U.S. House Committee on Energy and Commerce
Subcommittee on Oversight and Investigations
"Examining Ways to Enhance Our Domestic Critical Mineral Supply Chains"
May 21, 2025
Documents for the Record

1. A report from the National High Magnetic Field Laboratory entitled "Florida's Potential as a Production Center for Rare Earths, Critical Minerals, and Industrial Byproducts", submitted by Rep. Dunn.

NATIONAL HIGH MAGNETIC FIELD LABORATORY

Florida's Potential as a Production Center for Rare Earths, Critical Minerals, and Industrial Byproducts

June 2024

Florida's Potential as a Production Center for Rare Earths, Critical Minerals, and Industrial Byproducts

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1 Executive Summary

Florida has significant potential to become a leading hub for rare earths, critical minerals, and industrial byproducts (RE/CM/IB), offering immense human, environmental, and economic value. Current geopolitical risks and instability have created an urgent national security demand for domestic production and processing of rare earths and critical minerals. The U.S. Department of Defense and other federal agencies are accelerating development of this domestic industry through funding programs and other initiatives. Markets that are quick to respond will become the national hubs and centers of this critical domestic industry for generations to come at a fraction of the investment costs of later development.

In 2023, the Florida Legislature approved funds as part of Specific Appropriation 143, directing the National High Magnetic Field Laboratory (Mag Lab) at Florida State University (FSU) to create The Center for Rare Earths, Critical Minerals, and Industrial Byproducts (The Center) with the following directive: "The Center shall evaluate Florida's potential as a production center for rare earths, critical minerals, and industrial byproducts for national security, supply-chain independence, meeting state infrastructure needs, supporting emerging industries, and other beneficial uses." This report addresses the first year of progress for The Center, the existing conditions pertaining to its directive, a roadmap for future development, and the potential for the State of Florida.

Rare earth and critical minerals are recognized by the United States as pivotal to national security, the economy, and future technological advancements. From cell phones to defense systems, rare earth and critical minerals play an ever-increasing role in our lives. America has access to many of these minerals but lacks an independent supply chain, leaving America vulnerable to foreign pressures on the economy and national security. Presently, China dominates the global supply chain, overseeing approximately 61% of rare earth mining, 87% of refining and processing, and 91% of product manufacturing. This monopolistic control poses a considerable threat to national security and economic stability. In response, the Federal Government has intensified efforts to promote domestic production of these vital resources investing billions in the last 5 years and is anticipated to spend billions more in the coming years. While this represents a significant investment and a time-sensitive opportunity for the State of Florida to jump-start Florida industry with federal support, substantial work remains to be done.

Florida has the unique potential to be a cornerstone of America's independent rare earth and critical minerals supply chain, especially in the extraction and processing stages. The state boasts at least 21 domestic critical minerals and other valuable raw materials, at least 34 large reservoirs of industrial byproducts containing rare earths and critical minerals, and additional industrial byproducts generated annually. Combined with Florida's 16 deepwater seaports and railroad infrastructure that supports over $100 billion in annual freight cargo, Florida has the assets to become a national production center for rare earth and critical minerals.

Additionally, with a focus on rare earth and critical minerals production, the State can lead the way in the reuse of industrial byproducts. Florida has large quantities of industrial byproducts which contain rare earths or critical minerals, presenting valuable reuse opportunities. Embracing sustainable reuse practices, as an alternative to storage, can unlock economic and environmental advantages beyond rare earth production while aligning with critical strategic imperatives. With its rich natural resources, industrial capabilities, and economic prowess, Florida is primed to emerge as a national force in mineral extraction, development, and repurposing, thereby attracting innovative industries, mitigating environmental risks, and advancing national mineral independence. Achieving this vision necessitates a steadfast long-term strategy and unwavering focus.

In 2023, the Florida legislature recognized the State's need and potential to become a national leader in critical and rare earth minerals production when it created The Center for Rare Earths, Critical Minerals, and Industrial Byproducts. Over the last year, The Center's research has provided clarity to that vision and developed the data needed to design a clear path forward. This path will lead the State of Florida to becoming a national leader in mineral development which will benefit the people of Florida, protect Florida's natural resources, and provide Florida with economic prosperity and security.

As part of the Mag Lab, the Center has three teams of chemists and engineers studying cutting-edge research for industrial byproduct processing and extraction. The geochemistry team studies carriers of rare earths and radium and develops effective strategies for separating valuable process streams. The radiochemistry team studies separation and processing of radium and leverages collaborations with the Oak Ridge National Lab. The chemical engineering team is developing a novel rare earth separation process. This research is critical to unlocking Florida's potential to meet this strategic demand while reducing environmental liability.

To quantify the potential economic value of this research, look at the reuse potential for phosphogypsum industrial byproduct storage in Florida. There are three main reuse value streams from this phosphogypsum: gypsum (construction aggregate, soil amendment, etc.), rare earths (defense technology components, EV motors, etc.), and radium (cancer treatment radiotherapy drugs). For the storage in central Florida, there are approximately 1 billion metric tons of gypsum worth approximately $10 billion, 0.5 million tons of rare earths worth approximately $20 billion, and 20 kilograms of radium worth approximately $1 billion. These estimates refer to material resource value alone, not the downstream economic impacts. This also only looks at the beneficial reuse of one industrial byproduct. A comprehensive economic impact study should be developed aligned with the best opportunities identified for Florida.

In parallel to this cutting-edge scientific research, the Center has also evaluated the other barriers and opportunities for Florida's development of this production potential. From this evaluation, a key narrative has emerged:

- Significant federal and private funding exists and will continue to emerge in the near term to fuel the development of this industry.
- Florida has extensive natural resource assets primed for simultaneous value realization across people, environmental, and economic measures.
- Rapid industry development hinges on surgically applied influence in the areas of technology research, economic development, and natural resource management.
- Appropriate data is not readily accessible to precisely guide legislative and executive actions.
- There is a very short timeline for Florida to leverage the financial opportunities associated with this national security crisis.

The Center and its mission are critical to the State's ability to reach this goal. And in doing so ensure Florida meets its future infrastructure needs while protecting our security and environment. This can only be accomplished with support and collaboration across state government, leadership of the legislative and executive branches, and public-private partnerships. To this end, recommendations are made across all key stakeholders. Some of those key recommendations include:

- Advocate for National Critical Listing of key Florida minerals and develop a State program that mirrors the national listing programs.
- Develop and maintain the Florida Rare Earth, Critical Mineral, and Industrial Byproduct Data Repository to inform and align key stakeholders;
- Review regulatory framework affecting beneficial reuse of industrial byproducts;
- Expand research funding for processing and valorizing industrial byproducts; and
- Create a state critical minerals fund to promote the development of domestic critical mineral and rare earth production and processing capacity.

In its independent technical advisory capacity to the Florida Legislature, The Center has identified a framework by which the legislative and executive branches can act to generate exponential returns for the people of Florida, creating a robust RE/CM/IB industry to benefit all Floridians. The Center is prepared, as Florida's relevant industry subject matter expert, to facilitate the prioritization, coordination, and execution of the technical research and to establish necessary visibility and feedback systems to inform opportunities for precise future legislative and executive actions. To mark the state's progress, keep the legislative leadership apprised of the evolving markets and policies, and continue leveraging Federal or private funding and investment opportunities, The Center will provide an annual update to this report.

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What are rare earth elements, critical minerals, and industrial byproducts?

Why are rare earths and critical minerals important?

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How are industrial byproducts managed and regulated?

What industrial byproducts can be found in Florida?

How are rare earths, critical minerals, and industrial byproducts starting to be managed differently (in the US and abroad)?

2.1 Rare Earth Elements

Rare earth elements (REE) are the set of seventeen metallic elements shown in **Figure 1 - Rare Earth Elements**. This set includes the lanthanides (15 metallic elements with atomic numbers 57-71), scandium, and yttrium. Despite the name, rare earths are not particularly scarce, but they are rarely found in concentrated deposits and are therefore difficult to refine to a useable purity. REE are crucial components for many products, especially in advanced technology and defense applications. Of the 17 rare earth elements, neodymium, praseodymium, dysprosium, and terbium are especially in demand, given their use in permanent magnets for electric vehicles and wind turbines.

Globally the mining, processing, and production of REE is dominated by China. Many countries that mine rare earths still depend on China for the complex processing stages of production. Given their criticality to defense, renewable energy, electric vehicles, and other advanced technology, the United States and its allies have recently worked towards growing domestic production and processing. In the past decade, the United States has passed numerous legislations supporting the development of domestic rare earths and critical minerals production, including: the National Defense Authorization Act (NDAA), the Energy Act of 2020, the Infrastructure Investment and Jobs Act (2021), and the American Mineral Security Act of 2019.

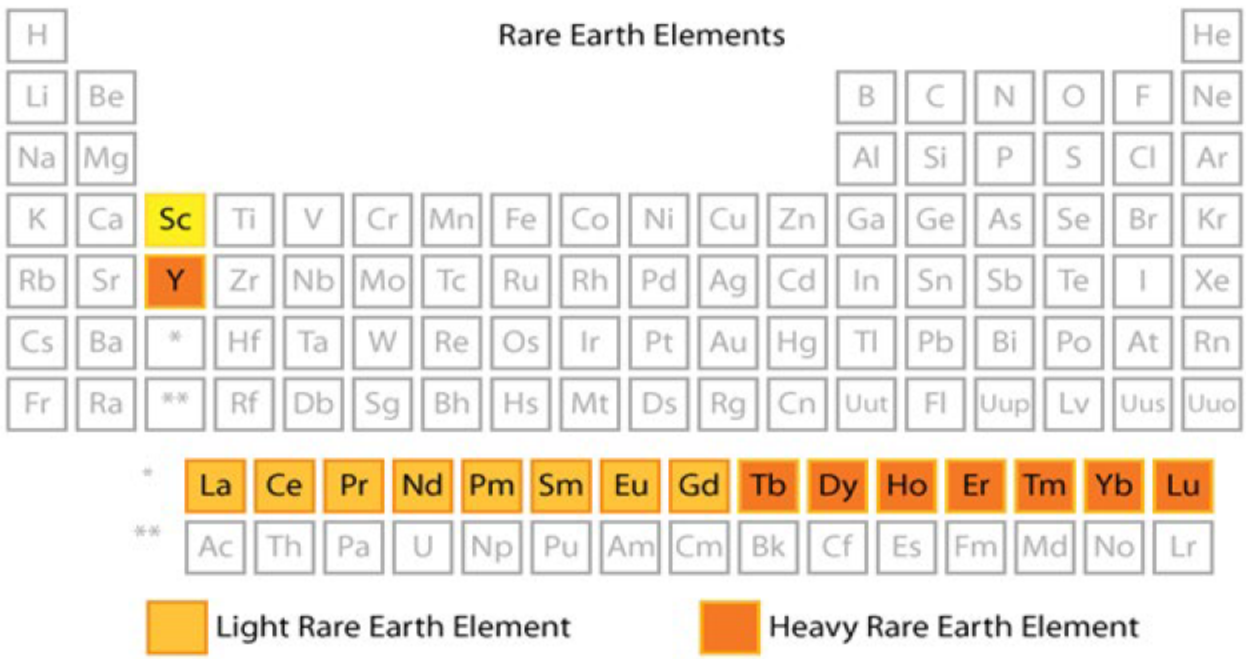


Figure 1 - Rare Earth Elements

2.2 Critical Minerals

The first US critical minerals list was developed in 2018 as directed by Executive Order 13817 (*A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*). The Energy Act of 2020 defined critical minerals as those which are essential to the economic or national security of the United States; have a supply chain that is vulnerable to disruption; and serve an essential function in product manufacturing, the absence of which would have significant consequences for the economic or national security of the US. Mineral criticality changes over time as supply and demand dynamics evolve, import reliance changes, and new technologies are developed. The Energy Act of 2020 requires the list and methodology to be reviewed at least every three years by the United States Geological Survey (USGS). The 2022 USGS Critical Mineral listing is shown in **Table 1 - 2022 USGS Critical Minerals**.

Table 1 - 2022 USGS Critical Minerals

Critical Mineral	Application(s)
Aluminum	Metallurgy and many sectors of the economy.
Antimony	Flame retardants and lead-acid batteries.
Arsenic	Pesticides and semiconductors.
Barite	Hydrocarbon production.

Critical Mineral	Application(s)
Beryllium	Aerospace and defense.
Bismuth	Medical, metallurgy, and atomic research.
Cerium	Catalytic converters, ceramics, glass, metallurgy, and polishing compounds.
Cesium	Research and development.
Chromium	Metallurgy.
Cobalt	Batteries and metallurgy.
Dysprosium	Data storage devices, lasers, and permanent magnets.
Erbium	Fiber optics, glass colorant, lasers, and optical amplifiers.
Europium	Nuclear control rods and phosphors.
Fluorspar	Cement, industrial chemicals, and metallurgy.
Gadolinium	Medical imaging, metallurgy, and permanent magnets.
Gallium	Integrated circuits and optical devices.
Germanium	Defense and fiber optics.
Graphite	Batteries, fuel cells, and lubricants.
Hafnium	Ceramics, nuclear control rods, and metallurgy.
Holmium	Lasers, nuclear control rods, and permanent magnets.
Indium	Liquid crystal displays.
Iridium	Anode coatings for electrochemical processes and chemical catalysts.
Lanthanum	Batteries, catalysts, ceramics, glass, and metallurgy.
Lithium	Batteries.
Lutetium	Cancer therapies, electronics, and medical imaging.
Magnesium	Metallurgy.
Manganese	Batteries and metallurgy.
Neodymium	Catalysts, lasers, and permanent magnets.
Nickel	Batteries and metallurgy.
Niobium	Metallurgy.
Palladium	Catalytic converters and catalysts.
Platinum	Catalytic converters and catalysts.
Praseodymium	Aerospace alloys, batteries, ceramics, colorants, and permanent magnets.
Rhodium	Catalytic converters, catalysts, and electrical components.

Critical Mineral	Application(s)
Rubidium	Research and development.
Ruthenium	Catalysts, electronic components, and computer chips.
Samarium	Cancer treatments, nuclear, and permanent magnets.
Scandium	Ceramics, fuel cells, and metallurgy.
Tantalum	Capacitors and metallurgy.
Tellurium	Metallurgy, solar cells, and thermoelectric devices.
Terbium	Fiber optics, lasers, permanent magnets, and solid-state devices.
Thulium	Lasers and metallurgy.
Tin	Metallurgy.
Titanium	Metallurgy and pigments.
Tungsten	Metallurgy.
Vanadium	Batteries, catalysts, and metallurgy.
Ytterbium	Catalysts, lasers, metallurgy, and scintillators.
Yttrium	Catalysts, ceramics, lasers, metallurgy, and phosphors.
Zinc	Metallurgy.
Zirconium	Metallurgy and nuclear.

There is some overlap between rare earth elements and critical minerals, but the distinction is worth explaining. Minerals are naturally occurring inorganic elements or compounds of multiple elements with an orderly internal structure and characteristic chemical composition, crystal form, and physical properties. Many minerals federally listed as critical by the USGS contain rare earth elements, but some do not. **Figure 2 - Elements and Minerals Deemed Critical by USGS and DOE** below shows a graphic of this relationship in the periodic table.

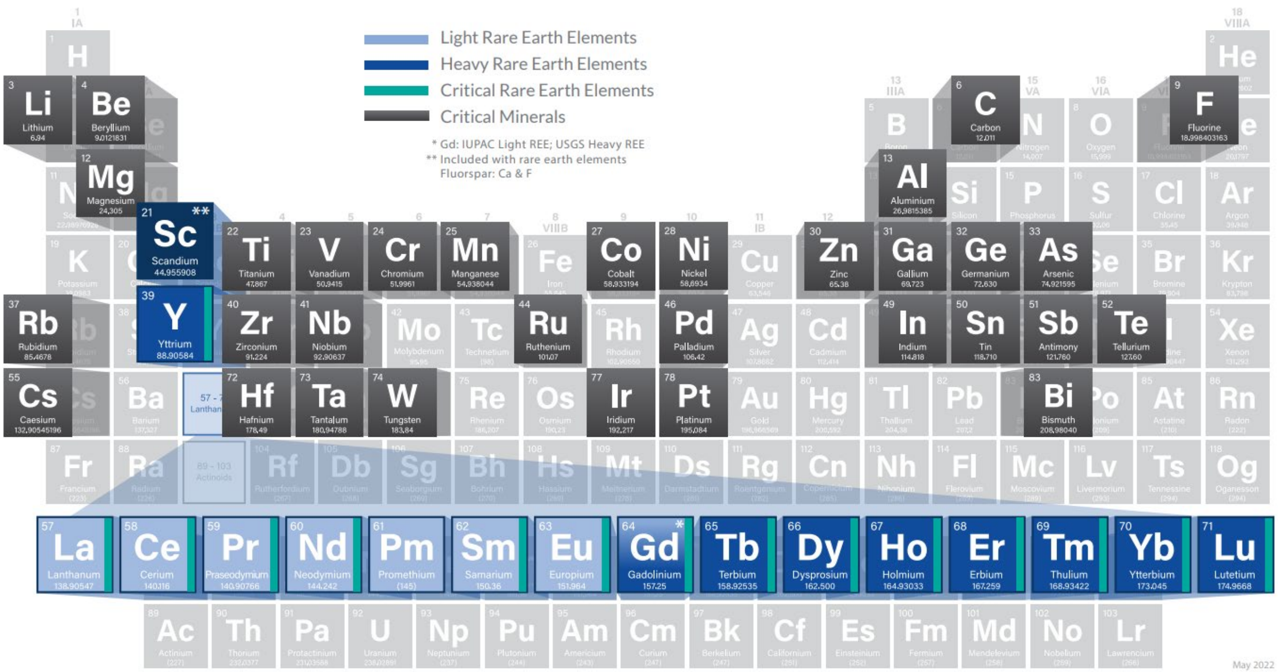


Figure 2 - Elements and Minerals Deemed Critical by USGS and DOE

The USGS catalogs geographic mineral supply through the Earth Mapping Resources Initiative (Earth MRI) which looks at natural resources and focuses on formations and deposits with the potential to contain critical mineral resources. **Figure 3 - Earth MRI Focus Areas for Potential Critical Minerals** depicts USGS focus areas based on this Earth MRI mapping of critical minerals (Dicken et al.). In Florida, the USGS and the Florida Geological Survey (FGS) have mapped deposits of rare earths and critical minerals. Currently, only four mines in northeast Florida actively mine critical minerals (zirconium and titanium). Like most of the world, Florida does not have natural concentrated deposits of rare earths. However, studies suggest an additional 10 rare earths and 9 critical minerals are present in various waste sources from the fertilizer and energy production industries of Florida.

