of the land owner, if he/she "decides that negotiation . . . is in the best interests" of the owner. See *id.* § 212.20(b).

¹²³ *Id.* §§ 211.20(b)(1)-(2) (rules for tribal land) & 212.20(b)(1)-(2) (rules for allotted land).

¹²⁴ In determining the amount of rents and royalties payable under mineral leases on tribal land, the Secretary of the Interior must consult with the owning tribe. See *id.* § 211.20(b)(2). The Secretary of the Interior is not required to consult with the owner of allotted land when determining rents and royalties for mineral leases thereon. See *id.* § 212.20(b)(2). Whereas the Secretary of the Interior

Neither the Indian Mineral Leasing Act nor the Allotted Lands Leasing Act specify minimum or maximum rent and royalty amounts for mineral leases. However, BIA regulations provide that rents must be no less than \$2.00 per acre,¹²⁵ and royalties no less than ten percent of the value of production.¹²⁶ The regulations could be amended to provide for lower rents and royalties on leases for the extraction of silicate materials to be used in enhanced weathering. However, while this may facilitate enhanced weathering by reducing the cost of acquiring materials, it could adversely impact tribal communities, which would receive lower payments under the mineral leases. Given the relatively high poverty levels in tribal communities, compared to the general population,¹²⁷ it is arguably unjust to require them to subsidize the cost of enhanced weathering to mitigate climate change, particularly when they bear little responsibility for creating the problem.

New approaches would likely need to be developed to calculate the royalties payable on silicate materials extracted for use in enhanced weathering. Current BIA regulations provide that royalties must be calculated based on “the value of [materials] produced and sold” from the leased area.¹²⁸ However, this approach may be unworkable where materials extracted for use in enhanced weathering are not be sold on the market (e.g., because they are extracted by enhanced weathering project developers for their own use or provided to those developers free of charge). BIA should consider amending its regulations to base the royalty calculation on the average market price for materials of the same type or some other proxy value.

Other regulatory changes could also be made to facilitate the extraction of silicate materials on tribal and allotted land. Most notably, BIA could ease current restrictions on the size and duration of mineral leases, so as to facilitate greater production of materials for use in enhanced weathering.¹²⁹ Existing BIA regulations require mineral leases on tribal and allotted land to be contained within

determines the amount of rental and royalty payments required under mineral leases, payments under mineral agreements are negotiated between the parties.

¹²⁵ *Id.* §§ 211.42(a) (rules for tribal land) & 212.42 (rules for allotted land).

¹²⁶ *Id.* §§ 211.43 (rules for tribal land) & 212.43 (rules for allotted land).

¹²⁷ See U.S. Census Bureau, *Poverty Status in the Past 12 Months*, <https://perma.cc/JV6V-3PNQ> (last visited Mar. 3, 2021).

¹²⁸ *Id.* §§ 211.43 (rules for tribal land) & 212.43 (rules for allotted land).

¹²⁹ It should be noted that there are currently no size or term restrictions on mineral agreements executed pursuant to the Indian Mineral Development Act. As such, the actions proposed below would only need to be taken with respect to mineral leases on tribal and allotted lands issued under the Indian Mineral Leasing Act and the Allotted Lands Leasing Act, respectively.

one governmental survey section and cover no more than 640 acres.¹³⁰ This size restriction could limit the amount of silicate minerals and rocks that can be developed on tribal lands. Since the restriction is not legislatively mandated, BIA could amend its regulations to establish a higher size limit for leases for the extraction of silicate materials for enhanced weathering, or eliminate the limit altogether.

BIA could also offer longer-term mineral leases for silicate materials. Under the Indian Mineral Leasing Act, mineral leases on tribal lands may only be issued for a primary term of ten years, but may continue thereafter “as long . . . as minerals are produced in paying quantities.”¹³¹ While there is no similar provision in the Allotted Land Leasing Act, BIA regulations impose an identical limit on the primary terms of mineral leases on allotted lands.¹³² Under the regulations, mineral leases on both tribal and allotted land may only continue beyond the primary ten year term if, during that period, mining operations commenced and there was some “actual removal of mineral materials for sale” from the leased site.¹³³ The requirement that materials be removed “for sale” could prohibit lease extensions in situations where silicate materials extracted for use in enhanced weathering are not sold (e.g., because the materials are provided to the project developers free of charge). BIA should consider waiving the sale requirement in such cases.

Additional difficulties may also arise from the requirement that materials be “produced in paying quantities” in order to maintain mining leases on tribal and allotted lands. BIA has taken the view that, to meet the paying quantities requirement, mining activities must generate sufficient income to offset all costs associated with producing the materials and still result in a reasonable profit.¹³⁴ This may be difficult to establish where materials used in enhanced weathering projects are not sold in the market.¹³⁵ Under the current statutory framework, BIA could eliminate the paying quantities requirement for mineral leases on allotted land, but not tribal land. Removing the

¹³⁰ 25 C.F.R. §§ 211.25(a) (tribal land) & 212.25 (allotted land).

¹³¹ 25 U.S.C. § 396a.

¹³² 25 C.F.R. §§ 211.27 (tribal land) & 212.27 (allotted land).

¹³³ *Id.*

¹³⁴ See e.g., BUREAU OF INDIAN AFFAIRS, FLUID MINERAL ESTATE: PROCEDURAL HANDBOOK (2012), <https://perma.cc/G62K-EGRH>

¹³⁵ However, even in such cases, it may be possible to structure a commercial arrangement between the miner and the enhanced weathering project developer so as to establish that the mine is producing materials in paying quantities.

requirement for mineral leases on tribal land would require Congressional amendment of the Indian Mineral Leasing Act.

It should be noted that, even if a mineral lease is granted or a mining agreement is executed, mining activities can only occur if specifically approved by DOI. Before conducting any surface disturbing activities to explore for minerals, the miner must submit an exploration plan to DOI's BLM for approval.¹³⁶ The miner must also have a mining plan approved by BLM before conducting any surface disturbing activities in connection with the extraction or processing of minerals.¹³⁷ All work must be conducted in accordance with the approved plan and steps must be taken to avoid or minimize air and water pollution, soil erosion, damage to vegetation, harm to fish and wildlife, and other adverse impacts of mining.¹³⁸ Miners are required to file, with the Secretary of the Interior, a bond sufficient to cover the costs of reclaiming the site.¹³⁹ The bond is forfeited if the miner fails to fully reclaim the site following the completion of mining activities.¹⁴⁰

2.1.3 State Land

Silicate materials suitable for use in enhanced weathering may also be found on the approximately 195 million acres of land in the U.S. that is owned by state governments. Many states, particularly in the western U.S., acquired land from the federal government through grants made for the specific purpose of supporting public schools and other institutions.¹⁴¹ State Constitutions or statutes often declare the land to be held in trust for the benefit of public institutions and require it

¹³⁶ 25 C.F.R. §§ 211.48 (requiring mineral lessees to obtain approval from BLM in accordance with the requirements of 45 C.F.R. Part 3590 before conducting operations on tribal land), 212.24 (providing that section 211.48 is applicable to lessees operating on allotted land), & 225.32 (requiring persons operating under mineral agreements to obtain approval from BLM under 45 C.F.R. Part 3590 before conducting operations on tribal or allotted land). *See also* 43 C.F.R. § 3592.1 (requiring exploration plans to be approved by BLM) & 25 C.F.R. § 216.6 (outlining additional requirements for exploration plans).