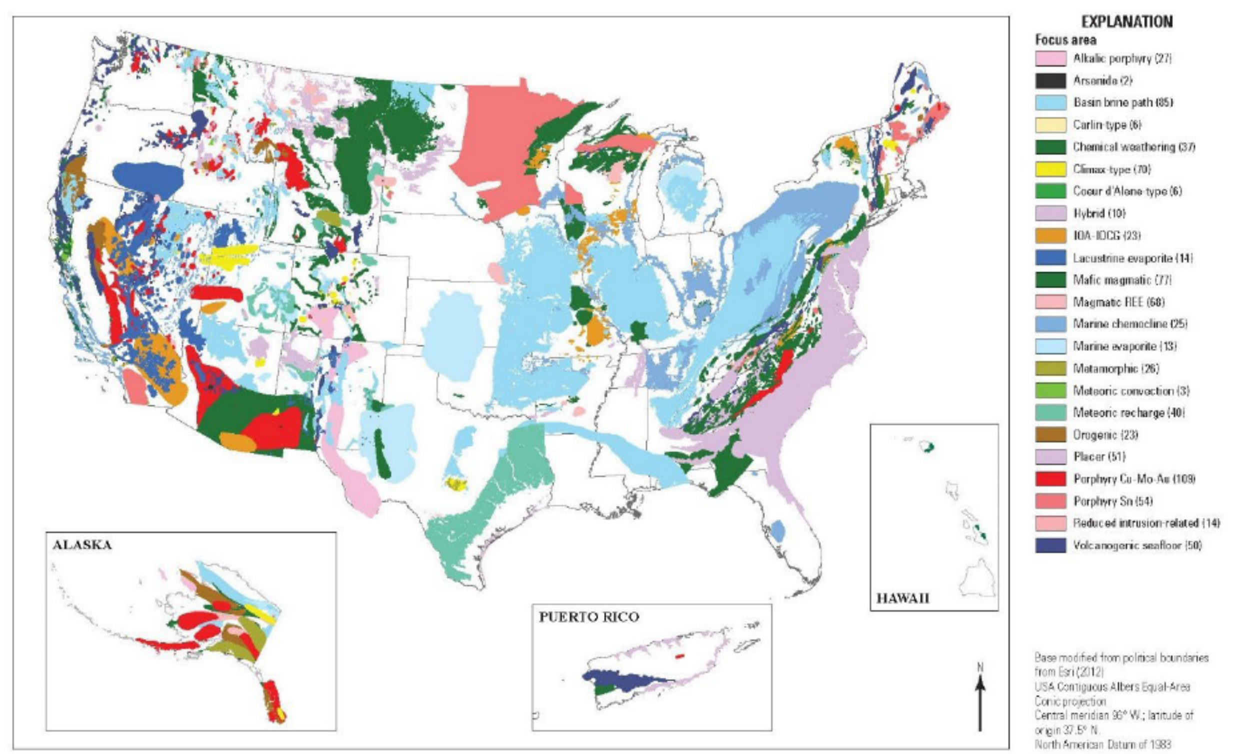


Figure 3 - Earth MRI Focus Areas for Potential Critical Minerals

2.3 Industrial Byproducts

Industrial byproducts are manufactured materials not part of the product streams of chemical industries. Some examples include phosphogypsum (phosphate manufacture), clay settling areas, coal ash (coal combustion), and red mud (aluminum refining). Many of these waste sources from the mineral industry are classified as industrial byproducts by the State of Florida, contain significant quantities of rare earths and critical minerals (Altıkulaç et al). Part IV of Chapter 403, Florida Statutes, Resource and Recovery Management, governs solid waste and solid waste management facilities in Florida. This law also exempts from regulation under the solid waste management act any industrial byproducts that meet the three stated criteria:

1. A majority of the industrial byproducts are demonstrated to be sold, used, or reused within 1 year.
2. The industrial byproducts are not discharged, deposited, injected, dumped, spilled, leaked, or placed upon any land or water so that such industrial byproducts, or any constituent thereof, may enter other lands or be emitted into the air or discharged into any waters, including groundwaters, or otherwise enter the environment such that a threat of contamination in excess of applicable department standards and criteria or a significant threat to public health is caused.
3. The industrial byproducts are not hazardous wastes as defined in s. 403.703 and rules adopted under this section.

From section 403.7045(1)(f), Florida Statues: "If the use of a material generated as part of an industrial activity meets the three above requirements, it would no longer be considered a solid waste, and therefore not be subject to regulation under the solid waste rule. 62-701.220(2)(d), F.A.C. "

At the federal level, hazardous waste is regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA). As part of this regulation, the EPA deferred hazardous waste requirements for four categories of "special wastes": cement kiln dust waste, crude oil and natural gas waste, fossil fuel combustion waste, and mining and mineral processing waste. Since the Solid Waste Disposal Act in 1980, under the Bevill and Bentsen Amendments, these special wastes have been exempted from regulation under Subtitle C of RCRA until further study due to the large volumes and low risk characteristics. Any new use of these materials would require EPA approval to assess potential human health and environmental risks.

Globally there is a wide variety of management techniques for industrial byproducts. Some nations with relaxed environmental protections allow dumping without pretreatment or containment. Coal ash, phosphatic clays, and phosphogypsum are three of the largest industrial waste streams in Florida, where the latter may have sufficient concentrations of radium that EPA regulations require storage when Ra-226 radioactivity exceeds 10 picocuries per gram. By contrast, Morocco, another major phosphate producer, dumps 20 million tons per year of phosphogypsum into the Atlantic Ocean (Chouaybi et al.). In the United States for certain industrial byproducts, neither discharge nor processing and reuse are permitted. This byproduct is therefore stored in large storage sites with liners and caps and large-scale water treatment facilities. Financial assurance regulation requires significant sums of capital be set aside to cover long-term environmental liability. The long-term financial burden of this liability can be significant, as cases such as Mississippi Phosphate and Piney Point, Florida, have proven.

Recently there has been movement in the United States and abroad to re-evaluate this storage approach. Florida Department of Transportation (FDOT) and the United States Environmental Protection Agency (EPA) are currently evaluating the suitability of processing phosphogypsum and using it as a component of road base. There are a wide variety of industrial byproducts and other "wastes" with unique re-use opportunities and challenges.

2.4 Strategic & Economic Importance

The United States currently imports approximately 80% of its raw rare earth elements from abroad, with the vast majority coming from China. The refining and processing stages are even more dominated by China. **Figure 4 - Rare Earths Global Supply Chain** from a 2022 presentation by the Australian mining and processing company Lynas Rare Earths, Ltd. shows this market domination across the supply chain. The only operational rare earths mine in the US ships its product to China for processing. Dependence on China for any stage of this supply chain for critical components to defense technology and key economic production such as renewable energy is a national security concern. China has recently shown it is willing to exploit its market control through blocking exports to specific countries and flooding the market to drive prices and profitability down. Expanding domestic production across every step of the supply chain will provide a critical national security benefit.

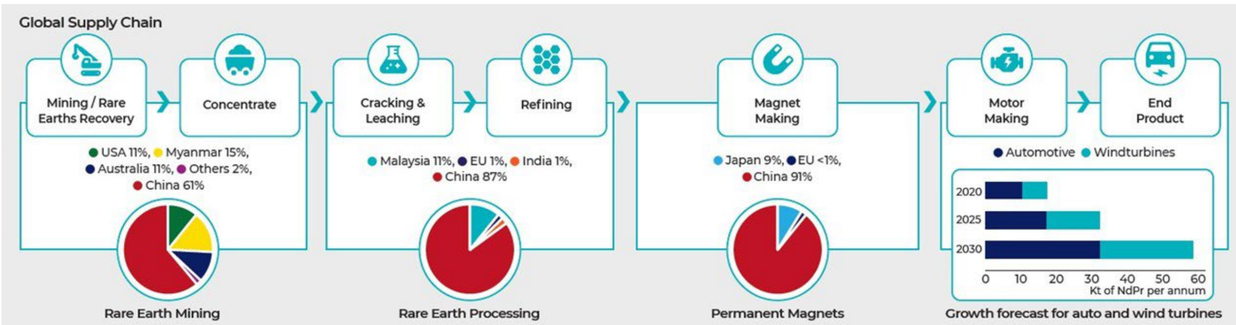


Figure 4 - Rare Earths Global Supply Chain

For decades, the country has aggressively built its rare earth mining and processing industrial base, with production increasing by an average of 40 percent per year between 1978 and 1995 ("History and Future"). During that time, China effectively shut out the rest of the world market for critical minerals by subsidizing the industry to discourage competition, taking advantage of lax environmental and labor laws, and restricting foreign investment ("Does China Pose a Threat").

In 2010, the country controlled a peak 97 percent of the supply of rare earths (Interagency Task Force). Then, during a diplomatic dispute with Japan, China abruptly slashed REE exports by 37 percent, and global prices jumped sevenfold (Bradsher). The market did not stabilize until a resolution between China and its trading partners was negotiated by the World Trade Organization in 2014. A snapshot of the current US import reliance for each mineral commodity is summarized in the figure below ("Mineral and Commodity Summaries").

Commodity	Net import reliance as a percentage of apparent consumption in 2023	Leading import sources (2019–22)[2]
ARSENIC, all forms	100	China,[3] Morocco, Malaysia, Belgium
ASBESTOS	100	Brazil, Russia
CESIUM	100	Germany
FLUORSPAR	100	Mexico, Vietnam, China, South Africa
GALLIUM	100	Japan, China, Germany, Canada
GRAPHITE (NATURAL)	100	China,[3] Mexico, Canada, Madagascar
INDIUM	100	Republic of Korea, Canada, Belgium
MANGANESE	100	Gabon, South Africa, Australia, Georgia
MICA (NATURAL), sheet	100	China, Brazil, India, Belgium
NIOBIUM (COLUMBIUM)	100	Brazil, Canada
RUBIDIUM	100	China, Germany, Russia
SCANDIUM	100	Japan, China, Germany, Philippines
STRONTIUM	100	Mexico, Germany, China
TANTALUM	100	China,[3] Germany, Australia, Indonesia
YTTRIUM	100	China,[3] Germany, France, Republic of Korea
GEMSTONES	99	India, Israel, Belgium, South Africa
ABRASIVES, fused aluminum oxide	>95	China,[3] Canada, Brazil, Austria
NEPHELINE SYENITE	>95	Canada
RARE EARTHS,[4] compounds and metals	>95	China,[3] Malaysia, Japan, Estonia
TITANIUM, sponge metal	>95	Japan, Kazakhstan, Saudi Arabia, Ukraine
BISMUTH	94	China,[3] Republic of Korea, Belgium, Mexico
POTASH	91	Canada, Russia, Belarus
STONE (DIMENSION)	87	Brazil, China,[3] Italy, Turkey
DIAMOND (INDUSTRIAL), stones	84	India, South Africa, Russia, Congo (Kinshasa)
PLATINUM	83	South Africa, Switzerland, Germany, Belgium
ANTIMONY, metal and oxide	82	China,[3] Belgium, India, Bolivia
ZINC, refined	77	Canada, Mexico, Peru, Republic of Korea
BARITE	>75	India, China,[3] Morocco, Mexico
BAUXITE	>75	Jamaica, Turkey, Guyana, Australia
IRON OXIDE PIGMENTS, natural and synthetic	75	China,[3] Germany, Brazil, Canada
TITANIUM MINERAL CONCENTRATES	75	South Africa, Madagascar, Australia, Canada
CHROMIUM, all forms	74	South Africa, Kazakhstan, Russia, Canada
PEAT	74	Canada
TIN, refined	74	Peru, Bolivia, Indonesia, Malaysia
ABRASIVES, silicon carbide	73	China,[3] Brazil, Canada, Netherlands
SILVER	69	Mexico, Canada, Poland, Switzerland
COBALT	67	Norway, Canada, Finland, Japan
GARNET (INDUSTRIAL)	67	South Africa, Australia, China,[3] India
RHENIUM	60	Chile, Canada, Germany, Kazakhstan
ALUMINA	59	Brazil, Australia, Jamaica, Canada
VANADIUM	58	Canada, Brazil, Austria, Russia
NICKEL	57	Canada, Norway, Finland, Russia
DIAMOND (INDUSTRIAL), bort, grit, and dust and powder	56	China,[3] Republic of Korea, Ireland, Russia
MAGNESIUM COMPOUNDS	52	China,[3] Israel, Canada, Brazil
GERMANIUM	>50	Belgium, China, Canada
IODINE	>50	Chile, Japan
MAGNESIUM METAL	>50	Canada, China,[3] Israel, Taiwan
SELENIUM	>50	Philippines, Mexico, Germany, Canada
TUNGSTEN	>50	China,[3] Germany, Bolivia, Vietnam
SILICON, metal and ferrosilicon	<50	Brazil, Russia, Canada, Norway
COPPER, refined	46	Chile, Canada, Mexico
ALUMINUM	44	Canada, United Arab Emirates, Bahrain, Russia
PALLADIUM	37	Russia, South Africa, Italy, Canada
LEAD, refined	35	Canada, Mexico, Republic of Korea, Australia
MICA (NATURAL), scrap and flake	28	China, Canada, India, Finland
PERLITE	26	Greece, China, Mexico
LITHIUM	>25	Argentina, Chile, China, Russia
TELLURIUM	>25	Canada, Germany, Philippines, Japan
SALT	25	Canada, Chile, Mexico, Egypt
BROMINE	<25	Israel, Jordan, China[3]
ZIRCONIUM, ores and concentrates	<25	South Africa, Australia, Senegal, Russia
CEMENT	22	Turkey, Canada, Greece, Mexico
VERMICULITE	20	South Africa, Brazil, Zimbabwe

Figure 5 - US Net Import Reliance (2023)

More recently, U.S. rare earth imports from China were temporarily hit with 25 percent tariffs as part of the 2018-2019 trade skirmish between China and the United States. In December 2023, China announced a ban of rare earth extraction and separation technologies (Baskaran).

With the extensive use of REEs in critical weapons, defense and communication systems, U.S. policymakers are particularly concerned about the national security implications of dependence on Chinese metals. A comprehensive interagency effort to build a domestic, vertically integrated REE supply chain is underway, including the departments of Defense, Energy, Interior and State.

- (**December 2017**) Executive Order 13817: A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals
- (**February 2018**) USGS designates 35 minerals as critical to economic and national security
- (**September 2019**) USGS begins Earth Mapping Resource Initiative (Earth MRI) to collect more data on rare earth deposits
- (**June 2019**) US Department of Commerce publishes "2019 Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals"
- (**September 2020**) Executive Order 13953: Addressing the Threat to Domestic Supply Chain from Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries
- (**December 2020**) Congress signs the Energy Act of 2020 into law
- (**February 2021**) Executive Order 14017: Securing America's Supply Chains
- (**March 2022**) Presidential authorization to use Defense Production Act Title III authorities to increase domestic mining and processing of critical minerals
- (**August 2022**) CHIPS and Science Act authorized funding for domestic research, commercialization, and manufacturing of semiconductors
- (**August 2022**) Inflation Reduction Act authorized funding for climate change and domestic energy production including tax incentives aimed at domestic manufacturing
- (**October 2022**) American Battery Materials Initiative was launched to leverage and maximize ongoing efforts throughout the US Government to meet resource requirements and bolster energy security
- (**December 2022**) National Defense Authorization Act included a provision requiring a federal strategy be developed to recycle and recover critical minerals from batteries used in the federal electric vehicle fleet

In response to EO 13817, the Department of Commerce published a report in June 2019 addressing strategies to reduce US reliance on critical minerals, increase recycling and substitutions, improve trade relationships in critical minerals, and develop better mapping and permitting processes. The strategies proposed by the Department of Commerce are based on a framework of six calls to action:

- Advance transformational research, development and deployment across critical mineral supply chains.
- Strengthen America's critical mineral supply chains and defense industrial base.
- Enhance international trade and cooperation related to critical minerals.

- Improve understanding of domestic critical mineral resources.
- Improve access to domestic critical mineral resources on federal lands and federal permitting timeframes.
- Grow the American critical minerals workforce.

In 2021, under Executive Order 14017, the President of the United States declared a policy shift, stating "The United States needs a resilient, diverse, and secure supply chains to ensure our economic prosperity and national security." In accordance with this order, the Secretary of Defense submitted a report identifying risks in the supply chain for critical minerals and other identified strategic materials, including rare earth elements (as determined by the Secretary of Defense), and policy recommendations to address these risks.