¹³⁷ 43 C.F.R. § 3592.1 (requiring mining plans to be approved by BLM) & 25 C.F.R. § 216.7 (outlining additional requirements for mining plans).

¹³⁸ 43 C.F.R. § 3591.1(a)-(b).

¹³⁹ 25 C.F.R. §§ 216.8 (requiring bonds to be submitted by mineral lessees) & 225.30 (requiring bonds to be submitted by persons operating under mineral agreements).

¹⁴⁰ *Id.* §§ 216.8 & 225.30. *See also* 43 C.F.R. § 3591.1(b) (requiring lessees to reclaim the surface of the leased area following the completion of mining activities).

¹⁴¹ *See generally*, Andy Laurenzi, Lincoln Institute of Land Policy, *State Trust Lands: Balancing Public Value and Fiduciary Responsibility*, LAND LINES (July 2004), <https://perma.cc/MW2K-NLPB>.

to be managed so as to generate revenue therefor.¹⁴² Consistent with the revenue generation goal, states typically allow the land to be leased to private parties for mineral development and other activities, subject to the payment of fees.¹⁴³

Some states prohibit the issuance of mineral leases in designated areas. In New York, for example, leasing is prohibited on approximately 2.6 million acres of state land in the Adirondack and Catskill State Parks (known as the “forest preserve”).¹⁴⁴ Article XIV of the New York State Constitution requires the land to be “forever kept as wild forest lands” and declares that it “shall not be leased, sold, or exchanged.”¹⁴⁵ The land management agencies in many states can also withdraw land from leasing. For example, legislation enacted in New Mexico authorizes the State Commissioner of Public Lands “to withhold any tract or tracts [of state-owned land] from leasing for . . . mineral purposes” if he/she determines that “the best interests of the state would be served by so doing.”¹⁴⁶ Pursuant to that authority, in 2019, the Commissioner of Public Lands ordered that approximately 73,000 acres of land in close proximity to the Chaco Culture National Historic Park be withheld from mineral leasing until at least 2024.¹⁴⁷

In areas where mineral leasing is permitted, leases are issued by the relevant state land management agency, either through competitive auctions¹⁴⁸ or on a first-come-first-served basis.¹⁴⁹ State law often requires that, before any lease is issued, the state land management agency must

¹⁴² See e.g., MINN. CONSTITUTION Art. XI, § 14; MINN. STAT. § 84.027, Subd. 19.

¹⁴³ See generally, Laurenzi, *supra* note 141.

¹⁴⁴ See generally, N.Y. Dep’t of Env’tl. Conservation, *New York’s Forest Preserve*, FORESTS, <https://perma.cc/FC3Z-PZVS> (last visited Feb. 10, 2021).

¹⁴⁵ N.Y. CONSTITUTION, Art. XIV, § 1.

¹⁴⁶ N.M. STAT. ANN. § 19-8-33.

¹⁴⁷ State of New Mexico Commissioner of Public Lands, Executive Order No. 2019-002: Moratorium on New Oil and Gas and Mineral Leasing in Greater Chaco Area (April 27, 2019), <https://perma.cc/7F5U-DA3V>.

¹⁴⁸ See e.g., FLA. STAT. ANN. § 253.45 (providing for the auction of minerals and certain other substances “in, on, or under any land the title to which is vested in the state”); HAW. REV. STAT. §§ 182-4 & 182-5 (authorizing the auction of minerals on state land).

¹⁴⁹ See e.g., ARIZ. REV. STAT. ANN. § 27-254 (authorizing the state Commissioner of Lands to issue mineral leases on application); GA. CODE ANN. § 50-16-43 (providing that the State Properties Commission “is authorized to enter into, without the necessity of prior public competitive bidding, a written contract” permitting any person to explore state owned lands for mineral resources and to “lease to any person the mineral resources located on state owned lands”).

determine that leasing is in the best interests of the state.¹⁵⁰ State land management agencies may also be required to conduct environmental and other reviews and consult with interested parties before issuing leases. Several states have laws similar to NEPA which require preparation of an EIS or similar document and public consultation thereon prior to issuance of a lease.¹⁵¹

State mineral leases are issued for a specified term, usually up to twenty years but sometimes longer,¹⁵² and can generally be renewed.¹⁵³ Many states impose restrictions on the size of leases, but there is often no limit on the number of leases (and thus the total number of acres) that can be held by a single lessee.¹⁵⁴ Where limits do apply, states could consider raising or eliminating the limits on leases for the extraction of silicate materials for use in enhanced weathering.¹⁵⁵

All states require lessees to pay fees, usually in the form of a fixed rent based on the size of the leased area,¹⁵⁶ and royalties on the extracted materials.¹⁵⁷ The amounts vary between states. For example, in Alaska, lessees are required to pay annual rents of between \$0.50 and \$2.50 per acre

¹⁵⁰ See e.g., ALASKA STAT. § 38.05.135 (providing that leases may be “offered only on a competitive bid basis when determined by the [state land] commissioner to be in the best interests of the state”); N.M. STAT. ANN. § 19-8-33 (authorizing the state land commissioner to offer or withhold areas from leasing “if, in his opinion, the best interests of the state would be served by so doing”).

¹⁵¹ For example, in New York, the State Environmental Review Quality Act requires preparation of an EIS for any action with potentially significant adverse environmental impacts. See N.Y. ENVTL. CONSERV. LAW § 8-0101 et seq. At the time of writing, fifteen other states, the District of Columbia, and Puerto Rico had similar “little NEPA” statutes. See NEPA.gov, *States and Local Jurisdictions with NEPA-like Environmental Planning Requirements*, <https://perma.cc/Z674-SSZJ> (last visited Jan. 21, 2021).

¹⁵² Compare e.g., ARIZ. REV. STAT. ANN. § 27-235(B) (providing that “[e]very mineral lease of state lands shall be for a term of twenty years”), with ALASKA STAT. § 38.05.205(c) (providing that a “mining lease shall be issued for any person up to 55 years”).

¹⁵³ See e.g., ALASKA STAT. § 38.05.205(c) (providing that leases are “renewable if requirements for the lease remain satisfied”); N.Y. PUB. LANDS LAW § 84(2) (allowing lease renewals “for successive periods each of thirty months”).

¹⁵⁴ See e.g., OKLA. ADMIN. CODE § 385:20-1-14(7) (limiting the size of leases to 160 acres); WASH. REV. CODE § 79.14.300 (limiting the size of leases to 640 acres).

¹⁵⁵ Even if this does not occur, miners may be able to avoid by limits, for example by having multiple separate corporate entities hold leases.

¹⁵⁶ See e.g., UTAH CODE ANN. § 65A-6-4(2)(a) (requiring annual rental payments of \$1.00 per acre); WASH. ADMIN. CODE § 332-16-035 (requiring annual rental payments of \$5.00 to \$10.00 per acre).

¹⁵⁷ See e.g., ARIZ. REV. STAT. § 27-234(B) (requiring payment of royalties of at least two percent); WASH. ADMIN. CODE § 332-16-035 (requiring payment of royalties of at least five percent).

(depending on the size of the lease)¹⁵⁸ and royalties equal to three percent of net income generated from the extracted materials.¹⁵⁹ For comparison, California charges a standard rent of \$1.00 per acre on all leases, and a royalty rate of ten percent on the gross value of extracted materials.¹⁶⁰ States could consider reducing or waiving rents and royalties for projects involving the extraction of materials for use in enhanced weathering. If royalties are charged, states may need to develop new approaches for calculating them. Similar to tribal lands, the royalties payable on minerals extracted from state land are often calculated based on gross or net income generated from the sale of the extracted materials, but this approach may be unworkable where materials extracted for use in enhanced weathering are not sold in the market. In such cases, states could base the calculation on the average market price for materials of the same type, or some other proxy value.

Like BLM and the Forest Service, state land management agencies often require lessees to submit a plan of operations or similar document, outlining the work to be performed, the steps that will be taken to mitigate adverse environmental impacts, and when and how the site will be reclaimed.¹⁶¹ Many states also require the lessee to submit a bond or other financial security sufficient to cover the cost of reclamation.¹⁶²

2.2 Environmental Approvals Required to Develop Silicate-Rich Minerals and Rocks

Persons wanting to extract basalt, dunite, or other silicate materials for use in enhanced weathering may, in addition to obtaining rights to the materials, also need to obtain various environmental permits from federal, state, and local government agencies. This Subpart discusses key permits that are likely to be required for most extraction and processing operations. However,

¹⁵⁸ ALASKA STAT. § 38.05.211.

¹⁵⁹ *Id.* § 38.05.212. *See also id.* § 43.65.060 (defining “net income” to mean the gross income generated from mining less allowable deductions).

¹⁶⁰ CAL. PUB. RES. CODE §§ 6895 & 6897

¹⁶¹ *See e.g.*, OKLA. STAT. tit. 45, § 45-745.5 (requiring approval of reclamation plans); WYO. STAT. ANN. § 35-11-405 (requiring approval of mining and reclamation plans).

¹⁶² *See e.g.*, MONT. CODE ANN. § 77-3-119 (authorizing the state land board to “require a mining lessee to file . . . a bond or bonds conditioned to protect the rights of the state”); N.M. STAT. ANN. § 19-8-24 (requiring each lessee to “execute and file with the commissioner [of state lands] a good and sufficient bond or undertaking in an amount . . . not less than five thousand dollars”).

it should be noted that other permitting requirements could also apply to some operations, depending on where and how extraction and processing occur.¹⁶³

2.2.1 Mining Permits

States typically require mining operations to be permitted.¹⁶⁴ The permitting requirements are often expressed to apply to all operations in the relevant state, regardless of whether they occur on land under private, state, tribal, or federal ownership. However, to the extent the state permitting laws are applied to tribal or federal lands, they are likely to be pre-empted by federal law.¹⁶⁵ In practice, then, state permits are likely to be required only for mining operations on private or state owned land.

Some state laws exempt small mining operations from the permitting requirements. In Nevada, for instance, permits are not required for operations that impact less than five acres of land in any calendar year.¹⁶⁶ In other states, the permitting exemption is based on the volume of materials extracted. As an example, New York provides an exemption for operations involving the removal of less than 1000 tons or 750 cubic yards of minerals in any twelve-month period.¹⁶⁷

Just as state permitting requirements vary, so too do their procedures for issuing permits. Generally, however, permit applications must include a detailed description of where and how mining will occur and plans for mitigating any adverse environmental impacts and remediating the site following the completion of work.¹⁶⁸ Many states require applicants to provide a bond or other

¹⁶³ For example, extraction projects that adversely affect listed threatened or endangered plant or animal species may need to be permitted under the ESA. *See* 16 U.S.C. §§ 1538 (prohibiting the “take” of listed species) & 1539 (providing for the issuance of permits authorizing “take” that is “incidental to, and not the purpose of, the carrying out of an otherwise lawful activity”).

¹⁶⁴ *See e.g.*, COLO. REV. STAT. § 34-32-109 (requiring “any operator proposing to engage in a new mining operation [to] first obtain a permit”); WIS. ADMIN. CODE NR § 135.16 (providing that “[n]o person may engage in nonmetallic mining . . . without obtaining a . . . permit”).

¹⁶⁵ *See generally*, *Ventura v. Gulf Oil Corp.*, 601 F.2d 1080 (9th Cir. 1979), *aff’d* 445 U.S. 947 (1980) (holding that a local ordinance requiring oil extraction operations to be permitted could not be enforced against operators on federal lands because it conflicted with federal law).

¹⁶⁶ NEV. REV. STAT. §§ 519A.080, 519A.120, & 519A.200.

¹⁶⁷ N.Y. COMP. CODES R. & REGS. tit. 6, § 421.1(a).

¹⁶⁸ *See e.g., id.* §§ 422.1 (requiring “[e]very applicant for a mining permit [to] submit . . . a mined land-use plan,” including a mining plan and reclamation plan); 422.2 (specifying the information to be included in the mining plan submitted as part of the permit application); & 422.3 (specifying the information to be included in the reclamation plan submitted as part of the permit application).

financial security, sufficient to cover the cost of reclamation, before a permit can be issued.¹⁶⁹ The amount of the financial security is typically determined on a case-by-case basis and intended to reflect, as closely as possible, the cost of successfully completing reclamation of the site.¹⁷⁰ In determining that cost, the permitting agency may consider the size and location of the site, the type of activities performed at the site, and the intended or anticipated post-reclamation use of the site.¹⁷¹

State laws often require applicants for permits or the permitting agency to notify the public about pending applications. In Colorado, for example, permit applicants must ensure that a copy of their application is made available for public inspection in the county in which the land covered by the application is located.¹⁷² The applicant must also publish a notice in a newspaper circulating in the local area and send a copy of that notice to nearby landowners.¹⁷³ Any person may file written comments on the application and the Colorado Mined Land Reclamation Board may, in its discretion, hold a public hearing to discuss whether the permit should be granted.¹⁷⁴ In some states, including Wisconsin, public hearings are mandatory in certain circumstances (e.g., if requested by nearby landowners).¹⁷⁵ Wisconsin and other states with “little NEPA” statutes also require environmental reviews to be conducted prior to issuance of permits.¹⁷⁶

2.2.2 Air Pollution Permits

Where mining activities release rock particles into the air, those activities may be regulated as a source of particulate matter under the Clean Air Act (“CAA”).¹⁷⁷ Enacted to “protect and

¹⁶⁹ See e.g., COLO. REV. STAT. § 34-32-117 (requiring each operator to file a “financial warranty” that “consist[s] of a written promise . . . to be responsible for reclamation costs up to the amount specified by the board); WIS. ADMIN. CODE NR § 135.40 (requiring each operator to “file a financial assurance . . . provid[ing] that the operator shall faithfully perform” all reclamation activities”).

¹⁷⁰ See e.g., WIS. ADMIN. CODE NR § 135.40(3) (providing that “[t]he amount of the financial assurance shall equal as closely as possible the cost to the regulatory authority of hiring a contractor to complete . . . reclamation”).

¹⁷¹ See e.g., N.Y. COMP. CODES R. & REGS. tit. 6, § 423.1(c) (outlining the factors to be considered by the NYDEC when determining the amount of any required reclamation bond).

¹⁷² COLO. REV. STAT. § 34-32-112(10)(a).

¹⁷³ *Id.* § 34-32-112(1)(b)-(c).