The Department of Defense has established the Manufacturing Capability Expansion and Investment Prioritization (MCEIP) program, which is comprised of two portfolios: Innovation Capability and Modernization (ICAM) and Defense Production Act Investments (DPAI). A base funding summary under Executive Order 14017 and recent awards under the Strategic and Critical Minerals focus area are included in the tables below ("Industrial Base Resilience"; *Defense Production Act Investments*).

Table 2 - EO 14017 Base Funding Summary

Focus Area	FY22 ($M)	FY23 ($M)	FY24 ($M)	FY25 ($M)
Kinetic Capabilities	55	172	206	84
Microelectronics	185	99	39	33
Strategic and Critical Minerals	85	24	-	-
Castings and Forgings	5	38	41	-
Energy Storage and Batteries	-	16	-	-
Other Efforts	58	24	302	276
Total	**388**	**373**	**588**	**393**

Table 3 - Recent "Strategic and Critical Mineral" Funding Awards

Project	Company	State	Awarded ($M)	Date Awarded
Manufacturing Facility for Sintered NdFeB RE Permanent Magnets and RE Metals and Alloys	E-VAC Magnetics LLC	KY	94.1	Sep 23
Titanium Processing Plant	IperionX Limited	NC	12.7	Oct 23
Near Term Domestic Solutions for Manufacturing Innovative Organic Substrates for Defense Overmatched Technologies	Calumet Electronics Corporation	PA	39.9	Nov 23
Upcycle Waste & Scrap to Prime Units for Critical Materials	6K Additive, LLC	PA	23.3	Dec 23
Expansion of Domestic Production Capability of Nickel and Cobalt	Expansion of Domestic Production Capability of Nickel and Cobalt	MO	7.0	Mar 24
Expansion of Domestic Production Capability and Capacity of Natural Flake Graphite, La Loutre	Lomiko Metals Inc.	Canada	8.4	May 24
Expanding Domestic Capacity and Production of Cobalt for the Battery Supply Chain	Fortune Minerals Limited	Canada	6.4	May 24
Accelerated Access to Domestic Manganese Ore for Advanced Materials Assessment	South32 Hermosa	AZ	20.0	May 24

The MCEIP has also invested $10 million to explore the development of extraction technology and alternative sources of rare earth minerals from coal ash, acid mine drainage, and other waste streams. Future MCEIP investments are expected to focus on closing remaining supply chain gaps and promoting integration among the tiers. DOD expects its support of these emerging capabilities will attract additional investment in rare earths from both defense and commercial manufacturers. There has been consistent, bipartisan support and funding towards these strategic objectives at the federal level.

Over the last five years, the Federal government has invested billions of dollars in critical mineral initiatives, and over the next five years, they will invest billions more. This presents a significant opportunity for Florida to invest in these initiatives and reap substantial benefits in terms of economic growth, job creation, and technological advancement.

3 The Center: Research Framework and Roadmap

Key Questions

What is the FSU Center and its legislative directive?

What laboratory research is currently being pursued?

What data is needed for legislators, regulators, industry, and investors to make decisions?

How can we all share a common communication model?

What is the roadmap for developing this research and data?

In 2023, the Florida Legislature approved funds as a part of Specific Appropriation 143, which directed the High Magnetic Field Laboratory (Mag Lab) at Florida State University (FSU) to create The Center for Rare Earths, Critical Minerals, and Industrial Byproducts (The Center) with the following directive: "The Center shall evaluate Florida's potential as a production center for rare earths, critical minerals, and industrial byproducts for national security, supply-chain independence, meeting state infrastructure needs, supporting emerging industries, and other beneficial uses." This report addresses the first year of progress for The Center, the existing conditions pertaining to its directive, a roadmap for future development, and the potential for the State of Florida.

The Center's initiatives should be evaluated through the lenses of the people of Florida, stewardship of natural resources, and economic prosperity and security. Historically, waste storage approaches in some mining and energy projects adhered to the best-known practices of their time. However, decades of experience and research have revealed that these methods often lack a long-term perspective on economic and environmental risks and opportunities. A modern sustainability approach should explore management options that minimize long-term impacts on the community, environment, and economy.

Florida's unique stores of industrial byproducts – currently managed as liabilities – present an opportunity for environmental impact benefits while fulfilling strategic production demands. Sustainable reuse opportunities transform these liabilities into assets, reducing environmental impacts by decreasing waste volumes and sourcing materials from waste instead of new mines or land disturbances. Additionally, reducing the footprint of coal ash, clay settling areas or phosphogypsum can enhance hurricane resiliency, lower insurance liabilities, and free up financial assurance funds for research and development.

3.1 Research

Researchers at the Mag Lab have been conducting research into industrial byproducts and resource recovery prior to this legislation. Formation of The Center has funded an acceleration of this research targeted towards the stated legislative goals. Currently, three research teams are working in parallel towards complementary objectives:

I. Geochemistry (FSU): find the carriers of rare earths and radium and create effective strategies for separating the byproduct storage or process streams into clean gypsum, rare earth carbonate and radium (Ra-226) concentrates.

II. Radiochemistry (Colorado School of Mines): separate radium from gypsum, or from mineral hosts extracted from gypsum; leveraging collaborations at Oak Ridge National Laboratory (ORNL) to irradiate to Ra-226 to alpha radiotherapy products (radiopharmaceuticals).

III. Chemical Engineering (FSU): develop a novel rare earth separation process to effectively separate bulk rare earth carbonate into individual rare earths for distribution into the domestic supply chain.

An overview of this team organization is in **Figure 6 - The Center Organizational Chart** below.

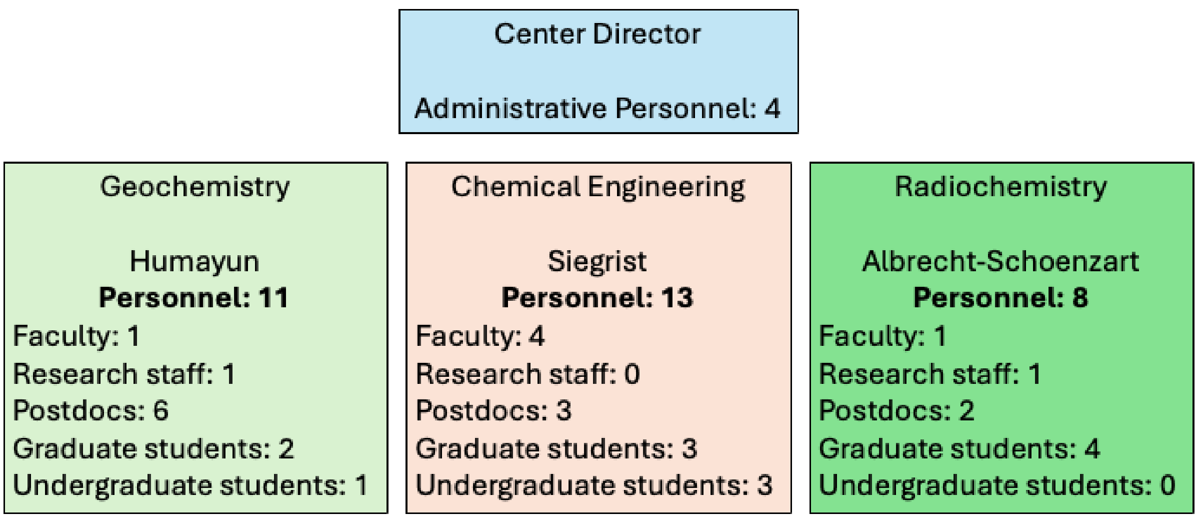


Figure 6 - The Center Organizational Chart

Industrial byproduct research has initially focused on phosphogypsum processing, as this is one of the more prominent and accessible industrial byproducts containing critical resources. Research teams have collected and analyzed samples from various locations at three different byproduct storage sites to understand changes in characteristics and processing. Funding from the state enabled the creation of a gamma ray spectrometry laboratory equipped with two sensitive, high-purity germanium detectors that can analyze low-level radium in gram-sized powdered phosphogypsum or in liquids derived from phosphogypsum. The microanalytical workflow begins with preparation of polished sections of phosphogypsum or phosphate ore that are imaged by alpha autoradiography, followed by electron microscopy that produces chemical maps of the major components of the minerals making the phosphogypsum. This is followed by laser ablation time-of-flight (TOF) mapping of the barium and rare earth elements,

elements too low in abundance to be imaged by scanning electron microscopy and energy dispersive X-ray spectrometry (SEM-EDS). The importance of microchemical analysis is illustrated in **Figure 7 - Scanning Electron Microscope Images of Trace Minerals**, where electron microscopy of phosphogypsum performed at the center reveals that mineral hosts of radium, etc., are present as grains smaller than a few microns in diameter, requiring the capabilities of modern electron microscopes for imaging. The figure below shows an example of this for phosphogypsum. The left image shows hexagonal iron phosphate crystals (roughly 3 microns in size) on gypsum. Radium is present at levels too low to form distinct radium-minerals but substitutes into other minerals, particularly those of barium. The right image is a barium X-ray map (barium presence shown in green) of a diffuse barium-rich cluster of submicron-size grains against a background of low-barium gypsum.

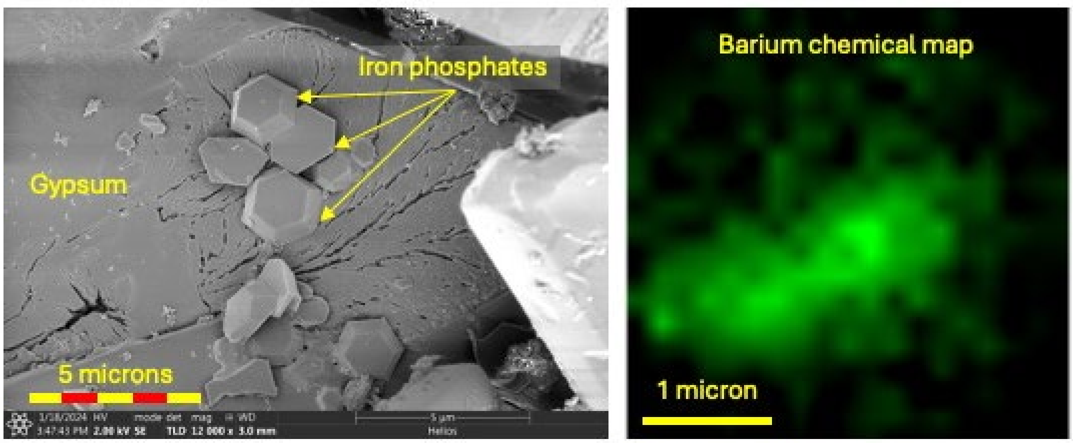


Figure 7 - Scanning Electron Microscope Images of Trace Minerals

The current research objective with the samples is to obtain a detailed picture of the mineral hosts of radium (and barium), and rare earth elements. That knowledge in turn informs the design of processes for the selective separation of these elements from the gypsum that the minerals are embedded in. That separation process is anticipated to yield a marketable gypsum product, a rare earth concentrate that would be high-graded to obtain individual rare earth elements, and a radium-rich concentrate that would be processed further to extract the isotope Ra-226. In Florida phosphogypsum, Ra-226 is a nuisance, but there is a considerable demand for pure Ra-226 as a precursor that is irradiated in the High Flux Isotope Reactor (HIFR) at Oak Ridge National Laboratory (ORNL) to form a series of medical isotopes: Ac-225, Ra-225, etc., that are in high demand for targeted alpha radiotherapy.

One of the focuses of the Center's research is separation of radium from industrial byproducts to enable viable reuse opportunities. Radioactivity inherited from the phosphate ore, particularly Ra-226, poses a radiological concern that has resulted in regulations requiring storage of the phosphogypsum byproduct. Phosphogypsum from Central Florida has Ra-226 abundances in the 15-25 picocuries per gram (pCi/g) range, while the EPA permitted maximum limit of Ra-226 in soils is 5 pCi/g. The EPA permits the use of phosphogypsum as an agricultural soil amendment at Ra-226 levels of 10 pCi/g or lower. Given the critical need to reduce Ra-226 levels in phosphogypsum, any technological solution must effectively decrease Ra-226 by factors of two to four. This reduction is essential to achieve levels below 10 pCi/g, with a preferred target of lowering Ra-226 to below 5 pCi/g for a broader scope of reuse applications. This goal is vital for ensuring safety and compliance with regulatory standards.

Early results by The Center to process phosphogypsum into these three value streams have been shared with policymakers and show significant potential. This research is critical to realizing the full scope of Florida's potential as a production center for rare earths, critical minerals, and industrial byproducts.

3.2 Necessity for a Zero Waste Framework: The Circular Economy

The concept of zero waste is not new; it is a goal pursued diligently by every high-performing business leader. Depending on the setting, many zero waste models exist, such as Lean for manufacturing, One Water for freshwater beneficial use sustainability, and Cradle to Cradle for product lifecycle management. It aims to gradually decouple economic activity from the consumption of finite resources and design waste out of the system. Inherently, waste serves nobody but adds cost to any business, industry, or civilization without providing any benefit. In this report, we use the Circular Economy as our zero-waste reference model (**Figure 8 - Circular Economy**) as it is well established for the legislative intent of this study and The Center.

Figure 8 - Circular Economy

The Circular Economy model emphasizes the continual use of resources, minimizing waste and making the most of available materials. The end goal is to establish a society where all of Florida's desired beneficial uses are sustained without the unwanted costs associated with waste—whether those costs are economic, environmental, or human. Thus, we reference the Circular Economy model to establish a clear picture of the end goal for Florida: zero waste and no unwanted costs.

3.3 Data Model – A Systems Framework

The Center appreciates that the analyses are intended to result in actions by the State of Florida, its citizens, and both existing and future corporate entities. To aid in communicating findings and facilitating the identification of precise points of influence that can generate the benefits envisioned by the Florida Legislature, The Center has developed a common framework of the processes and systems of rare earths, critical minerals, and industrial byproducts. This high-level framework describes the systems associated with beneficial use of these valuable assets.

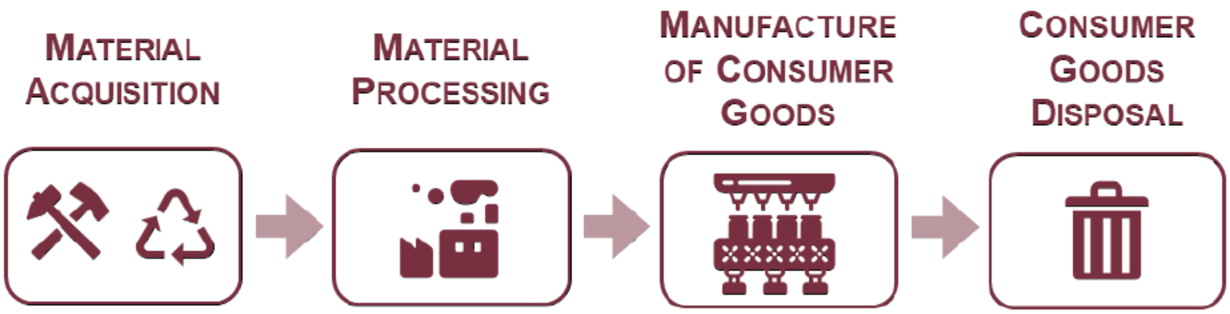


Figure 9 - Systems Framework

Figure 9 - Systems Framework demonstrates the simple model for communicating these complex interrelated systems and includes four steps: Material Acquisition, Material Processing, Manufacture of Consumer Goods, and Consumer Goods Disposal. The systems framework provides a common communication approach the Florida Legislature can use to address insights and decisions related to Rare Earths, Critical Minerals, and Industrial Byproducts.

3.3.1 MATERIAL ACQUISITION

Material Acquisition involves obtaining raw materials in their natural state or as byproducts from human activities. A mature circular-economy approach to rare earths, critical minerals, and industrial byproducts could lead to the acquisition and recovery of these assets from a very wide class of sources.

Ultimately, the potential for rare earths, critical materials, and other valuable material resourcing can stream from many sources, creating a mature circular economy to the benefit of the people of Florida, providing good stewardship of our natural resources, and ensuring a strong and healthy corporate community. The various methods of material acquisition are detailed in **Table 4 - Resource Acquisition Class** below.

Table 4 - Resource Acquisition Class

Resource Acquisition Class	Description
Mining	The process of extracting valuable minerals or other geological materials from the earth.
Process Solid Waste Recovery	The recovery of valuable materials from solid waste produced by industrial processes.
Process Wastewater Recovery	The recovery of valuable materials from wastewater produced by industrial processes.

Resource Acquisition Class	Description
Consumer Waste Recovery	The recovery of valuable materials from waste generated by consumers.
Construction Waste Recovery	The recovery of valuable materials from waste produced by construction activities.
Ocean Recovery	The recovery of valuable materials from ocean water or the ocean floor.
Recovery as Part of an Environmental Mitigation Process	The recovery of valuable materials as part of efforts to mitigate environmental damage.
Proactive Community Recycling Solicitation	The recovery of valuable materials through proactive recycling programs in communities.
Urban Mining	The recovery of valuable materials from urban environments, including buildings and infrastructure.
Recovery from Stagnant Inventories	The recovery of valuable materials from inventories that are no longer in active use.
Lake Recovery	The recovery of valuable materials from lake water or the lake bottom.