¹⁷⁴ *Id.* § 34-32-114.

¹⁷⁵ WIS. ADMIN. CODE NR § 135.20.

¹⁷⁶ See *supra* note 151.

¹⁷⁷ 42 U.S.C. § 7401 et seq.

enhance the quality of the Nation’s air resources so as to promote public health and welfare,”¹⁷⁸ the CAA directs the Environmental Protection Agency (“EPA”) to establish national standards to control air pollution.¹⁷⁹ Those standards are implemented and enforced principally by the states with some oversight by EPA.

Under section 108 of the CAA, EPA must identify so-called “criteria air pollutants” that are emitted by numerous mobile or stationary sources and cause or contribute to air pollution, which may reasonably be anticipated to endanger public health or welfare.¹⁸⁰ Pursuant to that section, EPA has listed two classes of particulate matter as criteria pollutants, namely:

- (1) inhalable particles that are 2.5 microns or less in diameter (“PM2.5”); and
- (2) inhalable particles that are 10 microns or less in diameter (“PM10”).

Section 109 of the CAA requires EPA to establish, for each criteria pollutant, primary and secondary National Ambient Air Quality Standards (“NAAQS”) that reflect the maximum safe concentration of the pollutant in air.¹⁸¹ Specifically, EPA must set primary NAAQS at the level required “to protect public health,” with an “adequate margin of safety.”¹⁸² Secondary NAAQS must be set at the level required “to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air.”¹⁸³

The primary and secondary NAAQS are typically implemented through State Implementation Plans (“SIPs”) that are developed and enforced by the states (with the approval of EPA). In areas not covered by an approved SIP (i.e., either because no SIP was developed by the relevant state or the state-developed SIP was not approved by EPA), EPA prepares and enforces Federal Implementation Plans (“FIPs”). All SIPs and FIPs must include provisions requiring permits to be obtained prior to the construction or modification of any “major stationary source” of PM2.5, PM10, or other criteria air pollutant.¹⁸⁴ The size threshold for major stationary sources differs depending on, among other things, local air quality in the area where the source is located. In areas

¹⁷⁸ *Id.* § 7401(b)(1).

¹⁷⁹ *Id.* §§ 7408 & 7409.

¹⁸⁰ *Id.* § 7408(a)(1).

¹⁸¹ *Id.* § 7409(a). EPA has established primary and secondary NAAQS for PM2.5 and PM10. *See* National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3086 (Jan. 15, 2013).

¹⁸² *Id.* § 7409(b)(1).

¹⁸³ *Id.* § 7409(b)(2).

¹⁸⁴ *Id.* §§ 7475, 7502, & 7503.

that have already attained the NAAQS (“attainment areas”), a source is generally classified as “major” if it emits, or has the potential to emit, 250 tons or more of a pollutant annually.¹⁸⁵ In non-attainment areas, sources that emit, or have the potential to emit, 100 tons or more of a pollutant annually are generally classified as “major.”¹⁸⁶ The major source threshold is, however, lower in some non-attainment areas.¹⁸⁷

Some states’ SIPs also require smaller stationary sources (i.e., below the major source threshold) (“minor sources”) to be permitted. In Virginia, for example, permits are required for all new stationary sources emitting more than ten tons of PM_{2.5} or fifteen tons of PM₁₀ per year.¹⁸⁸ Florida has gone even further, requiring permits for facilities emitting any amount of PM_{2.5}, PM₁₀, or other air pollutants, subject to limited exceptions.¹⁸⁹

The extraction and subsequent processing of silicate materials for use in enhanced weathering could result in PM_{2.5} or PM₁₀ emissions. Such emissions are especially likely to occur during grinding of the materials to produce a powder suitable for use in enhanced weathering. If emissions are above the major source threshold or any lower threshold established in an applicable SIP, a permit would need to be obtained from EPA or an authorized state or local authority.

The CAA establishes different permitting requirements, based on the nature of a source and its location. Where a major source is located in an attainment area, a permit can only be issued if the source applies the best available control technology for limiting emissions, and emissions from the source will not cause or contribute to a violation of the NAAQS or other applicable standards.¹⁹⁰

¹⁸⁵ Certain sources emitting 100 tons or more annually in attainment areas are considered “major.” *See id.* § 7479(1).

¹⁸⁶ *Id.* § 7602.

¹⁸⁷ *See* 40 C.F.R. § 51.165(a)(iv)(A)(1) (defining a “major source” as one that emits 70 tons or more per year of PM₁₀ or PM_{2.5} in any serious non-attainment area for PM₁₀ or PM_{2.5} (respectively)).

¹⁸⁸ 9 VA. ADMIN. CODE §§ 5-80-1100 & 5-80-1105(C).

¹⁸⁹ FLA. ADMIN. CODE ANN. r. 62-210.300. The Florida Department of Environmental Protection has issued general permits for various categories of activities. Persons engaged in covered activities do not need to apply for an individual permit, but can instead operate under the general permit, after registering with the department. *See generally*, Fl. Dept. of Env’tl. Prot., *Air General Permits*, OFFICE OF PERMITTING AND COMPLIANCE, <https://floridadep.gov/air/permitting-compliance/content/air-general-permits> (last updated Apr. 22, 2020).

¹⁹⁰ 42 U.S.C. §§ 7475 & 7479. *See also id.* § 7479(3) (defining “best available control technology”).

Additional requirements may be imposed where emissions from a major source in an attainment area could affect visibility in any designated national park or wilderness area.¹⁹¹

Major sources in non-attainment areas can only be permitted if the source achieves the lowest available emissions rate and secures offsets for any increase in emissions.¹⁹² Even if these requirements are met, permits cannot be issued for major sources in non-attainment areas if emissions from the source would have adversely affect visibility or other air quality-related values in any designated national park or wilderness area.¹⁹³

In all cases, before issuing a permit, EPA or the state or local authority must notify the public and invite comments.¹⁹⁴ Notably, unlike for many other federal agency decisions, an environmental review under NEPA is not required prior to the issuance of permits by EPA.¹⁹⁵ Some state and local authorities are, however, required to conduct environmental reviews prior to permitting under “little NEPA” statutes.¹⁹⁶

Regardless of whether they require a permit, facilities used in rock extraction and processing may be subject to other requirements. EPA regulations establish particulate matter emission limits for crushers, grinding mills, and certain other facilities used in non-metallic mineral processing plants.¹⁹⁷ Compliance with those limits will require the installation of capture systems or control devices that prevent or limit particulate matter emissions. Some SIPs impose additional requirements on the storage of ground rock and mineral materials. For example, the SIP for Maricopa County in Arizona requires materials stored in the open to be covered with a tarp or similar material, or sprayed with water to minimize the release of particulate matter.¹⁹⁸ Similarly, in

¹⁹¹ 40 C.F.R. § 51.307.

¹⁹² 42 U.S.C. § 7503. *See also id.* § 7501(3) (defining “lowest achievable emission rate”).

¹⁹³ 40 C.F.R. § 51.166(p)(3).

¹⁹⁴ *Id.* §§ 51.161, 51.166, & 52.21.

¹⁹⁵ 15 U.S.C. § 793(c)(1) (providing that “[n]o action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act”). It should be noted that, where a project also requires approval by other federal agencies (e.g., BLM or the Forest Service), those agencies may be required to conduct an environmental review of the project under NEPA.