Typical inputs for material acquisition processes include raw environmental materials and stored byproducts. These inputs are transformed into extracted and collected materials ready for processing. Material acquisition processes can vary significantly based on factors such as geography/geology, current and historic technology, supply chain, corporate structure, workforce, government regulations, and many more. Outputs from materials acquisition activities are highly aligned with the inputs for Material Processing, discussed below.

3.3.2 MATERIAL PROCESSING

Material Processing refers to the refinement and conversion of raw materials into usable forms. This step transforms the extracted materials from the acquisition phase into refined elements and compounds.

Typical inputs to material processing are the resourced and acquired materials, which tend to be in the form of masses of complex materials. In the context of rare earths, critical minerals, and industrial byproducts, these inputs can be described as follows:

- **Ore and Mineral Concentrates**: These are raw materials extracted from mining operations. For rare earths and critical minerals, this includes ore containing elements like cerium, neodymium, dysprosium, and others. The concentrates may contain a mix of valuable minerals and gangue (non-valuable material) that need to be separated.
- **Industrial Byproducts**: These materials are recovered from industrial processes, such as phosphogypsum from phosphate fertilizer production, fly ash from coal combustion, and slag from metal smelting. These byproducts often contain valuable rare earth elements and critical minerals that can be extracted and refined.
- **Recycled Materials**: This includes waste from consumer goods, construction activities, and urban mining. These materials often contain mixed metals and other compounds that require separation and refinement. Examples include electronic waste, which contains rare earth elements used in components like magnets and batteries.

The material processing phase involves several steps to separate and purify the desired elements. These steps can include:

- **Crushing and Grinding**: Reducing the size of the raw material to increase the surface area for subsequent processing.
- **Physical Separation**: Techniques such as magnetic separation, gravity separation, and flotation are used to separate valuable minerals from the gangue based on their physical properties.
- **Chemical Processing**: Leaching, solvent extraction, and precipitation processes are used to dissolve and extract specific elements from the raw materials. This is common in the processing of rare earths and other critical minerals.
- **Thermal Processing**: Processes like roasting and smelting are used to extract metals from their ores by heating them to high temperatures. This is often used in the processing of metal ores and certain industrial byproducts.
- **Refining and Purification**: The final step involves refining the extracted materials to achieve the desired purity levels. This can involve further chemical treatment, electrolysis, or other purification methods.

The refined outputs are usable forms of rare earth elements, critical minerals, and other valuable materials. These outputs are then ready to be used in the manufacture of consumer goods. Examples include:

- **High-purity metals and alloys**: Such as neodymium for magnets, lithium for batteries, and platinum for catalytic converters.

- **Chemical compounds**: Such as rare earth oxides used in various high-tech applications.
- **Refined byproducts**: Such as purified gypsum from phosphogypsum for potential use in construction or agriculture. This refining process may include valuable resource recovery for extracted rare earths or critical minerals.

Understanding the inputs and outputs of material processing provides insight into the efficiency and effectiveness of the overall system. This phase is crucial for ensuring that the maximum value is extracted from the acquired materials and that the refined products meet the quality standards required for their subsequent use in manufacturing.

3.3.3 MANUFACTURE OF CONSUMER GOODS

The Manufacture of Consumer Goods involves using processed materials to produce finished products for consumers. This phase transforms the refined elements and compounds obtained from the material processing phase into market-ready products. In the context of rare earths, critical minerals, and industrial byproducts, the inputs and outputs are crucial to understand.

Typical rare earth, critical mineral, and other valuable materials inputs to the manufacture of consumer goods may include:

- **Refined Rare Earths**: Elements like neodymium, dysprosium, and terbium, essential for producing high-performance magnets, batteries, and other advanced technologies.
- **Critical Minerals**: Materials such as lithium, cobalt, and graphite, used extensively in the production of batteries, electronics, and various high-tech applications.
- **Processed Byproducts**: Materials recovered from industrial waste streams, which can be repurposed into useful components. For example, purified phosphogypsum can be used in construction materials.

Typical outputs to these processes may include:

- **Consumer Electronics:** Smartphones, tablets, laptops, and other devices that rely on rare earth elements for their screens, batteries, and electronic components.
- **Renewable Energy Components:** Wind turbine magnets, solar panel components, and electric vehicle batteries that use critical minerals to enhance performance and efficiency.
- **Advanced Manufacturing Products:** Aerospace components, medical devices, and other high-tech products that require the unique properties of rare earths and critical minerals.
- **Construction Aggregates:** Road base, landfill cover, and other construction aggregate applications for processed industrial byproducts.

Manufacturing techniques and technologies in this phase are sophisticated and specialized, focusing on transforming raw materials into high-value products. These processes include a variety of advanced engineered systems and direct work with the materials. Technologies might include chemical processing systems, which purify and combine materials to form new compounds; robotics, which automate precision tasks and assembly processes; additive manufacturing (3D printing), which creates complex and precise components; precision machining, which accurately shapes parts; and metallurgical processes, such as smelting and alloying, to produce high-purity metals. Each of these technologies is crucial for producing the high-performance and high-tolerance parts required in modern consumer goods.

3.3.4 CONSUMER GOODS DISPOSAL

Consumer Goods Disposal encompasses the end-of-life management of products, playing a crucial role in the broader waste management and recycling systems. Consumers, as active participants, significantly shape this phase by determining how products are sorted, packaged, and ultimately directed towards disposal or recovery channels. This active involvement highlights the consumer's influence over the initial steps of the disposal process, affecting the efficiency and outcome of waste management strategies.

Typical rare earth, critical mineral, and other valuable materials inputs to the consumer goods disposal system may include:

- **Household Trash:** Comprising mixed waste like food scraps, paper, and plastics, often bagged together, making separation difficult. Large items such as furniture and appliances require significant space and pose challenges in material recovery.
- **Consumer Electronics:** Includes whole appliances and small devices, which contain valuable materials like rare earth elements but are often discarded with personal data intact, complicating their processing.
- **Retail and Commercial Waste:** Consists of expired products and operational waste like unsold items and packaging materials, adding to the waste volume.
- **Specialty Items:** Such as batteries and oils, collected separately but sometimes mixed with general waste, necessitating careful handling due to their hazardous nature.

These inputs illustrate the complexity and diversity of waste streams, each requiring tailored handling strategies to mitigate environmental impacts and maximize material recovery.

The outputs from the Consumer Goods Disposal system are diverse, reflecting the varied nature of the inputs and the consumer's role in sorting and packaging:

- **Landfill Storage:** Where mixed and often unsorted waste accumulates, including non-recyclable materials that have not been separated for recovery.

- **Separated Recyclable Materials:** Includes sorted materials like paper, plastics, metals, and glass, processed through materials recovery facilities or curbside recycling programs.
- **Residual Contaminants:** Such as leachate, which can contaminate groundwater and soil, and greenhouse gases like methane, produced by the decomposition of organic waste in landfills.
- **Incineration Ash and Emissions:** Ash containing heavy metals and other toxins, and flue gases that must be treated to remove harmful pollutants.

The disposal process also yields hazardous waste outputs from items like chemicals and pharmaceuticals, which require special treatment, and electronic waste residues, where components are removed for recycling, but residual materials often end up in landfills.

3.4 Federal Program Alignment

One of the missions of The Center in a funded five-year strategic plan would be to track existing federal programs and initiatives to inform alignment with them at the state level and capitalize on opportunities. This includes research, funding programs, regulatory changes, revisions to the federal critical mineral program, and public-private projects such as the DOD-Lynas venture in Texas.

According to the USGS, "Extracting critical minerals from waste streams is one of a few solutions that several federal agencies, research institutions, and public/private ventures in the U.S. are pursuing. Federal agencies such as the Department of the Interior's USGS and Office of Surface Mining Reclamation and Enforcement, the Department of Energy, and the Environmental Protection Agency are investigating innovative and environmentally sustainable potential sources for critical minerals, such as obtaining rare earth elements from coal, hard rock mining wastes, acid mine drainage and various recycling and reprocessing programs." The DOD is also investing millions into the development of extraction technology and alternative sources of rare earth minerals from coal ash, acid mine drainage, and other waste streams.

3.5 Report Limitations and Future Work

This report marks the initial phase of data collection and analysis within this network of variables. Further refinement of this analysis holds the potential to uncover more accurate insights that can inform strategic actions by the State of Florida. These insights aim to enhance the well-being of Florida's residents, ensure responsible stewardship of our natural resources, and strengthen the financial resilience of Florida's corporate sector.

4 Potential Value of Rare Earth Elements, Critical Minerals, and Industrial Byproducts for Florida

Legislative Directive

Report the scientific studies that establish the potential value of the rare earths, critical minerals, and industrial byproducts.

Key Questions

What is the strategic and economic value of rare earth elements, critical minerals, and industrial byproducts?

How is this strategic and economic value projected to change over time?

What data supports this value, and how reliable and comprehensive is this data?

How can The Center improve this data over the next 3-5 years?

4.1 Introduction

Rare earth elements and critical minerals are vital components in modern technology, renewable energy, and national defense. They play a crucial role in the production of everything from smartphones and electric vehicles to military equipment and wind turbines. As global demand for these materials increases, understanding their potential value becomes essential for strategic planning and economic development.

Currently, the United States relies heavily on imports for rare earth elements and critical minerals, with a significant portion coming from China. This dependency poses both economic and national security risks. Developing a robust domestic supply chain for these resources, particularly in Florida, presents a unique opportunity to enhance economic prosperity, ensure environmental sustainability, and bolster national security.

The purpose of this section is to evaluate the potential value that rare earth elements, critical minerals, and industrial byproducts can offer to the state of Florida. By doing so, we aim to provide actionable insights for policymakers, stakeholders, and industry leaders to harness these opportunities effectively.

4.2 Framework for Communicating Value

The Center appreciates that potential value for rare earths, critical minerals, and industrial byproducts encompasses a wide range of perspectives. To foster a unified understanding in evaluating both potential and realized value, The Center has devised a comprehensive framework comprising three distinct lenses. These lenses—People of Florida, Stewardship of Natural Resources, and Economic Prosperity and Security—provide clarity and focus, shaping our methodologies for data collection and analysis. By employing this framework, The Center aims to generate well-rounded findings that cater to the varied requirements of the State of Florida.

4.2.1 LENS 1: THE PEOPLE OF FLORIDA

The primary lens focuses on the value for the people of Florida, highlighting opportunities for entrepreneurship, employment, improved living standards, health, and community development. Our aim is to align our insights with the broader public interest, ensuring that our work benefits the diverse population of the state across generations.

4.2.2 LENS 2: STEWARDSHIP OF NATURAL RESOURCES

The second lens underscores the importance of stewardship over Florida's rich natural resources, encompassing land, water, air, oceans, groundwater, and biological systems. We prioritize sustainable practices and environmental protection to minimize ecological impact and conserve our natural heritage for present and future generations.

4.2.3 LENS 3: ECONOMIC PROSPERITY AND SECURITY

The third lens concentrates on fostering a robust economic environment that promotes job creation, wealth generation, and industry growth. By supporting responsible use of rare earths, critical minerals, and industrial byproducts, we aim to stimulate innovation, attract investments, and enhance economic security. Our goal is to cultivate a resilient economy that encourages investment, ensures stability, and promotes prosperity for all Floridians.

These lenses were chosen to address the most critical aspects of developing rare earth elements, critical minerals, and industrial byproducts industries. They reflect the interconnected goals of improving public welfare, protecting the environment, and fostering economic growth. By viewing the potential value through these lenses, we provide a comprehensive perspective on the benefits these resources can bring to Florida's economy, environment, and communities, aligning with broader state and national objectives such as economic diversification, environmental sustainability, and strategic security.

4.3 Value for the People of Florida

4.3.1 ECONOMIC OPPORTUNITIES AND FEDERAL SUPPORT

The recent federal funding of over $17 million to build a domestic supply chain for critical minerals and materials underscores an interest by the Federal government to support this sector. For Florida, the implications are substantial. With an organized effort, Florida could attract comparable federal funding to support the state's unique needs in rare earths, critical minerals, and industrial byproducts (RE/CM/IB). This could lead to the development of new industries within the state, creating numerous opportunities for entrepreneurship and employment. Specifically, federal investments can help stimulate research and development activities that are essential for fostering innovation and technological advancements in this sector.

Furthermore, these projects demonstrate how federal funding can be leveraged to revitalize communities by creating good-paying jobs and ensuring meaningful community engagement. The Community Benefits Plans associated with these projects ensure that local communities benefit directly through quality job creation and the inclusion of disadvantaged communities. For Florida, this means that similar projects could not only drive economic growth but also promote social equity and community development ("Biden-Harris Administration Invests").

Building a resilient supply chain for critical minerals in Florida will not only enhance economic prosperity but also strengthen national security by reducing dependence on imports and ensuring a stable supply of these essential materials (Department of Defense, 2021).

4.3.2 CHALLENGES AND STRATEGIC IMPORTANCE

The market for strategic and critical materials often suffers from asymmetric information, where one party has more or better information than the other. This can lead to inefficiencies and misinformed decision-making, impacting the development of the critical minerals sector. Addressing this issue is crucial for Florida's efforts to build a robust and transparent critical minerals industry (Department of Defense, 2021).

Countries with lax environmental or labor regulations now produce critical materials at lower costs than the US, weakening suppliers in regions with stringent regulations (Department of Defense, 2021). The decline in U.S. production and processing of critical minerals due to stringent environmental regulations and high compliance costs underscores this vulnerability (see Mountain Pass case study, Section 7.4.1., below). By leveraging innovative technologies and sustainable practices, Florida can mitigate these challenges and enhance its competitiveness.

Florida's critical mineral economy has significant potential through the exploration of unconventional and secondary sources (Critical Minerals and Materials Program). Unconventional resources such as marine phosphates and coal ash present unique opportunities for extraction and processing, requiring innovative assessment and extraction methods. These resources align with the state's phosphate wastes including phosphatic clays and phosphogypsum, which contain valuable materials like gypsum, rare earth elements, and radium. Working with existing phosphate industry to develop unconventional phosphate resources saves the costs of exploration, mining, beneficiation and even dissolution of the rare earth host minerals, that are covered by production of phosphoric acid. By focusing on these unconventional sources, Florida can develop a robust and sustainable critical minerals industry.

4.3.3 WORKFORCE DEVELOPMENT AND STRATEGIC COOPERATION

The strategic importance of building resilient and responsible supply chains for critical minerals has been highlighted in the context of the global shift toward clean energy. According to a recent report by the Asian Development Bank (ADB), critical mineral production and processing must be integrated with global and regional supply chains for clean energy manufacturing ("Building Resilient"). This integration requires creating business- and investment-friendly environments to attract investment and promote domestic value addition beyond mining. By leveraging such strategic insights, Florida can position itself as a key player in the clean energy transition, tapping into the growing demand for sustainably sourced and processed critical minerals.

Additionally, the ADB report emphasizes that regional cooperation and engagement by multilateral organizations can help unlock opportunities and aid responsible and sustainable environmental resource management. This approach aligns with Florida's potential to collaborate with neighboring states and international partners to develop a robust critical minerals sector. Such cooperation can enhance the state's ability to attract investments, foster technological innovation, and create high-quality jobs, thereby boosting entrepreneurship and employment.

A key component of this effort is workforce development. Addressing the current deficit in skilled mining professionals is essential. Gracelin Baskaran highlights several strategies for achieving this, including (Baskaran):

1. Developing a Florida-specific workforce advisory board to include mining workforce needs.
2. Forming partnerships between mining companies and universities to enhance curriculum and provide practical experience.
3. Offering scholarship programs to support socioeconomically disadvantaged students.
4. Rebranding the mining industry to highlight its technological and environmental advancements.
5. Supporting mining education programs through capacity building and financing (Baskaran, 2024).

These initiatives can help build a skilled workforce, drive economic growth, and ensure that Florida remains competitive in the critical minerals sector.

Beyond mining, the state would need the development of a highly skilled workforce (chemists, physicists, engineers, materials scientists, environmental scientists, etc.) to develop refining of critical minerals, magnet synthesis, production of electric motors and generators, design of high temperature superconductors (MRI, nuclear fusion, etc.) and waste disposal. The growth of new industries derived from critical minerals would be coupled with the growth of STEM fields in Florida higher education institutions and the attraction of talent from beyond the state.

4.4 Stewardship of Natural Resources

4.4.1 REGULATORY PROCESSES AND CHALLENGES

The permitting process for mining operations in the U.S. often involves lengthy and complex procedures, which can delay the development of critical mineral projects. Streamlining these regulatory processes is essential to facilitate the growth of Florida's critical minerals industry while ensuring compliance with environmental standards. According to the Department of

Defense (2021), the average time to obtain permits for full-scale operations can range from seven to ten years, posing a significant challenge to timely project execution.

Balancing the need for additional supply of critical materials with environmental impact is crucial. The production of strategic and critical materials can have significant environmental impacts, including habitat destruction and pollution. However, recovery from legacy sites and the implementation of sustainable practices can mitigate these effects. According to the Department of Defense (2021), pairing reclamation efforts with production can turn past industrial waste into materials needed for green energy products, promoting both environmental sustainability and economic development.

4.4.2 SUSTAINABLE PRACTICES AND ENVIRONMENTAL BENEFITS

Emphasizing sustainable practices in the extraction and usage of rare earth elements, critical minerals, and industrial byproducts is crucial for Florida's future. According to Gielen and Papa (2021), processing existing stores of industrial byproducts and solid waste landfills can significantly reduce the emissions associated with mining activities, including transportation and processing (Gielen, Dolf, Papa). This approach supports environmental sustainability by minimizing the need for new mining activities and conserving natural resources.

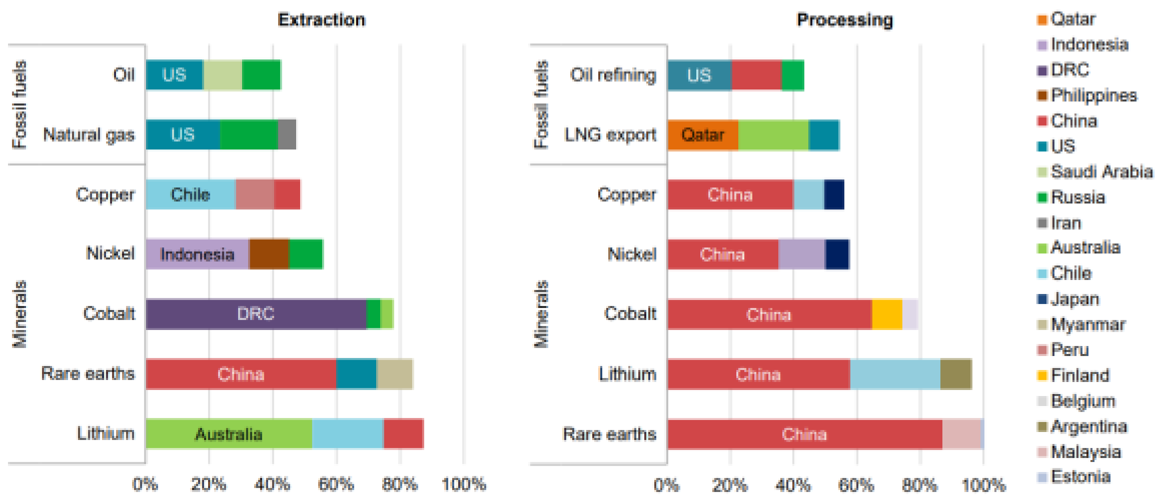
4.4.3 OPPORTUNITIES IN PHOSPHOGYPSUM REUSE

Florida's accumulated phosphogypsum presents a unique opportunity. These storage sites contain gypsum, rare earth elements, and radium, all of which can be repurposed for various industrial and technological applications. The reuse of these materials aligns with sustainable practices by reducing waste and lowering the carbon footprint associated with the extraction and processing of virgin materials. Moreover, processing these byproducts can significantly lower emissions compared to traditional mining operations. This approach not only supports environmental sustainability but also aligns with economic interests by providing a more cost-effective supply of critical materials.

4.5 Economic Prosperity and Security

4.5.1 THE STRATEGIC IMPORTANCE OF RARE EARTH ELEMENTS (REES)

China’s strategic investments and government support allowed it to dominate the global market for rare earth elements (REEs). As early as 1927, China discovered REEs and, through continuous development and state support, has become the world’s largest producer of these critical materials. By the late 1980s, China’s focus on REE mining and processing led to large-scale exports, driving other global producers out of the market (Andrews-Speed and Hove). This example highlights the importance of establishing a robust domestic supply chain for REEs in Florida.



Source: IEA (2021)

Figure 10 - Share of Top Five Countries in Critical Element Extraction and Processing

Rising tensions between China and the USA have highlighted the economic and strategic risks posed by dependency on foreign REE supplies **(Figure 10 - Share of Top Five Countries in Critical Element Extraction and Processing** (this data is not limited to rare earths). Recent policy actions to reduce Chinese dominance in REE supply chains include designating REEs as critical materials, streamlining approval processes for extraction, offering subsidies for processing, and forming international coalitions to diversify production (U.S. Department of Energy).

The current concentration of rare earth production in China poses significant supply risks, as evidenced by past price volatility and supply disruptions. To mitigate these risks, the automotive industry has been compelled to explore alternative sources and invest in new projects outside of China (Schmid). Florida, with its potential for developing REE extraction and processing capabilities, can play a crucial role in stabilizing supply chains and securing economic prosperity.

4.5.2 FEDERAL INVESTMENTS AND ECONOMIC IMPACT

The federal investments in critical minerals and materials production illustrate the potential for job creation and industry growth. Similar investments in Florida could stimulate the local economy, attract new businesses, and generate wealth. The focus on developing advanced processing techniques and technologies can drive innovation and position Florida as a leader in the rare earths and critical minerals industry. This can attract further investments and foster a culture of technological advancement. Establishing a domestic supply chain for critical minerals can enhance economic security by reducing dependence on foreign sources. This diversification can make Florida's economy more resilient and better prepared for future challenges.

To further illustrate the economic impact of the mineral industry, consider **Figure 11 - The Role of Nonfuel Minerals in the US Economy (2023)**, which maps out the value added by mineral materials to the U.S. economy. It showcases how domestically mined and processed mineral materials contribute to the gross domestic product (GDP) through various stages, including exports, imports, and recycling.

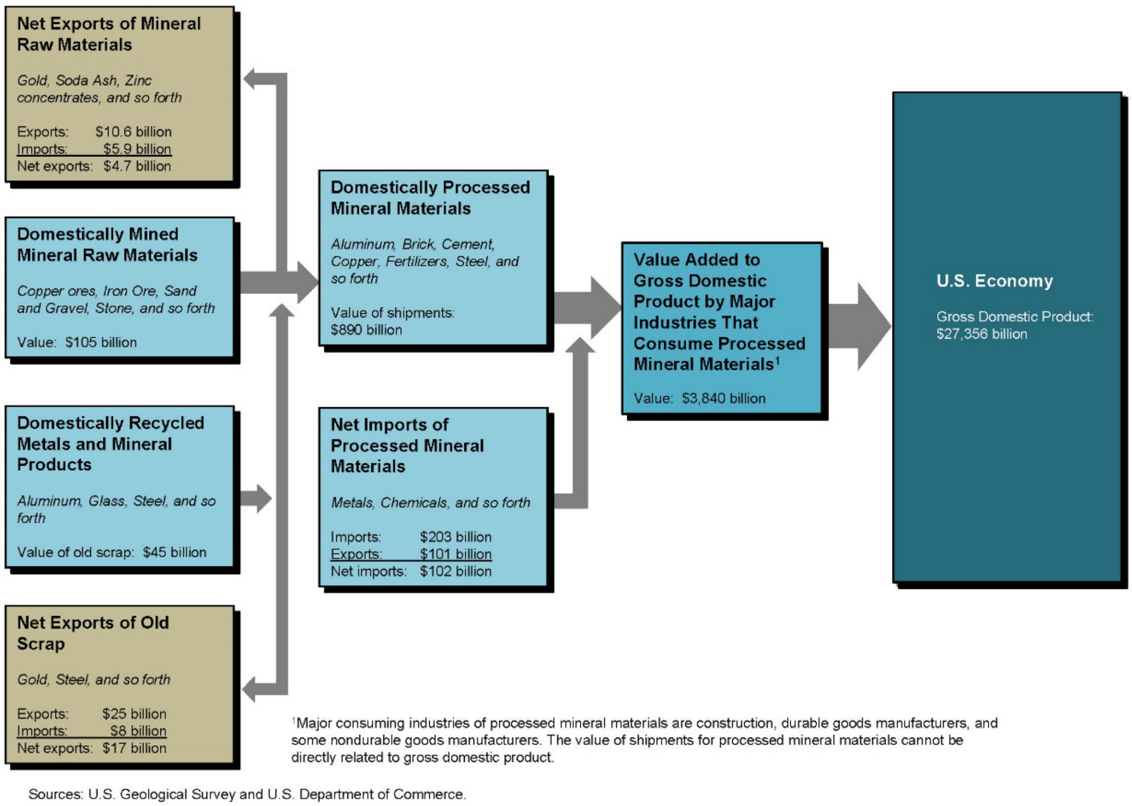


Figure 11 - The Role of Nonfuel Minerals in the US Economy (2023)

This figure highlights the critical role of domestically processed mineral materials which contribute approximately $890 billion in shipments. Additionally, it emphasizes the substantial value added to the GDP by industries consuming processed mineral materials, amounting to $3,840 billion. These figures underscore the economic significance of developing robust domestic capabilities in the processing and recycling of mineral materials.

Additionally, two tables from the 2024 USGS Mineral Commodity Summary with a detailed view of the trends in the U.S. mineral industry and its economic contributions: **Figure 12 - US Mineral Industry Trends** and **Figure 13 - US Mineral-Related Economic Trends**.

	2019	2020	2021	2022	2023[e]
Total mine production (million dollars):					
Metals	26,900	27,600	36,900	35,400	34,900
Industrial minerals	56,500	54,000	58,200	65,300	69,900
Coal	25,500	16,800	21,000	32,300	31,700
Employment (thousands of workers):					
Coal mining, all employees	51	40	38	40	41
Nonfuel mineral mining, all employees	140	136	138	143	150
Chemicals and allied products, production workers	559	537	541	570	570
Stone, clay, and glass products, production workers	312	296	300	315	310
Primary metal industries, production workers	301	272	270	282	290
Average weekly earnings of workers (dollars):					
Coal mining, all employees	1,617	1,517	1,618	1,762	1,800
Chemicals and allied products, production workers	1,066	1,065	1,103	1,119	1,200
Stone, clay, and glass products, production workers	968	981	1,017	1,086	1,100
Primary metal industries, production workers	1,027	1,006	1,073	1,172	1,200

[e]Estimated.

Sources: U.S. Geological Survey, U.S. Department of Energy, and U.S. Department of Labor.

Figure 12 - US Mineral Industry Trends

	2019	2020	2021	2022	2023[e]
Gross domestic product (billion dollars)	21,521	21,323	23,594	25,744	27,356
Industrial production (2017=100):					
Total index:	102	95	99	103	100
Manufacturing:	99	93	98	100	100
Nonmetallic mineral products	101	97	101	109	110
Primary metals:	97	87	96	95	95
Iron and steel	95	87	102	96	97
Aluminum	101	92	97	96	91
Nonferrous metals (except aluminum)	102	92	95	106	110
Chemicals	97	95	100	102	100
Mining:	121	103	106	113	120
Coal	92	69	75	77	78
Oil and gas extraction	130	122	123	130	140
Metals	96	95	92	88	85
Nonmetallic minerals	104	98	102	102	100
Capacity utilization (percent):					
Total industry:	79	73	78	80	79
Mining:	87	72	82	90	93
Metals	68	66	63	60	59
Nonmetallic minerals	88	82	86	87	87
Housing starts (thousands)	1,292	1,397	1,606	1,551	1,400
Light vehicle sales (thousands)	16,961	14,472	14,947	13,754	15,500
Highway construction, value, put in place (billion dollars)	99	103	104	114	130

[e]Estimated.

Sources: U.S. Department of Commerce and Federal Reserve Board.

Figure 13 - US Mineral-Related Economic Trends

Figure 12 - US Mineral Industry Trends shows total mine production values for metals, industrial minerals, and coal, as well as employment and average weekly earnings for various sectors within the mining industry. This table highlights the significant economic activities and employment opportunities generated by the mineral industry.

Figure 13 - US Mineral-Related Economic Trends provides insights into the gross domestic product (GDP) contributions from the industrial production of mineral products. It includes detailed indices for manufacturing sectors and capacity utilization, showcasing the broader economic impact of mineral-related industries.

Figure 14 - Value of Nonfuel Mineral Commodities Produced by State (2023) provides a geographical perspective on the value of nonfuel mineral production across the United States.

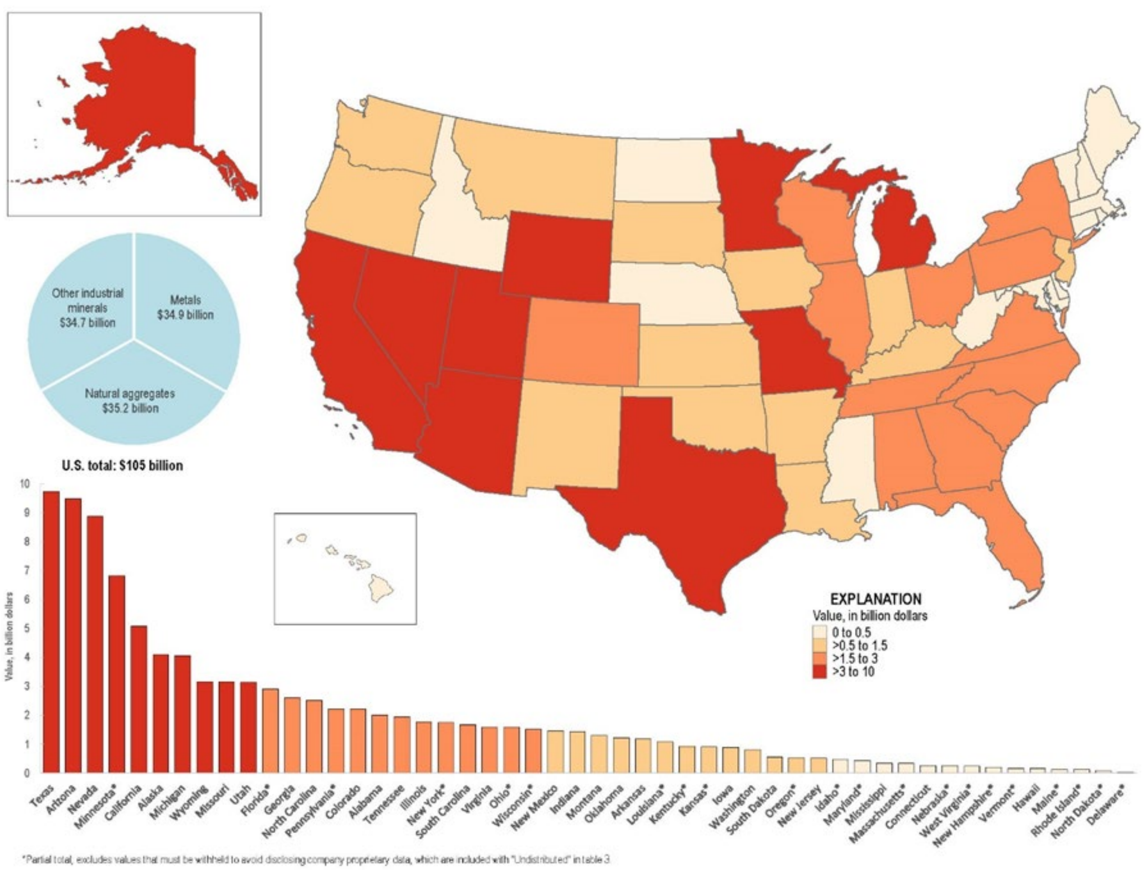


Figure 14 - Value of Nonfuel Mineral Commodities Produced by State (2023)

This figure illustrates the economic impact of nonfuel mineral production by state, emphasizing the substantial value generated in states like Texas, California, and Nevada. It highlights the distribution of mineral production value across the country and underscores the potential for states like Florida to enhance their economic contributions through the development of robust mineral production capabilities.

4.5.3 ESTABLISHING POTENTIAL VALUE FOR FLORIDA

To further contextualize the potential for Florida, consider the case of the Round Top mine in Texas. Starting in 2023, USA Rare Earth will be mining 950 acres of state land at the Round Top deposit in Sierra Blanca, Texas. The mine is likely to yield 16 of the 17 rare earths and more than 300,000 metric tons of REO. The company intends to process ores on site and eventually create a fully domestic supply chain of rare earth magnets – consolidating nearly every aspect of the manufacturing process within the nation's borders. The operation is expected to meet 17 percent of projected U.S. demand with $140 million in annual sales.

According to the company, the Round Top project is likely to produce nearly $400 million in economic impact, plus another $200 million from magnet production. Once up and running, USA Rare Earth expects its facility to provide between 130 and 195 direct, full-time permanent jobs with above-average salaries. And the company plans to use a proprietary process to reduce the environmental impacts that similar operations experience elsewhere.

Additionally, USA Rare Earth's expansion into Stillwater, Oklahoma, demonstrates how even the same company will scale out and expand across logical resource acquisition, processing, and consumer product manufacturing footprints (Francis-Smith). The Stillwater facility, a first-of-its-kind $100 million manufacturing plant, will bring into domestic production nearly half of the 50 critical minerals identified by the U.S. Geological Survey as critical to national security and the economy. This expansion is expected to create over 100 new jobs and generate significant wages, showcasing the economic benefits of developing a domestic supply chain for critical minerals.

In Florida, the potential economic value of this industry is significant. Florida does not have the world-class natural rare earth deposits of the California desert or west Texas, but Florida has critical resources accessible without mining. Florida's biggest opportunities in the rare earth and critical mineral economy lie in extraction and separation from waste, processing, and downstream production.

For an example of this potential economic value, look at the reuse potential for phosphogypsum storage in Florida. There are three main reuse value streams from this phosphogypsum: gypsum (construction aggregate, soil amendment, etc.), rare earths (defense technology components, EV motors, etc.), and radium (cancer treatment radiotherapy drugs). For the accumulated phosphogypsum in central Florida, there are approximately 1 billion metric tons of gypsum worth approximately $10 billion, 0.5 million tons of rare earths worth approximately $20 billion, and 20 kilograms of radium worth approximately $1 billion. These estimates refer to material resource value alone, not the downstream economic impacts.