¹⁹⁶ *See supra* note 151.

¹⁹⁷ 40 C.F.R. Pt. 60, Subpt. OOO.

¹⁹⁸ Maricopa County, Az., Air Pollution Control Regulations § 305.5.

Virginia, water or chemicals must be applied to storage piles that could create dust or other “reasonable precautions” taken to prevent particulate matter becoming airborne.¹⁹⁹

2.2.3 Water Pollution Permits

Mining operations may also be regulated under the Federal Water Pollution Control Act (commonly known as the Clean Water Act (“CWA”))²⁰⁰ in some circumstances. The CWA was enacted to “restore and maintain the chemical, physical, and biological integrity of the Nation’s waters” and, to that end, controls the discharge of pollutants into navigable waters.²⁰¹ Under the CWA, no person may discharge pollutants, unless he/she holds a permit issued by EPA, the Army Corps of Engineers (“ACE”), or an authorized state agency.²⁰²

The CWA defines “pollutant” broadly to include “rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water.”²⁰³ That definition would encompass mining over-burden, tailings, and similar waste materials generated during mining (“mining waste”). For the purposes of the CWA, such materials are considered to be “discharged” where they are added to navigable waters from a “point source,”²⁰⁴ defined as “any discernible, confined and discrete conveyance.”²⁰⁵ The definition of “point source” includes pipelines, tunnels, and similar structures that carry materials to navigable waters, as well trucks and other vehicles from which materials are deposited into waters.²⁰⁶ Thus, for example, a discharge will be considered to occur where mining waste is added to a waterbody via pipeline or truck. Such discharges would need to be permitted under the CWA.

The CWA establishes two separate regimes for permitting the discharge of pollutants into navigable waters. One regime, established in section 404 of the CWA, provides for the issuance of permits for the discharge of “dredged or fill material” by ACE and state agencies that have been

¹⁹⁹ 9 VA. ADMIN. CODE § 5-40-90.

²⁰⁰ 33 U.S.C. § 1251 et seq.

²⁰¹ *Id.* § 1251(a).

²⁰² *Id.* §§ 1311, 1342, & 1344.

²⁰³ *Id.* § 1362(6).

²⁰⁴ *Id.* § 1362(12). *See also id.* § 1362(7) defining “navigable waters”).

²⁰⁵ *Id.* § 1362(14).

²⁰⁶ *Id.*

authorized to administer the section 404 permitting program in their respective states.²⁰⁷ Permits for the discharge of all other pollutants are issued by EPA and authorized state agencies under a second regime, established in section 402 of the CWA, and known as the National Pollutant Discharge Elimination System (“NPDES”).²⁰⁸

The CWA does not define what constitutes “dredged or fill material” covered by the section 404 permitting regime. However, regulations issued under the CWA define “fill material” to mean material that, when placed into water, has the effect of “[r]eplacing any portion of the water . . . with dry land,” or “[c]hanging the bottom elevation” of the water.²⁰⁹ The regulations list, as examples of fill material, “overburden from mining or other excavation activities,”²¹⁰ and other rock, sand, soil, and clay.²¹¹ Rock-based mining waste would, therefore, be considered “fill material” and could only be discharged into navigable waters with a section 404 permit issued by ACE or an authorized state agency.

Under section 404(e) of the CWA, ACE can issue general permits, authorizing discharges that have minimal adverse environmental impacts.²¹² Pursuant to that section, ACE has issued a general permit covering discharges into non-tidal open waters (e.g., rivers and lakes) associated with small mining operations that do not involve the extraction of coal and cover no more than 0.5 acres.²¹³ Operators covered by the general permit must notify ACE before discharging materials, but do not have to obtain an individual permit via the process described below.²¹⁴

²⁰⁷ *Id.* § 1344. Section 404 of the CWA establishes a process through which a state may apply to the EPA Administrator for approval to administer its own program for permitting the discharge of dredged or fill material into navigable waters. *See id.* § 1344(g)-(k). At the time of writing, only Florida, Michigan, and New Jersey had been authorized to implement the section 404 permitting program. *See* Env'tl. Prot. Agency, *U.S. Interactive Map of State and Tribal Assumption Under CWA Section 404*, <https://perma.cc/MB2C-KD66> (last updated Feb. 5, 2021).

²⁰⁸ 33 U.S.C. § 1342.

²⁰⁹ 33 C.F.R. § 323.2(e)(1).

²¹⁰ The term “overburden” is not defined in the regulations. It is typically used to refer to waste rock and other material that overlies a valuable mineral deposit and is removed during mining but not processed. *See generally*, RPM GLOBAL, GLOSSARY OF MINING TERMS 27 (2019), <https://perma.cc/C4S8-FJFE>.

²¹¹ 33 C.F.R. § 323.2(e)(2).

²¹² 33 U.S.C. § 1344(e).

²¹³ ARMY CORPS OF ENGINEERS, DECISION DOCUMENT: NATIONWIDE PERMIT 44 (2021), <https://perma.cc/ERT9-BRHP>.

²¹⁴ *Id.*

Mining-related discharges that are not covered by the general permit would require an individual permit. ACE and authorized state agencies can only issue individual permits if:

- (1) there is no practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem;²¹⁵ and
- (2) the proposed discharge will not:
 - (a) cause or contribute to a significant degradation of waters²¹⁶ or a violation of any applicable water quality standards or toxic effluent standards;²¹⁷
 - (b) jeopardize the continued the continued existence of any species listed as endangered or threatened under the ESA or result in the destruction or adverse modification of any critical habitat designated under the Act;²¹⁸ or
 - (c) violate any requirement imposed by the Secretary of Commerce to protect a marine sanctuary.²¹⁹

Before issuing a permit, ACE or the relevant state agency must issue a public notice, providing information about the proposed discharge and inviting comments from interested parties.²²⁰ In addition, where ACE is the permitting agency, the state in which the discharge will originate must certify that the discharge will comply with all applicable water quality requirements or waive certification before a permit can be issued.²²¹ ACE must also conduct an environmental review under NEPA²²² and, if the discharge could affect endangered or threatened species, consult with FWS

²¹⁵ *Id.* § 323.6(a); 40 C.F.R. § 230.10(a).

²¹⁶ 33 C.F.R. § 323.6(a); 40 C.F.R. § 230.10(c).

²¹⁷ 33 C.F.R. § 323.6(a); 40 C.F.R. § 230.10(b)(1)-(2).

²¹⁸ 33 C.F.R. § 323.6(a); 40 C.F.R. § 230.10(b)(3).

²¹⁹ 33 C.F.R. § 323.6(a); 40 C.F.R. § 230.10(b)(4).

²²⁰ 33 C.F.R. §§ 325.2(a)(2) & 325.2(a). The public notice must be posted in public places in the vicinity of the discharge site and sent to adjoining property owners, appropriate city and county officials, state, and federal agencies, local news media, and other interested parties. *See id.* § 325.3(d).

²²¹ 33 U.S.C. § 1341 (requiring the applicant for a federal license or permit to “provide the licensing or permitting agency [with] a certification from the State in which the discharge originates or will originate . . . that any such discharge will comply with” applicable water quality standards); 33 C.F.R. § 325.1(d)(4) (providing that “[c]ertification under section 401 of the Clean Water Act is required for . . . discharges [or dredged or fill material] into waters of the United States”).