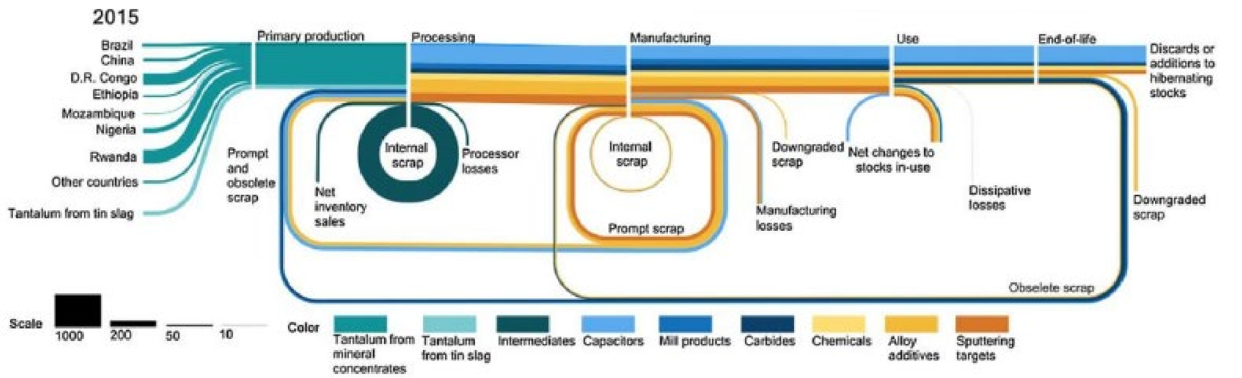


Figure 15 - Sample Material Flow Diagram, Tantalum

Material flow analyses, such as the one illustrated in **Figure 15 - Sample Material Flow Diagram, Tantalum** from the Department of Defense, are crucial for understanding the pathways and economic potential of critical materials. By mapping the flow of materials through various stages of extraction, processing, and end-use, these analyses help identify key points for resource efficiency and supply security. The reuse potential for Florida's phosphogypsum can similarly be mapped to highlight economic opportunities and inform strategic decisions.

4.5.4 INNOVATION AND TECHNOLOGICAL ADVANCEMENT

Implementing low-cost, environmentally friendly recovery technologies in Florida can significantly enhance the state's critical minerals industry. For instance, the successful project by Altex Technologies Corporation, which developed a novel sorption technology to recover minerals from produced water, highlights the potential for similar innovative approaches in Florida (Altex). Such technologies not only reduce dependency on imports but also promote sustainable practices and economic viability, positioning Florida as a leader in the critical minerals sector.

4.5.5 ECONOMIC SECURITY THROUGH DIVERSIFICATION

Building a resilient domestic supply chain for critical minerals is strategically crucial for Florida's economic and national security. The Critical Minerals and Materials Program's focus on unconventional and secondary sources demonstrates the potential for Florida to lead in this area (National Energy Technology Laboratory). The concentration of supply and reliance on single-source suppliers for critical materials present significant risks to the stability of supply chains. Diversifying supply sources is essential to enhance economic security and mitigate the risks associated with supply disruptions. The Department of Defense (2021) notes that the lack of supplier diversity creates vulnerabilities, as a large portion of global supply is subject to single-point disruption risks, such as natural disasters and shifting industrial policies. By developing extraction and processing technologies tailored to the state's unique resources, Florida can reduce dependency on foreign sources, stimulate economic growth, and bolster national security.

4.6 Data

The established source type credibility in descending order is primary source, published meta-analysis of existing literature, published peer reviewed studies/reports/books, government/agency sourced data, regulatory/government committee reports, privately/industry developed reports, news articles, org reports, industry seminars. Weight of consideration given to each source listed for this study will default to this existing hierarchy and the relevance of that source.

Data from government sources which aggregated many scientific and credible sources to inform strategic and funding decisions were given the most weight. For example, economic analysis which DOD cites for significant funding projects (such as the Mountain Pass Mine in California or the Lynas USA project in Texas) was given far more weight than another scientific source.

Economic impact potential for other facets of this Florida economy are not well studied yet:

- Rare earth and critical mineral extraction from other industrial byproduct storage (coal ash and phosphatic clays)
- Rare earth recovery from other industry – active waste streams (aircraft turbine coating)
- Rare earth processing (cracking & leaching, refining)
- Rare earth product manufacturing
- Other industrial byproduct & solid waste beneficial reuse development

The data for this economic value should be further developed and maintained under this framework. In the future, The Center should be directed to continuously update and calibrate this data to inform stakeholders of the value of research and investment in this dynamic market.

4.7 Insights and Questions

This subsection delves into the key insights derived from our analysis of potential value of developing the rare earth, critical minerals, and industrial byproduct reuse systems in Florida. We will also pose critical questions that arose during our study, highlighting areas requiring further investigation or clarification. This structured approach aims to provide actionable guidance for policymakers, stakeholders, and industry leaders to realize the potential value of market development.

Insights

- Establishing a Domestic Supply Chain Enhances Economic and National Security.
- Federal Funding for Innovation and Development Drives Economic Growth.
- Implementing Sustainable Practices Minimizes Environmental Impacts.
- Advancing Recovery Technologies Promotes Sustainability and Economic Viability.
- Diversifying Supply Sources Enhances Economic Security.
- Strategic Cooperation and Partnerships Foster Technological Innovation.

Questions

- Technical understanding and research questions.
- Systems and policy development questions.
- Stakeholder engagement and collaboration

Insight: Establishing a Domestic Supply Chain Enhances Economic and National Security

Creating a robust domestic supply chain for rare earth elements and critical minerals is essential for both economic stability and national security. By reducing reliance on imports, particularly from geopolitical rivals, Florida can mitigate risks associated with supply disruptions and market volatility. A secure supply chain ensures a steady flow of these essential materials for technology, renewable energy, and defense sectors, fostering economic resilience and safeguarding national interests.

Insight: Federal Funding for Innovation and Development Drives Economic Growth

The infusion of federal funding into Florida's rare earth elements and critical minerals sector can catalyze significant economic growth. Such investments support research and development initiatives, encouraging technological advancements and fostering new industries within the state. By leveraging federal resources, Florida can attract additional investments, create high-paying jobs, and stimulate local economies, positioning the state as a leader in the critical minerals market.

Insight: Implementing Sustainable Practices Minimizes Environmental Impacts

Adopting sustainable practices in the extraction and processing of rare earth elements and critical minerals is crucial for minimizing environmental impacts. Techniques such as recycling industrial byproducts and reducing emissions from mining activities can significantly lower the ecological footprint. By prioritizing environmental stewardship, Florida can balance economic development with the preservation of natural resources, ensuring a healthier environment for future generations.

Insight: Advancing Recovery Technologies Promotes Sustainability and Economic Viability

Innovative recovery technologies are vital for promoting both sustainability and economic viability in Florida's critical minerals sector. Technologies that efficiently extract minerals from unconventional sources, such as produced water or industrial waste, not only reduce environmental impacts but also lower operational costs. These advancements enable Florida to maximize resource utilization, decrease dependency on foreign imports, and enhance the competitiveness of its critical minerals industry.

Insight: Diversifying Supply Sources Enhances Economic Security

Diversifying the supply sources for critical minerals is essential for enhancing Florida's economic security. Relying on a single or limited number of suppliers exposes the state to significant risks, including supply chain disruptions and price volatility. By developing a broad range of domestic and regional sources, Florida can ensure a stable and resilient supply chain, mitigating risks and fostering long-term economic stability.

Insight: Strategic Cooperation and Partnerships Foster Technological Innovation

Strategic cooperation and partnerships with neighboring states, international entities, and private sector stakeholders are crucial for fostering technological innovation in Florida's critical minerals industry. Collaborative efforts can drive research and development, share best practices, and pool resources for large-scale projects. These alliances enable Florida to stay at the forefront of technological advancements, enhance its competitive edge, and support sustainable economic growth in the critical minerals sector.

4.7.1 QUESTIONS: TECHNICAL UNDERSTANDING AND RESEARCH

These questions represent gaps in our insights and highlight areas requiring further investigation. The questions fall primarily within the sphere of concern for The Center and through answering will develop a deeper understanding of the complexities involved with pursuing associated value opportunities in the RE/CM/IB market.

> **How can the impact of federal funding on innovation and economic growth in Florida's rare earth elements and critical minerals sector be measured and reported?** Measuring and reporting the impact of federal funding is essential to demonstrate the value of investments. This includes developing specific metrics to track economic growth, job creation, and technological advancements resulting from federal support.

What research is needed to identify the most promising areas for federal investment in Florida's rare earth elements and critical minerals sector? Identifying areas with the highest potential for federal investment requires comprehensive research. This includes geological surveys, economic feasibility studies, and assessments of current and future market demands to guide effective allocation of resources.

How can the effectiveness of sustainable practices in reducing environmental impacts be measured and reported in Florida's rare earth elements and critical minerals sector, and what specific metrics will be used? Developing metrics to measure the effectiveness of sustainable practices is critical for environmental management. This involves defining key performance indicators (KPIs) that quantify reductions in emissions, waste, and resource consumption, and establishing reporting mechanisms to track progress.

What additional research is needed to understand the long-term environmental benefits of sustainable practices in Florida's rare earth elements and critical minerals sector? Long-term studies are necessary to fully understand the environmental benefits of sustainable practices. This research should focus on longitudinal data collection, ecosystem impact assessments, and comparative analyses of traditional versus sustainable extraction and processing methods.

How can the impact of advanced recovery technologies on sustainability and economic viability be measured and tracked in Florida's critical minerals sector, and what specific metrics will be used? Tracking the impact of advanced recovery technologies requires specific metrics that assess both sustainability and economic viability. Metrics should include resource recovery rates, cost efficiency, environmental impact reduction, and overall contribution to the circular economy.

What are the most promising recovery technologies for extracting rare earth elements and critical minerals from unconventional sources, and how can these technologies be implemented in Florida? Identifying and implementing the most effective recovery technologies is crucial for resource optimization. This involves evaluating various technologies, conducting pilot projects, and developing implementation plans tailored to Florida's unique geological and industrial context.

How can potential new supply sources for critical minerals within Florida and its regions be identified and evaluated? Identifying and evaluating new supply sources involves comprehensive geological surveys and market analysis. This research should focus on unconventional and secondary sources, assessing their feasibility, economic viability, and environmental impact.

4.7.2 QUESTIONS: SYSTEMS AND POLICY DEVELOPMENT

These questions highlight gaps that require formal actions and policy decisions, primarily within the purview of the Florida Legislature and Executive Branch. Addressing these questions will support the development of robust systems and policies to effectively manage and mitigate environmental impacts.

What specific policies or legislative actions are necessary to attract and secure federal funding for innovation and development in Florida's rare earth elements and critical minerals sector? Attracting and securing federal funding requires targeted policies and legislative actions. This includes proposing new legislation, amending existing laws, and creating incentive programs to encourage federal investment in the sector.

What specific legal or regulatory changes are needed to promote the adoption of sustainable practices in the extraction and processing of rare earth elements and critical minerals in Florida? Promoting sustainable practices requires specific legal and regulatory changes. This may involve setting environmental standards, providing tax incentives, and enforcing regulations that encourage the adoption of eco-friendly extraction and processing methods.

How can Florida create incentives and a favorable regulatory environment for industries to adopt sustainable practices and advanced recovery technologies in the extraction and processing of rare earth elements and critical minerals? Creating incentives and a favorable regulatory environment involves designing policies that reduce financial and operational barriers for industries. This includes tax credits, grants, and streamlined permitting processes to facilitate the adoption of sustainable practices and advanced technologies.

How can Florida create a strategic plan to identify, develop, and regulate new supply sources for critical minerals? Developing a strategic plan requires a comprehensive approach to identify, develop, and regulate new supply sources. This involves stakeholder consultations, resource mapping, regulatory alignment, and the creation of long-term development frameworks to ensure sustainable growth.

4.7.3 QUESTIONS: STAKEHOLDER ENGAGEMENT AND COLLABORATION

These questions emphasize the importance of engaging key stakeholders and fostering collaboration. They highlight the need for actions that bring attention and exert influence, within the scope of the Florida Legislature and Executive Branch. Addressing these questions will ensure comprehensive stakeholder involvement and support for environmental and industry initiatives.

How can Florida effectively engage key stakeholders, including local communities, industry leaders, environmental groups, and federal agencies, in the development of a domestic supply chain for rare earth elements and critical minerals? Effective stakeholder engagement requires inclusive strategies that bring together diverse groups. This involves organizing forums, creating advisory committees, and developing communication channels to ensure all voices are heard and considered in the supply chain development process.

What strategies can be implemented to foster collaboration between public and private sectors, including technology developers, mining companies, and regulatory agencies, in the development of a domestic supply chain and advanced recovery technologies for rare earth elements and critical minerals in Florida? Fostering collaboration between public and private sectors involves creating partnership frameworks, joint ventures, and public-private initiatives. These strategies should focus on aligning goals, sharing resources, and leveraging expertise to develop a robust supply chain and advanced recovery technologies.

What strategies can be implemented to build strong partnerships between state and federal agencies, as well as international entities, to secure funding for innovation and development and to promote sustainable practices in Florida's rare earth elements and critical minerals sector? Building strong partnerships requires strategic alliances and cooperative agreements. This includes developing joint funding applications, collaborative research projects, and international cooperation to secure resources and promote sustainable practices.

What policies or legislative actions are needed to promote strategic cooperation and partnerships in Florida's critical minerals sector? Promoting strategic cooperation and partnerships requires supportive policies and legislative actions. This involves enacting laws that facilitate collaboration, provide incentives for joint ventures, and remove barriers to partnership formation in the critical minerals sector.

5 Environmental Impacts

Legislative Directive
Report the environmental impacts to be eliminated or ameliorated by developing Florida's potential for producing rare earths, critical minerals, and industrial byproducts.

Key Questions
What environmental impacts could be eliminated or ameliorated by developing this production?
How can the initiative of this FSU Center align with other sustainability and resilience objectives?
How can industrial byproducts be treated as a separate opportunity for economic and environmental benefits?
What potential environmental impacts associated with this production must be mitigated and regulated?
What progress has the FSU Center made in the first year towards mitigating these environmental impacts?
What can the FSU Center and Florida executive agencies do to maintain public trust?
What data supports these estimated impacts, and how reliable and comprehensive is this data?
How can The Center improve this data over the next 3-5 years?

This section focuses on identifying and addressing the environmental impacts that can be eliminated or ameliorated by developing the rare earth and critical minerals industries in Florida. For this report, we identify an environmental impact as any adverse change to the environment resulting from human activities, affecting ecosystems, air, water, and land quality.

5.1 Approach

Our mandate at The Center was to explore the environmental impacts that could arise from the development of a broad market encompassing a variety of interrelated products and industries. This task presented a highly complex and multi-layered analysis challenge. It became evident that the prevailing environmental management frameworks in the United States, and particularly in the State of Florida, often fail to recognize the interconnected nature of these impacts, opting instead for a geographically segmented approach.

In Florida, the classification of environmental impacts is traditionally divided into three main categories: air, land, and water. However, this segmentation oversimplifies the reality. The spectrum of environmental influences extends beyond these categories to include noise, visual intrusions, and light pollution, among others. Moreover, certain impacts such as odors, which affect air quality, or oceanic factors, which influence water systems, are not adequately addressed within the existing frameworks.

Given these complexities, the current scientific understanding of Florida's earth and hydro systems is insufficient to fully characterize the potential environmental impacts of expanding the state's industries related to rare earths, critical minerals, and industrial byproducts. While our analysis has identified certain impacts, it is important to recognize that the actual benefits of developing these resources, such as the environmental advantages of reclaiming accumulated phosphogypsum in Central Florida, are likely even more significant than our findings suggest. In this report, we cautiously state that the environmental benefits, while significant, are potentially far greater than we can currently substantiate.

5.2 Overview of Methodology

Our methodology adhered to geographic point-based analyses, consistent with the frameworks used in current regulatory systems. This method evaluates environmental impacts at specific site locations. An exhaustive environmental impact assessment for each site would be ideal, mapping and quantifying every potential impact, but such a comprehensive analysis was beyond the scope and funding of this project.

Instead, The Center opted for a Systems Model approach, focusing on identifying common process outputs at each system stage and their associated environmental impacts. To prioritize our efforts, we applied the Pareto Principle, selecting a subset of outputs that, if addressed, could potentially yield the most significant environmental benefits for the State of Florida.

For quantification of these impacts, we relied on existing research and publications. This approach allowed us to utilize available data to estimate the environmental impacts, adhering to the technical scope and resources allocated to this project.

5.3 Geographic Dispersion of the RE/CM/IB Supply Chain

Understanding the environmental impacts of the rare earth and critical minerals supply chain requires an appreciation of its global dispersion. **Figure 16 - Logistics Waste in RE/CM Global Value Stream** illustrates how the semiconductor value chain, particularly in the manufacturing phase, can traverse the globe multiple times, further emphasizing the interconnectedness of environmental impacts (Semiconductor Industry Association). In just one consumer product type it is clear how globally inefficient the RE/CM value stream is. This figure only shows the consumer product manufacturing, this waste expands when considering material acquisition, processing, and consumer product waste systems. Most RE processing occurs in China, meaning that the full supply chain crosses the globe at least two more times. This geographic dispersion highlights the complexity of managing and mitigating environmental impacts effectively.

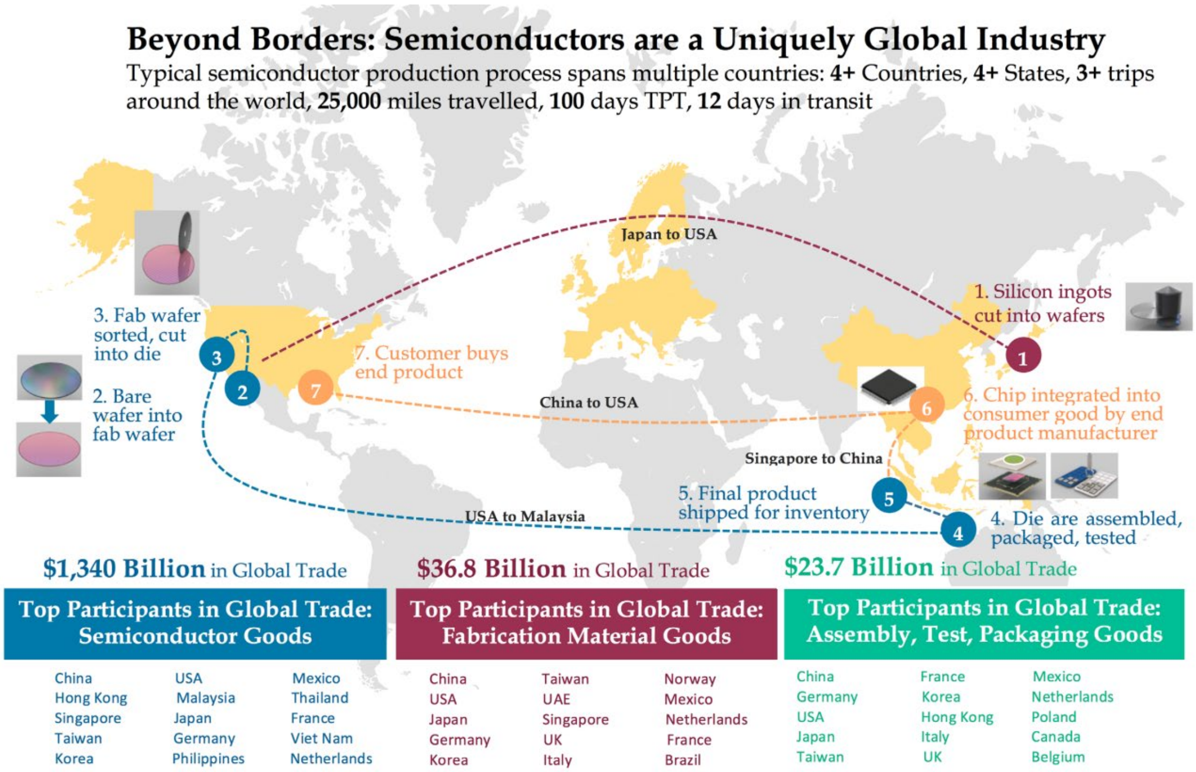


Figure 16 - Logistics Waste in RE/CM Global Value Stream

5.4 Catalog of Environmental Impacts Across the System

In alignment with **Figure 9 - Systems Framework**, we established a catalog of typical environmental impacts associated with each of the interrelated systems.

5.4.1 MATERIAL ACQUISITION ENVIRONMENTAL IMPACTS

Typical environmental impacts from rare earth and critical mineral material acquisition are detailed in

Table 5 - Material Acquisition Environmental Impacts. The environmental impacts from various classes of material recovery operations are highly diverse, primarily because these activities historically depend on the specific natural geographic and geological conditions of locations where process inputs exist.

Table 5 - Material Acquisition Environmental Impacts

Resource Acquisition Class	Regulatory Framework Media Classification		
	Air	**Land**	**Water**
Mining	Dust, emissions from machinery and explosives	Waste rock, tailings	Contaminated runoff, acid mine drainage
Process Solid Waste Recovery	Dust, particulate emissions	Residual solid waste	Leachate from solid waste
Process Wastewater Recovery	Emissions from treatment processes	Sludge from wastewater treatment	Residual contaminants in treated water
Consumer Waste Recovery	Emissions from recycling processes	Non-recyclable consumer waste	Contaminated runoff from waste handling
Construction Waste Recovery	Dust, emissions from machinery	Construction debris	Runoff containing construction materials
Ocean Recovery	Emissions from recovery vessels	Marine debris	Potential oil spills, disturbance of marine sediments
Recovery as Part of an Environmental Mitigation Process	Emissions from remediation equipment	Contaminated soil	Contaminated water from cleanup efforts
Proactive Community Recycling Solicitation	Emissions from collection and sorting processes	Non-recyclable residual waste	Contaminated runoff from collection sites

Urban Mining	Emissions from extraction processes	Electronic waste, non-recyclable materials	Contaminated runoff from urban environments
Recovery from Stagnant Inventories	Emissions from handling and processing old inventories	Obsolete materials	Potential leachate from stored materials
Lake Recovery	Emissions from recovery equipment	Sediment from lake bottom	Disturbed lake water, potential release of contaminants

Historically, the material acquisition processes associated with rare earths and critical minerals has predominantly involved mining processes. The current environmental impacts analyzed from material acquisition processes in this report are primarily associated with these mining operations.

5.4.2 MATERIAL PROCESSING ENVIRONMENTAL IMPACTS

The known environmental impacts from the material processing phase of rare earths and critical minerals are outlined in **Table 6 - Material Processing Environmental Impacts**. Although there are specific variabilities of environmental impacts within material processing, current capabilities to influence chemistry and physics properties are highly normalized leading to a much less diverse of system environmental impacts. This stage is critical for transforming raw materials acquired from various sources into usable forms through several specialized processes, each associated with distinct environmental impacts.

Table 6 - Material Processing Environmental Impacts

Material Processing Class	Regulatory Framework Media Classification		
	Air	**Land**	**Water**
Crushing and Grinding	Dust, emissions from machinery	Waste rock, tailings	Contaminated runoff, sediment discharge
Physical Separation	Dust, particulate emissions from separators	Residual solid waste, gangue	Contaminated water from separation

Chemical Processing	Emissions from chemical reactions, volatile organic compounds (VOCs)	Chemical residues, contaminated soil	Contaminated water from leaching process
Thermal Processing	Emissions from furnaces, particulate matter	Slag, other solid waste	Contaminated cooling water
Refining and Purification	Emissions from electrolysis cells, gases	Spent electrolytes, sludge	Contaminated process water

The processing of rare earths and critical minerals typically involves multiple stages, starting with crushing and grinding, which primarily generate dust and other particulate emissions, alongside significant solid waste and potential for water contamination. Advanced processes such as magnetic separation and chemical processing further introduce a variety of air and water pollutants, from VOCs to contaminated runoff. The subsequent stages, including thermal processing and refining, are notable for their contributions to air pollution and the creation of substantial solid and water waste. The cooccurrence of radioactive elements uranium and thorium in most REE deposits, as well as the use of toxic chemicals in REE processing has previously made it difficult for western producers to meet environmental standards at a cost competitive with Asian projects.

5.4.3 CONSUMER GOODS MANUFACTURING ENVIRONMENTAL IMPACTS

The known environmental impacts from the consumer goods manufacturing phase of rare earths and critical minerals are summarized in **Table 7 - Consumer Goods Manufacturing Environmental Impacts**. Consumer goods manufacturing represents the final phase in the value stream for rare earths and critical minerals, distancing it from the natural state. As such, it is the most predictable and controlled system, characterized by lower volumes and less variability in environmental impacts. This phase involves the transformation of processed materials into components or final products that reach consumers, encompassing a variety of manufacturing processes each bearing unique environmental burdens.

Table 7 - Consumer Goods Manufacturing Environmental Impacts

Consumer Goods Manufacturing Class	Regulatory Framework Media Classification		
	Air	**Land**	**Water**
Electronics Manufacturing	Emissions from soldering, assembly processes	E-waste, non-recyclable materials	Contaminated water from cleaning processes
Battery Production	Emissions from chemical reactions, particulate matter	Battery waste, spent materials	Acidic/alkaline wastewater
Renewable Energy Components	Emissions from manufacturing processes, VOCs	Waste composites, leftover materials	Contaminated process water
Aerospace Components	Emissions from machining, assembly processes	Composite waste, metal scraps	Cooling water contamination
Medical Devices	Emissions from sterilization, assembly processes	Biomedical waste, non-recyclable materials	Contaminated water from sterilization

The manufacturing of electronics, batteries, renewable energy components, aerospace parts, and medical devices each contribute distinct types of environmental pollution. For example, electronics manufacturing often leads to significant e-waste and water contamination from cleaning processes, while battery production is known for its emissions and the creation of acidic wastewater. Similarly, the production of aerospace components and medical devices not only emits harmful substances into the air but also leaves behind substantial quantities of specialized waste.

5.4.4 CONSUMER GOODS DISPOSAL ENVIRONMENTAL IMPACTS

The environmental impacts associated with the Consumer Goods Disposal phase are outlined in **Table 8 - Consumer Goods Disposal Environmental Impacts**. The outputs from consumer goods disposal mirror the complexity of the inputs from Material Acquisition. These outputs are shaped by the diverse actions of consumers who disassemble, combine, sort, and introduce materials into the waste stream. Individual priorities and classification efforts, along with varying timelines, significantly influence the nature of these outputs, adding layers of complexity to their management and processing. This phase marks the end of the lifecycle for consumer products, where various disposal methods exert distinct effects on the environment, covering air, land, and water domains. The impacts arise from the diverse processes used to handle the broad array of consumer goods entering the waste stream.

Table 8 - Consumer Goods Disposal Environmental Impacts

	Regulatory Framework Media Classification		
Consumer Goods Disposal Class	**Air**	**Land**	**Water**
Landfill Disposal	Emissions from waste decomposition, landfill gas	Landfill storage fill, leachate generation	Contaminated runoff, leachate seepage
Incineration	Emissions from burning waste, toxic fumes	Ash, slag	Runoff from ash disposal
Recycling Facilities	Emissions from processing and sorting operations	Residual non-recyclable waste	Contaminated water from cleaning processes
E-Waste Recycling	Emissions from dismantling and processing	Hazardous waste from electronic components	Runoff containing heavy metals and chemicals
Hazardous Waste Handling	Emissions from hazardous material handling	Contaminated soil	Leachate containing hazardous substances
Informal Disposal	Emissions from open burning	Illegal dumping sites	Contaminated runoff, illegal dumping

The disposal of consumer goods related to rare earths and critical minerals involves diverse environmental impacts based on the disposal method used. Landfill disposal generates methane and other gases from decomposing organic materials, along with leachate that can contaminate groundwater. Incineration reduces waste volume but emits harmful air pollutants and leaves toxic ash. Recycling facilities, crucial for material recovery, can also release dust and contaminate water. E-waste recycling requires careful handling to prevent the release of hazardous substances like heavy metals. Handling hazardous waste demands stringent controls to prevent contamination of soil and water. Informal disposal methods, such as open burning and illegal dumping, directly pollute air, land, and water, highlighting the need for stringent regulatory oversight and effective waste management practices. Each method contributes uniquely to environmental degradation, underscoring the complex challenges in managing consumer goods disposal.

5.5 Insights and Questions

This subsection delves into the key insights derived from our analysis of environmental impacts associated with the rare earth and critical minerals systems. We will also pose critical questions that arose during our study, highlighting areas requiring further investigation or clarification. This structured approach aims to provide actionable guidance for policymakers, stakeholders, and industry leaders to navigate the complex landscape of environmental impacts and opportunities.

Insights

- System Leveling Can Significantly Reduce Environmental Impacts
- Focusing on High-Density Resource Acquisition Improves Efficiency and Environmental Outcomes
- Advances in Extraction Technology Are Essential for Environmental Progress
- Positioning FSU as a National Research Hub Will Drive Economic and Environmental Benefits
- Robust Feedback Mechanisms Enhance Decision-Making for Environmental Impact
- Developing Domestic Processing Capabilities is Key to Achieving Environmental Goals

Questions

- Technical understanding and research questions.
- Systems and policy development questions.
- Stakeholder engagement and collaboration

5.5.1 INSIGHT: SYSTEM LEVELING CAN SIGNIFICANTLY REDUCE ENVIRONMENTAL IMPACTS

Our first step was to create an inventory of all the unique environmental impacts across the four systems of rare earths, critical minerals, and industrial byproducts. Initially, this comprehensive catalog revealed a broad and diverse array of environmental impacts, which seemed overwhelming and disparate.

Unsatisfied with the surface-level analysis, we conducted an affinity analysis to identify broader categories of environmental impacts. This resulted in a more streamlined view, grouping the impacts into macro categories across air, land, and water media (**Table 9 - Macro-Analysis of Environmental Impacts**). While this analysis simplified the data, it initially appeared too broad to draw specific insights. A macro analysis of environmental impacts demonstrates that an increase in any single system across the rare earths, critical minerals, and industrial byproducts systems may yield increased environmental impacts, but this actually highlights the opportunity for system leveling. Unfortunately, the scope of this study does not allow for granular analyses by site or even by industry within Florida.

Table 9 - Macro-Analysis of Environmental Impacts

Broad Environmental Impact Category	Material Acquisition	Material Processing	Consumer Goods Manufacturing	Consumer Goods Disposal
Air Pollution				
Emissions from machinery and processes	YES	YES	YES	YES
VOCs and toxic fumes	YES	YES	YES	YES
Land Pollution				
Solid waste and debris	YES	YES	YES	YES
Hazardous waste and contaminated soil	YES	YES	YES	YES
Non-recyclable materials	YES	YES	YES	YES
Water Pollution				
Contaminated runoff and leachate	YES	YES	YES	YES
Contaminated process water	YES	YES	YES	YES

At first glance, it might seem that any increase in system activity would merely amplify these environmental impacts. However, this is only the case if we overlook a crucial factor: wastes from one process can serve as inputs for another. Additionally, logistics—a significant driver of emissions waste—can be optimized if the overall ecosystem has a tighter geographic footprint.

Upon analyzing which wastes could be repurposed as inputs for other processes, we discovered that significant land wastes present opportunities for reduction if they are used effectively within the system (**Table 10 - Conversion of System Waste Into System Inputs**). Numerous existing waste streams have the potential to be converted into system inputs. With each conversion the identified waste stream is ameliorated or eliminated in addition to related land, air, and water environmental impacts, such as leachate runoff or emissions. This approach would help eliminate or ameliorate not only the identified waste, but additional related air, land, and water environmental impacts.

Table 10 - Conversion of System Waste Into System Inputs

Waste/Byproduct	Waste From System	As Input To System
Mining Tailings	Material Acquisition	Material Processing
Slag	Material Processing	Consumer Goods Manufacturing
E-waste Components	Consumer Goods Manufacturing	Material Processing
Process Wastewater	Material Processing	Consumer Goods Manufacturing
Recycled Metals	Consumer Goods Disposal	Material Processing
Recovered Rare Earths	Consumer Goods Disposal	Material Processing
Refined Byproducts	Material Processing	Consumer Goods Manufacturing
Construction Debris	Consumer Goods Disposal	Material Processing
Non-recyclable Materials	Consumer Goods Manufacturing	Consumer Goods Disposal
Hazardous Waste from E-Waste	Consumer Goods Disposal	Material Processing (Specialized)
Recycled Plastics	Consumer Goods Disposal	Consumer Goods Manufacturing

While increasing system activities inherently raises emissions, this can be counterbalanced by tightening the operational footprint across all four systems. By doing so, the current emissions can be reduced, creating a potential for offsetting emissions across the entire system.

The key to this insight lies in the lean manufacturing concept of process leveling. In this context, we refer to system leveling. There is an ideal level of activity across the four systems in Florida that would optimize environmental impacts by balancing related systems. For example, for existing mining operations, there is an ideal profile of processing and manufacturing capacity that utilizes land waste as an input and minimizes total emissions when considering both the increase in system activities and the reduction in logistics and other emissions.

A detailed, living model of existing Florida RE/CM/IB operations across the four systems would precisely inform the types and characteristics of industries that would benefit the overall environmental outcomes across the state. This model could guide which operations to initiate or accelerate to achieve the best environmental outcomes.

System leveling holds significant promise, especially since most rare earth processing is currently centralized in China due to artificially low pricing, which has monopolized the supply chain. Establishing RE/CM/IB processing in Florida offers the potential to reduce environmental impacts by leveraging historical mining and energy byproducts as an asset rather than a waste.

System leveling, often referred to as 'Heijunka' in lean methodologies, is the process of smoothing out operational workflows to achieve a more consistent and predictable output. This concept is crucial in managing production variability and balancing workloads across processes to minimize waste and enhance efficiency.

5.5.2 INSIGHT: FOCUSING ON HIGH-DENSITY RESOURCE ACQUISITION IMPROVES EFFICIENCY AND ENVIRONMENTAL OUTCOMES

The challenge of acquiring rare earth elements efficiently is largely due to their low density in natural and synthetic environments. These materials are often dispersed and not sufficiently concentrated, which complicates their extraction and requires more energy-intensive and invasive methods that can lead to greater environmental degradation. By prioritizing acquisition based on material density, Florida can enhance operational efficiency and reduce environmental impacts.

Enhanced Efficiency: Focusing on high-density sources reduces the volume of material that needs to be processed, thus lowering energy consumption, reducing the amount of waste generated, and minimizing the overall environmental footprint.

Cost Reduction: Extraction and processing costs are significantly lowered when starting with materials of higher density. These cost savings can be reinvested into R&D and more sustainable practices, further accelerating industry growth.

Environmental Benefits: By reducing the need to process vast amounts of low-density materials, the industry can lessen its impact on local ecosystems and lower its carbon emissions. Moreover, prioritizing urban and industrial byproduct recovery diverts waste from landfills and mitigates the environmental damage associated with new mining sites.

Industry Growth: With increased efficiency and reduced costs, the industry can scale operations more rapidly. This growth is supported by improved sustainability, which is increasingly demanded by consumers and regulators, potentially leading to expanded markets and new applications for REs, CMs, and IBs.