²²² 42 U.S.C. § 4332 (requiring preparation of an environmental impact statement for any “major federal action significantly affecting the quality of the human environment”); 33 C.F.R. §

under the ESA.²²³ Some state agencies are also required to conduct environmental reviews and/or consult with other agencies before issuing permits.²²⁴

Whereas discharges of dredged and fill material into navigable waters must be permitted under section 404 of the CWA, section 402 (NPDES) permits are required for the discharge of other pollutants into navigable waters from point sources.²²⁵ Thus, for example, a NPDES permit would be required to discharge non-rock-based mining wastes (e.g., wastewater from mineral processing) into navigable waters via pipeline or truck. NPDES permits can be issued by EPA or an authorized state agency. Similar to ACE, EPA cannot issue a NPDES permit unless the state in which the discharge will occur certifies that the discharge complies with applicable water quality requirements, or waives certification.²²⁶ EPA and state agencies must also engage in public consultation²²⁷ and complete any required environmental reviews (e.g., under NEPA or state equivalents) before issuing NPDES permits.²²⁸

2.2.4 Waste Management Permits

The Resource Conservation and Recovery Act (“RCRA”)²²⁹ will also apply to the handling of mining waste. RCRA aims to “promote the protection of health and the environment and to conserve valuable material and energy resources” by ensuring “careful planning and management” of solid waste.²³⁰ For the purposes of RCRA, “solid waste” is defined as any “discharged material, including

325.2(a)(4) (providing that an ACE “decision on a permit application will require [preparation of] either an environmental assessment or environmental impact statement” under NEPA). *See also* 33 C.F.R. Pt 230 (outlining the procedures for NEPA review of projects by ACE).

²²³ 16 U.S.C. § 1536(a)(2) (requiring federal agencies to consult with the Fish and Wildlife Service before authorizing, funding, or carrying out any activity that could jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of any critical habitat for such species); 33 C.F.R. § 325.2(b)(5) (providing that permit applications “will be reviewed for the potential impact on threatened or endangered species pursuant to section 7 of the Endangered Species Act”).

²²⁴ *See supra* note 151.

²²⁵ 33 U.S.C. § 1342.

²²⁶ *Id.* § 1341(a)(1); 40 C.F.R. § 124.53.

²²⁷ 40 C.F.R. §§ 124.10-124.12.

²²⁸ EPA must conduct an environmental review under NEPA where the permitted discharge will originate from a new source constructed at a site where no existing source is located or will replace or operate independently of an existing source. *See id.* §§ 122.29 & 124.61.

²²⁹ 42 U.S.C. § 6901 et seq.

²³⁰ *Id.* §§ 6901 & 6902.

solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial, mining and agricultural operations.”²³¹ EPA regulations, adopted under RCRA, exclude “[m]aterials subject to in-situ mining techniques which are not removed from the ground as part of the extraction process” from the definition of solid waste.²³² Other mining waste would, however, fall within the definition.

RCRA divides solid waste into two broad categories—(1) hazardous and (2) non-hazardous—and establishes separate regulatory frameworks for each. Hazardous waste is regulated under Subtitle C of RCRA, which imposes strict controls on waste handling and disposal.²³³ Fewer controls apply to the handling and disposal of non-hazardous waste, which is regulated under Subtitle D of RCRA.²³⁴

Most mining wastes have been exempt from regulation as hazardous wastes. In May 1980, EPA adopted regulations, providing that “[m]ining overburden returned to the mine site” does not qualify as a hazardous waste. Subsequently, in the Bevill Amendment to RCRA, Congress temporarily excluded “solid waste from the extraction, benefaction, and processing of ores and minerals” from regulation as hazardous waste.²³⁵ The Bevill Amendment provided that the exemption would remain in force until at least six months after EPA completed a “detailed and comprehensive study on the adverse effects” of mining waste on humans and the environment and the “adequacy of means and measures currently employed . . . to dispose of” such waste.²³⁶ Based

²³¹ *Id.* § 6903(27). Regulations adopted by EPA under RCRA further define “discarded materials” as those that are “abandoned, recycled, [or] considered inherently waste-like” and include definitions of each of those terms. *See* 40 C.F.R. § 261.2. The regulations expressly exclude “industrial wastewater discharges that are point source discharges” regulated under the CWA from the definition of “solid waste.” *See id.* § 261.4(2).

²³² 40 C.F.R. § 261.4(a)(5).

²³³ 42 U.S.C. § 6921 et seq.

²³⁴ *Id.* § 6941 et seq.

²³⁵ *Id.* §§ 6921(b)(3)(A)(ii) & 6982(f). The terms “extraction, benefaction, and processing” were not defined in the Bevill Amendment. EPA has defined “benefaction” to include “crushing; grinding; washing; dissolution; crystallization; filtration; sorting; sizing; drying; sintering; pelletizing; briquetting’ calcining to remove water and/or carbon dioxide; roasting, autoclaving, and/or chlorination in preparation for leaching . . . ; gravity concentration; magnetic separation; electrostatic separation; flotation; ion exchange; solvent extraction; electrowinning; precipitation; amalgamation; and heap, dump, vat, tank, and in situ leaching.” EPA defines “processing” as any activity which is not listed above and occurs after a benefaction step. *See* 40 C.F.R. § 261.4(b)(7).

²³⁶ 42 U.S.C. §§ 6921(b)(3)(A)(ii) & 6982(f).

on that study, EPA was to determine whether mining waste should be regulated as hazardous and, if so, adopt the necessary regulations.

EPA completed an initial study of mining waste associated with the extraction and beneficiation of minerals in December 1985²³⁷ and a second study of waste from mineral processing in July 1990.²³⁸ Following the studies, EPA concluded that most mining waste, including mining overburden and tailings, should be treated as non-hazardous.²³⁹ Such wastes are, therefore, regulated under subtitle D of RCRA. Under that subtitle, the states are primarily responsible for regulating the management non-hazardous waste and must develop and implement solid waste management plans, with the support of EPA. State plans typically allow mining waste to be disposed of on- or off-site, in accordance with the procedures set out in the operator's reclamation plan.²⁴⁰ Pending disposal, waste stockpiles must generally be covered or treated to prevent them becoming unstable, hazardous, or a source of pollution.²⁴¹

3. SOURCING ARTIFICIAL SILICATES FOR USE IN ENHANCED WEATHERING

Due to the potential negative impacts of increased mining, there is growing interest in the possibility of performing enhanced weathering using artificial silicates, particularly silicate-rich wastes. To date, most discussion has focused on the possibility of using mining wastes, including tailings, which comprise ground rock or sand and process water and chemicals used to extract minerals from ore during mining operations.²⁴² In recent decades, miners have been forced to develop ores with lower mineral concentrations (i.e., because higher grade reserves have already been exploited), leading to an increase in the volume of tailings produced relative to mineral

²³⁷ ENVTL. PROT. AGENCY, REPORT TO CONGRESS: WASTES FROM THE EXTRACTION AND BENEFICATION OF METALLIC ORES (1985), <https://www.epa.gov/hw/report-congress-wastes-extraction-and-beneficiation-metallic-ores-phosphate-rock-asbestos>.

²³⁸ ENVTL. PROT. AGENCY, REPORT TO CONGRESS ON SPECIAL WASTES FROM MINERAL PROCESSING (1990), <https://www.epa.gov/radiation/report-congress-special-wastes-mineral-processing>.

²³⁹ 40 C.F.R. § 261.4(b)(7).

²⁴⁰ See e.g., N.Y. COMP. CODES R. & REGS. tit. 6, § 422.2(c)(v).

²⁴¹ *Id.*

²⁴² UN ENV'T & GRID ARENDAL, MINE TAILINGS STORAGE: SAFETY IS NO ACCIDENT 6 (2017), <https://perma.cc/KY97-T7KM>.

output.²⁴³ Tailings often contain heavy metals and other potentially harmful substances which makes their handling and disposal challenging.²⁴⁴ Tailings are most commonly stored above ground, behind earth-filled embankments, commonly known as tailing dams.²⁴⁵ There is no comprehensive inventory of tailings dams,²⁴⁶ but one partial database lists over 2,000 dams globally, and nearly 300 in the U.S.²⁴⁷

In the past, tailing dams have been prone to leakage and collapse which can result in damage to, and endanger, local communities and ecosystems.²⁴⁸ Using tailings for enhanced weathering could help to mitigate these problems by reducing the need for long-term storage in tailings dams. Further research is, however, needed to evaluate the environmental and other risks associated with enhanced weathering using mine tailings.²⁴⁹

Assuming that any risks are found to be manageable or outweighed by the benefits, a number of steps could be taken to facilitate the use of mine tailings in enhanced weathering. First, it would be useful to identify and catalogue existing tailing dams, since no comprehensive registry currently exists. A federal government agency (e.g., EPA or DOI) could develop and maintain a national registry or a state-by-state approach could be taken.

Legal issues associated with the use of mine tailings in enhanced weathering will also need to be addressed. Determining the ownership of mine tailings is often difficult, particularly where they were generated during mining operations that concluded many years earlier. Moreover, even

²⁴³ *Id.* at 16.

²⁴⁴ *Id.* at 20.

²⁴⁵ *Id.* at 6.

²⁴⁶ UN Env't & Grid Arendal, *supra* note 242, at 6.

²⁴⁷ *Global Tailings Portal*, <https://tailing.grida.no/> (last visited Feb. 25, 2021). The database was developed using information submitted by approximately 100 mining companies globally. The database developers requested, but did not receive, information from several hundred other companies. The database does not, therefore, include all tailing dams globally. Previous studies have estimated the total number of tailing dams globally at around 3,500. See M.P. Davies & T.E. Martin, *Upstream Constructed Tailings Dams – A Review of the Basics*, PROC. TAILING AND MINE WASTE 3 (2000). Subsequent studies have, however, suggested that the number may be even higher. See UN Env't & Grid Arendal, *supra* note 242, at 6 (the 3,500 figure “is likely an underestimate as there could be more than 30 000 industrial mines”).

²⁴⁸ See generally, Zongjie Lyu et al., *A Comprehensive Review of Reasons for Tailings Dam Failures Based on Case History*, ADVANCES IN CIVIL ENGINEERING 1 (2019) (finding that tailing dams have a failure rate of 1.2 percent, compared to 0.01 percent for traditional water storage dams).

²⁴⁹ Royal Society & Royal Academy of Engineering, *supra* note 5, at 51.

if the owner of mine tailings can be identified, many states restrict their sale or transfer. These issues, and recommendations for addressing them, are discussed further below.

It should be noted that, prior to their use in enhanced weathering, mine tailings may require processing, including grinding and crushing. Where this is the case, the air pollution permitting requirements discussed in Part 2.2.2 above may apply (i.e., depending on the type and amount of any air pollution created). Similarly, to the extent that the processing of mine tailings generates waste, the water quality and waste management rules discussed in Parts 2.2.3 and 2.2.4 above could also apply.

3.1 Ownership of Mine Tailings

As discussed in Part 2.1 above, the mineral estate underlying land may be owned by the owner of the surface estate, or another person.²⁵⁰ Minerals are ordinarily considered a form of real property while in the ground but, when removed from the soil, become the personal property of the miner. The associated waste may, in some circumstances, also be treated as personal property owned by the miner. In other circumstances, however, the waste may be considered real property belonging to the owner of the land on which it is deposited.

At the time of writing, no state had statutory or regulatory provisions defining who owns mining waste, leaving ownership issues to be decided by the courts on a case-by-case basis. State courts have articulated multiple, sometimes overlapping, tests for deciding ownership cases. The courts in several states use an abandonment test (among others). That test was neatly summarized by the Alaska Supreme Court in *Hayes v. Alaska Juneau Forest Industries Inc.* as follows: “[i]f [mine] tailings are abandoned, they become real estate [belonging to the owner of the land on which they are deposited], if they are not abandoned, they remain the personal property of the mine or mill which created them.”²⁵¹

²⁵⁰ The mineral estate can be severed from the surface estate and transferred in separately, resulting in a so-called “split estate,” where the surface is owned by one party and the minerals by another. *See supra* Part 2.1.

²⁵¹ *Hayes v. Alaska Juneau Forest Indus. Inc.* 748 P.2d 332, 335 (Alaska 1988). *See also*, *Stephens Hays Estate, Inc. v. Togliatti*, 85 Utah 137, 144 (Utah 1934) (declaring that, where mine tailings have been abandoned by the miner and “lodge on the land of another,” they become the real property of that other person); *Conway v. Fabian*, 108 Mont. 287 (Mont. 1939) (holding that mine tailings are treated as real estate when abandoned and thus become the property of the relevant

In determining whether tailings have been abandoned, the courts consider both the conduct of the miner, and his/her intention.²⁵² As the Kentucky Court of Appeals observed in *Elk Horn Coal Corporation v. Allen*, “[i]n order to establish an abandonment of property, there must be a showing of actual acts of relinquishment, accompanied with the intention to abandon.”²⁵³ In *Elk Horn*, the court found that a miner had not abandoned waste coal, slate, and other materials by dumping them on nearby land. The court noted that the materials were “not scattered indiscriminately over the land, but . . . placed in an orderly pile” by the miner, suggesting that he did not intend to abandon them.²⁵⁴ Moreover, the miner periodically took materials from the dump, while preventing others from doing so.²⁵⁵ The court noted that, at the time of the case, the miner had not taken materials from the dump for several years, but concluded that “[m]ere lapse of time and nonuser [sic], unaccompanied by any other evidence showing intent,” is not sufficient to establish abandonment.²⁵⁶

As an alternative or in addition to the abandonment test, the courts in some states apply other rules to determine the ownership of mine tailings. For example, in *Hayes*, the Alaska Supreme Court held that:

Abandonment of tailings is one way that tailings become real estate [owned by the person on whose land they are deposited], but it is not the only way. When tailings are deposited for the purpose of disposal, as distinct from being stockpiled for future use, they become real estate even though they are not abandoned.²⁵⁷

land owner); *Baker v. Waite*, 158 Cal. App. 2d 379, 384 (Cal. App. 3d, 1958) (holding that mine “tailings which are dumped on nonmineral land and abandoned become, on abandonment, a part of the realty” belonging to the land owner).

²⁵² See e.g., *Gilberton Contracting Co. v. Hook*, 255 F Supp 687, 693-694 (E.D. Pa. 1966) (applying Pennsylvania law) (stating that “[w]hen considering the question of abandonment, the nature of the property, and the conduct of the one who claims it, must be given due weight . . . The intention to abandon must coalesce with external acts giving effect to such intention” and that “[t]he intention to abandon, absent some declaration, must necessarily be inferred from the acts and conduct of the party alleged to have abandoned”).

²⁵³ *Elk Horn Coal Corp. v. Allen*, 324 S.W.2d 829, 830 (Ky. Ct. App. 1959).

²⁵⁴ *Id.* at 831.

²⁵⁵ *Id.*

²⁵⁶ *Id.* at 830.

²⁵⁷ *Hayes*, 748 P.2d at 334-335.

This rule, which is also used in some other states, requires courts to examine the intent with which the miner deposited the mine tailings on land.²⁵⁸ In the absence of an express statement,²⁵⁹ courts will infer intent from the miner's conduct. Some courts have looked at whether the miner went to the effort and expense of constructing embankments, bulkheads, or other structures to contain the mine tailings. For example, in *Conway v. Fabian*, the Montana Supreme Court held that the construction of bulkheads to hold mine tailings suggested an "intent to impound and preserve the tailings . . . until by improved metallurgical processes and the invention of more efficient machinery the mineral values remaining might be recovered."²⁶⁰ The court in *Conway* attached significant weight to the fact that the miner had expended large sums constructing and maintaining the impoundment to prevent the tailings escaping.²⁶¹

Relatedly, in Montana and some other states, the courts have also determined the ownership of mine tailings by looking at whether they are separated from, or intermingled with, the soil on the land.²⁶² In *Foreman v. Beaverhead*, the Montana Supreme Court held that, where mine tailings "are permitted to spread upon and to mingle with the earth, they become a part thereof and are real estate" belonging to the landowner (i.e., regardless of the miner's intent in depositing them on the land).²⁶³

The above tests must be applied on a case-by-case basis, with the courts typically engaging in a highly-fact specific analysis, which necessarily makes it difficult to predict the outcome of future cases. Compounding this problem, in past cases, the courts have often not clearly articulated

²⁵⁸ See e.g., *Steinfeld v. Omega Copper Co.* (1914) 16 Ariz. 230, 234 (Ariz. 1914) (holding that "the purpose and intention of the [mine] owner [when he/she/it] placed [mine tailings] on the dump is controlling" in determining whether the tailings are the personal property of the mine owner or real property belonging to the relevant land owner"); *State ex rel. Department of Water Resources v. Superior Court of Butte County*, 208 Cal. App. 2d 659, 664-665 (Cal. App. 3d, 1962) (applying the rule articulated in *Steinfeld*).

²⁵⁹ For an example of a case in which there was an express statement of intent, see *Steinfeld*, 16 Ariz. at 234 (noting that a supervisor from the mining company testified that, at the time the tailings were generated, "we had no intention of doing anything with" them).

²⁶⁰ *Conway*, 108 Mont. at 299.

²⁶¹ *Id.*

²⁶² See e.g., *Rogers v. Cooney*, 7 Nev. 213 (Nev. 1872); *Foreman v. Beaverhead County*, 117 Mont. 557 (Mont. 1945); *In Re Appropriation of Easements for Highway Purposes*, 190 N.E.2d 446 (Ohio 1963).

²⁶³ *Foreman*, 117 Mont. at 559.

precisely what test they were applying or the factual considerations that bore on their decision. The resulting uncertainty could discourage the use of mine tailings in enhanced weathering projects, including because project developers are unable to identify the owner of particular tailings, or fear that ownership claims will be challenged. To reduce uncertainty, states could enact legislation clarifying the ownership of mine tailings.

3.2 Restrictions on the Transfer of Mine Tailings

The sale or transfer of mine tailings for use in enhanced weathering may be restricted by state waste management programs developed pursuant to RCRA or state statutes. As discussed in Part 2.2.4 above, RCRA establishes a national framework for the handling, storage, and disposal of “solid waste.” RCRA defines “solid waste” broadly to include any “discarded material, including solid, liquid, semisolid or contained gaseous material resulting from industrial, commercial, mining and agricultural operations.”²⁶⁴ In some circumstances, material may be classified as “solid waste” covered by RCRA even if it is ultimately reused, for example in enhanced weathering.²⁶⁵

State waste management plans often require solid waste to be sent to a landfill or other facility licensed to receive it. Generally, solid waste cannot be transferred to other (unlicensed) individuals or entities, though some states provide an exemption where the individual or entity will put the waste to beneficial use. In New York, for example, an unlicensed person must not accept solid waste unless its use thereof has been pre-approved by the NYDEC through a beneficial use determination (“BUD”).²⁶⁶ The NYDEC and agencies in some other states have issued standing or general BUDs, which allow persons to accept specified waste for use in specified ways, without obtaining individual approval from the relevant agency. At the time of writing, no state had a standing BUD, authorizing the use of mine tailings for enhanced weathering. Persons wanting to receive mine tailings for such use would, therefore, need to obtain an individual BUD. The requirements for obtaining an individual BUD for enhanced weathering were discussed in a previous paper by the author.²⁶⁷ The paper concluded that enhanced weathering projects will often

²⁶⁴ 42 U.S.C. § 6903(27).

²⁶⁵ Webb, *supra* note 14, at 34-35.

²⁶⁶ N.Y. COMP. CODE R. & REGS. tit. 6, §§ 360.9 (providing that a person “must not . . . accept waste except at” an authorized facility) & 360.12 (authorizing the NYDEC to permit the use of wastes in certain circumstances).

²⁶⁷ Webb, *supra* note 14, at 38-39.

not qualify for individual BUDs and thus recommended that state legislatures or (where authorized) regulatory agencies change the qualification requirements for individual BUDs or establish a standing BUD for enhanced weathering.²⁶⁸

4. CONCLUSION

There is growing interest in the possibility of using enhanced weathering to remove carbon dioxide from the atmosphere and sequester it in mineral form. The technique is based on natural weathering processes, whereby carbon dioxide reacts with silicate-based rocks, forming carbonate minerals (e.g., limestone). The goal is to speed up this natural process, typically by grinding silicate-based rocks to increase their surface area, and then spreading the powder over land or ocean waters. It may also be possible to perform enhanced weathering using so-called artificial silicates, such as silicate-rich mining and other wastes, but further study is needed to evaluate the possible risks thereof.

To perform enhanced weathering at scale, large amounts of silicate-based material would be required. This would likely necessitate a significant increase in the mining of silicate minerals and rocks, such as olivine and dunite, which could raise a host of legal and other issues. The legal framework for mining on federal, tribal, and state-owned land in particular is highly complex, with numerous permitting and other requirements.²⁶⁹ Many of those requirements were put in place to mitigate the risks of environmental and other harm from mining activities and thus should not be eliminated. However, some modest changes could be made to facilitate access to minerals for use in enhanced weathering, without compromising environmental or other outcomes.

Sourcing artificial silicates, particularly mine tailings, for use in enhanced weathering could also be challenging. There is often significant uncertainty as to owns mine tailing and, even if ownership can be determined, restrictions on their transfer to third parties.²⁷⁰ Again, however, there are a range of modest steps that could be taken to address these issues.

²⁶⁸ *Id.*

²⁶⁹ *See supra* Part 2.

²⁷⁰ *See supra* Part 3.