By strategically prioritizing resource acquisition based on material density, the industry not only becomes more efficient but also contributes to a more sustainable and environmentally conscious approach. This strategy requires a nuanced understanding of material distribution and a commitment to integrating advanced technologies and practices that enhance the extraction and processing phases.

5.5.3 INSIGHT: ADVANCES IN EXTRACTION TECHNOLOGY ARE ESSENTIAL FOR ENVIRONMENTAL PROGRESS

The current technologies used for extracting rare earths (REs), critical minerals (CMs), and industrial byproducts (IBs) are not efficient enough to handle the diverse and dispersed sources from which these materials can be obtained. Many potential sources, such as consumer waste, construction debris, and ocean recovery, remain underutilized due to technological limitations.

To address the inefficiencies associated with current extraction processes, technological innovation is essential. Key areas for development include:

Advanced Separation Techniques: Improving methods for separating valuable materials from waste streams, such as magnetic separation, flotation, and chemical leaching.

Enhanced Recycling Technologies: Developing new recycling processes that can handle complex consumer and industrial waste streams to recover REs and CMs more efficiently.

Sustainable Extraction Methods: Innovating eco-friendly extraction techniques that minimize environmental impact, such as bioleaching and phytomining.

Automated and Robotic Systems: Utilizing automation and robotics to enhance precision and efficiency in extracting materials from diverse sources, especially in challenging environments like oceans and landfills.

By investing in and developing advanced technologies, Florida can significantly enhance its capability to recover valuable materials from existing waste streams and underutilized sources.

5.5.4 INSIGHT: POSITIONING FSU AS A NATIONAL RESEARCH HUB WILL DRIVE ECONOMIC AND ENVIRONMENTAL BENEFITS

Establishing Florida State University (FSU) Center for Rare Earths, Critical Minerals, and Industrial Byproducts as the national hub for research in this space presents a unique and transformative opportunity. This development can lead to significant economic benefits for the community, the university, and the state of Florida. Drawing parallels with other successful research hubs, such as Norman, Oklahoma for severe weather research and Corvallis, Oregon for ocean research, we can envision the potential impact on Florida.

A relevant example of this transformation is currently unfolding in Tuscaloosa, Alabama, where the National Water Center (NWC) is becoming the nation's leading center for water research. The NWC's development has provided a clear vision of how establishing a research hub can drive economic growth and innovation. The NWC program approach is outlined below.

Vision for 2035: By 2035, Tuscaloosa is expected to be recognized as the leading center for water research in the nation. This vision highlights the convergence of research, innovation, and education to address pressing water-related issues and create sustainable solutions. Similar aspirations can be projected for FSU's Center, positioning it as a leader in rare earths and critical minerals research.

The Future Workforce: The NWC aims to nurture the next generation of scientists and leaders in applied water research, leveraging local community engagement. This approach ensures that the emerging workforce reflects the diversity of the population, inspiring future generations. FSU's Center can adopt a similar strategy, focusing on fostering a diverse and skilled workforce in rare earths and critical minerals research.

Current Partnerships: The success of the NWC is supported by a network of key partners, including:

1. **University of Alabama** - Providing infrastructure and intellectual leadership.
2. **Alabama Water Institute** - Advancing water prediction technologies.
3. **USGS Hydrologic Instrumentation Facility** - Enhancing hydrological observation and instrumentation.
4. **Cooperative Institute for Research to Operations in Hydrology (CIROH)** - Bridging university research with federal operational needs.
5. **City of Tuscaloosa** - Supporting local community engagement and infrastructure.
6. **Saban Center** - Encouraging youth engagement in STEM and arts.

Similar partnerships can be envisioned for FSU's Center, involving key stakeholders from academia, government, industry, and the community to drive collaborative research and innovation.

By developing a model like the NWC, FSU's Center can achieve several milestones in the first decade:

Establish a Strong Research Foundation: Develop state-of-the-art research facilities and attract top talent.

Forge Strategic Partnerships: Collaborate with key stakeholders to support research and innovation.

Foster Economic Growth: Drive local and regional economic development through job creation and industry partnerships.

Translate Research into Practice: Work with the private sector to develop practical applications and services based on research findings.

By establishing itself as the national hub for rare earths, critical minerals, and industrial byproducts research, FSU's Center can significantly contribute to economic development, innovation, and sustainability, benefiting all Florida citizens.

5.5.5 INSIGHT: ROBUST FEEDBACK MECHANISMS ENHANCE DECISION-MAKING FOR ENVIRONMENTAL IMPACT

To effectively eliminate or ameliorate environmental impacts through developing Florida's rare earths, critical minerals, and industrial byproducts industries, it is essential for the Florida Legislature and Executive Agencies to have robust visibility and feedback mechanisms. Such mechanisms will provide timely insights into the environmental outcomes of Florida actions.

By implementing detailed, real-time feedback mechanisms on environmental impacts, decision-makers can significantly enhance environmental protection, ensuring that both policies and industry practices contribute to tangible environmental benefits. Such feedback allows for the continuous refinement of strategies based on actual environmental outcomes, which increases policy efficiency and reduces the risk of ineffective or counterproductive measures. Furthermore, a feedback-enriched decision-making process supports sustainable industrial growth by aligning operational activities with environmental sustainability goals, fostering a balanced and responsible development of the rare earths, critical minerals, and industrial byproducts sectors.

5.5.6 INSIGHT: DEVELOPING DOMESTIC PROCESSING CAPABILITIES IS KEY TO ACHIEVING ENVIRONMENTAL GOALS

To achieve system leveling and environmental impact objectives, developing domestic rare earth processing capabilities is crucial, as most of the rare earth (RE) processing currently occurs in China. Establishing RE processing facilities within Florida will enable integration into local environmental management strategies, ensuring activities contribute positively to overall environmental goals. By localizing RE processing, Florida can better manage and mitigate the environmental impacts associated with rare earth extraction and processing, ultimately contributing to a more sustainable and environmentally responsible industry. This development not only aligns with the state's environmental objectives but also enhances Florida's strategic position in the rare earths market, reducing dependency on foreign processing and fostering economic growth within the state.

5.5.7 QUESTIONS: TECHNICAL UNDERSTANDING AND RESEARCH

These questions represent gaps in our insights and highlight areas requiring further investigation. The questions fall primarily within the sphere of concern for The Center and through answering will develop a deeper understanding of the complexities involved with associated environmental impacts that developing RE/CM/IB market in Florida will eliminate or ameliorate.

What specific environmental factors in Florida's ecosystem need to be considered in tailored impact assessments? Florida's unique ecosystem, characterized by its interconnected water systems and distinctive atmospheric patterns, requires a tailored approach to environmental impact assessments. Understanding these specific factors is crucial to developing accurate and effective mitigation strategies.

What additional research is needed to fully understand the unique environmental dynamics of Florida? The complexities of Florida's environmental dynamics, including its water systems and atmospheric interactions, necessitate further research to develop comprehensive environmental management strategies. This research will inform better policy and operational decisions.

What are the current technological gaps in the extraction of REs, CMs, and IBs, and which technologies need to be developed or improved to enhance extraction efficiency? Identifying technological gaps is essential for improving extraction efficiency and minimizing environmental impacts. Advances in technology can lead to more sustainable extraction methods, reducing the environmental footprint of these operations.

What technologies are currently available or need development to effectively process high-density materials? Processing high-density materials efficiently is crucial for reducing waste and environmental impact. Understanding current technological capabilities and identifying areas for development can help optimize processing operations and support sustainable growth.

What data and metrics are essential for creating robust feedback mechanisms to monitor environmental impacts? Establishing effective feedback mechanisms requires identifying key data and metrics that accurately reflect environmental impacts. This information is vital for ongoing monitoring and adjustment of strategies to ensure sustainable practices and intended outcomes.

5.5.8 QUESTIONS: SYSTEMS AND POLICY DEVELOPMENT

These questions highlight gaps that require formal actions and policy decisions, primarily within the purview of the Florida Legislature and Executive Branch. Addressing these questions will support the development of robust systems and policies to effectively manage and mitigate environmental impacts.

What measures and adaptations are needed to ensure and facilitate system leveling across all RE/CM/IB operations in Florida? System leveling can significantly reduce environmental impacts by optimizing the balance of activities across different operations. Identifying necessary measures and adaptations is key to implementing this strategy effectively.

What are the potential economic impacts of system leveling on local businesses and communities? Understanding the economic implications of system leveling can help policymakers balance environmental goals with economic growth. This analysis will inform strategies that support local businesses and communities while achieving environmental objectives.

How can existing environmental impact assessment frameworks be adapted to better fit the unique characteristics of Florida's ecosystem? Adapting existing frameworks to address Florida's unique environmental characteristics is essential for accurate impact assessments. This adaptation will improve the effectiveness of environmental management strategies in the state.

What investments are necessary to establish domestic processing facilities for REs, CMs, and IBs in Florida? Developing domestic processing capabilities requires significant investment. Identifying the necessary financial resources and investment strategies will support the establishment of these facilities and reduce dependence on foreign processing.

What model needs to be developed to generate feedback on the elimination and amelioration of environmental impacts through focused high-density resource acquisition and resource recovery/reuse? Developing a feedback model is critical for monitoring the success of high-density resource acquisition and recovery efforts. This model will help track environmental benefits and guide future policy and operational decisions.

How can policies and incentives be structured to support the development of domestic processing capabilities? Effective policies and incentives can drive the development of domestic processing facilities. Structuring these measures to support industry growth while ensuring environmental sustainability is key to achieving long-term success.

5.5.9 QUESTIONS: STAKEHOLDER ENGAGEMENT AND COLLABORATION

These questions emphasize the importance of engaging key stakeholders and fostering collaboration. They highlight the need for actions that bring attention and exert influence, within the scope of the Florida Legislature and Executive Branch. Addressing these questions will ensure comprehensive stakeholder involvement and support for environmental and industry initiatives.

How can stakeholder engagement be enhanced to incorporate local knowledge into environmental assessments effectively? Engaging stakeholders and incorporating local knowledge into environmental assessments can improve the accuracy and relevance of these assessments. This approach fosters community support and ensures that local concerns are addressed.

What partnerships and collaborations are essential for the success of the research hub at FSU, and what are the potential economic impacts of establishing this hub? Successful partnerships and collaborations are crucial for the research hub's success. Understanding the potential economic impacts of the hub can help attract investment and support from various stakeholders, driving innovation and economic growth.

What specific feedback mechanisms are needed to enhance decision-making for environmental impacts, and how can they be implemented effectively within existing government structures? Effective feedback mechanisms are essential for informed decision-making. Identifying and implementing these mechanisms within existing government structures will enhance the ability to monitor and respond to environmental impacts.

How can high-density resource acquisition be incentivized through policy measures? Incentivizing high-density resource acquisition can drive sustainable practices and optimize resource use. Developing policy measures that encourage this approach will support environmental goals and industry efficiency.

6 Critical Minerals

Legislative Directive

Report the minerals comprised of or contained in Florida industrial byproducts and solid wastes that are recommended for designation as critical minerals by U.S. Geological Survey.

Key Questions

What are the criteria for critical minerals as listed by USGS?

Which other state and federal perspectives may inform criticality?

What minerals are comprised of or contained in Florida industrial byproducts and solid wastes?

Which of these minerals are recommended for designation as critical minerals by the U.S. Geological Survey?

Based on these criteria, should phosphate be managed differently at the state or federal level?

What can the state of Florida do to manage critical minerals at the state level?

Issues related to security of supply for certain minerals and manufacturing materials have received increasing attention over the past two decades. Tensions and trade wars with China elevated international attention to the vulnerability of supply of rare earths. Following Executive Order 13817 (*A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals)*, the USGS developed the first US Critical Minerals List (CML) in 2018. The USGS is the federal agency responsible for reviewing and revising the methodology utilized to evaluate and update the U.S. CML. As required by the Energy Act of 2020 (Public Law 116–260, December 27, 2020, 116th Cong.), the CML is updated at least every three years. Nassar and Fortier (1) provide an overview of the process which is intended to be continually evolving to "represent current data on supply, demand, concentration of production and current policy priorities" (Burton) for non-fuel minerals in the United States (U.S. Geological Survey, Department of the Interior). As described in Nassar and Fortier (1), the USGS develops the CLM through a risk modeling framework that considers supply chain risk of various minerals based upon three primary considerations:

- Global production is concentrated in nations that may in the future be unwilling or unable to supply to the United States
- Consumption within the U.S. is currently mostly dependent on foreign supplies

- High consumption/expenditure in industries with low profitability but are important to the U.S. economy

These three primary considerations are evaluated in a series of quantitative and qualitative steps as detailed in Nasser and Fortier: the USGS relies upon the following methodology to list and evaluate the potential of a mineral to qualify as critical: quantitative evaluation of supply risk whenever sufficient data is available calculated as the geometric mean of three components traditionally used to characterize risk: hazard (i.e., disruption potential), exposure, and vulnerability.

- **Disruption potential (hazard)** is calculated as the sum of the squares of each producing country's share of global production (not including the U.S.), weighted by each producing country's willingness or ability to continue to supply (Nassar and Fortier 3) as characterized by the following indices:
- ASI (ability to supply index) for a county is based upon political stability, security, availability of labor, adequacy of infrastructure, trade barriers, regulations, taxation, uncertainties regarding protected areas and disputed land claims, and other factors that can affect a jurisdiction's attractiveness for mining activities (Nassar and Fortier 3)
- WSI (willingness to supply index) is based upon trade, ideological, and defense ties that a producing country has with the United States to provide an estimate for the likelihood it may purposefully disrupt supplies to U.S. manufacturers (Nassar and Fortier 3)
- **Trade exposure** which is a measure of the dependence of U.S. consumption on foreign sources, calculated based on imports, exports, changes in industry and U.S. stockpiles, and domestic consumption. Trade exposure ranges from 0 for a mineral commodity for which the U.S. is a net exporter to 1 for a mineral that is sourced entirely from foreign countries (Nassar and Fortier 4)
- **Economic vulnerability** is calculated based on industry expenditure on a mineral commodity relative to the industry's contribution to the U.S. gross domestic product (GDP) and its operating profit (Nassar and Fortier 4). Scoring is also on a 0 to 1 scale with higher values indicating greater vulnerability.

In addition to this quantitative approach, mineral commodities that have a single domestic producer (even if the U.S. is a net exporter of that commodity) are automatically recommended to be listed on the CML due to having a single point of failure (SPOF) (U.S. Geological Survey, Department of the Interior).

In some circumstances, the criteria for listing minerals can be highly subjective (as seen in qualitative evaluations). In that instance, a "judgment call" or qualitative evaluation focusing on circumstances not able to be defined numerically is oftentimes utilized (Layani and Adcock 52). According to the Energy Act of 2020, qualitative evidence may be used if current data is insufficient to analyze using the quantitative methodology (Nassar and Fortier 5).

The procedure and methodology behind the CML have been revised since first publication in 2018 in order to take into account outlying scenarios that arose and is intended for reevaluation every three years (U.S. Geological Survey, Department of the Interior). However, there are numerous industries that are expanding rapidly due to an increase in demand for energy technologies such as solar and electric vehicles (Ladislaw et al). These industries may eventually rely upon a critical mineral that has not yet been considered under the umbrella of the CML. This further highlights the importance of reassessing and continually revisiting the approaches on which the criteria are based. It is worth noting that legislation, under The National Strategic and Critical Minerals Production Act, has been introduced into Congress to alter the methodology and definition of the Critical Minerals List currently being used but has not yet been passed (Layani and Adcock 52).

Separate from the Energy Act of 2020, Department of Energy has provided a roadmap with the goal being to expand supplies, produce alternate resources, and to improve reuse and recycling for minerals critical to energy production in the United States. The Defense Production Act (DPA) was put in motion to increase mineral production in the United States, however it is only applied to those critical minerals relating to defense procedures and only partially overlaps with the CML (Layani and Adcock 52).

The CML brings focus to the supply chain and helps to promote policies and research focused upon the supplies most at risk. For example, development of the CML has revealed that while the U.S. has abundant mineral reserves that contain many of these critical minerals, the country is currently essentially absent from the global supply chain of more than a dozen critical minerals and more than 75% reliant on imports for an additional ten critical minerals (Humphries). Currently, the greatest impact to a mineral commodity due to listing on the CML is a heightened interest in opportunities to increase domestic supply or otherwise assure the continued reliable availability of the mineral (Layani and Adcock 52). As detailed in Layani and Adcock, once a mineral is placed on the CML, various actions can be implemented to ensure a stabilized supply chain, including:

- Multiple supply pathways
- Developing alternatives that use supplies more readily available in replacement of critical minerals
- Improved extraction and refinement methods
- Improving recycling and reuse procedures

The research and policies behind critical minerals is relatively new so at this point in time the list acts as a fast track to focus further research and generate an understanding on how best to eliminate the risk of supply chain issues before they happen. This has spurred research on mapping and identification of domestic critical mineral sources by both federal agencies (Earth Mapping) and states (Bipartisan Infrastructure Law Investments).

While listing on the CML does serve to identify the need to reduce supply risk and may expand availability for grant or other funding associated with identification, assessment, and planning related to critical mineral resources (Critical Minerals & Materials Program; Earth Mapping; National Science Foundation), it does not currently confer additional special treatment. The Mining and Minerals Policy Act of 1970 does encourage developing the mining industry through using recycling and reuse, however there is no specific provision for critical minerals (Humphries 43). For example, while several bills have been introduced just since 2021 to reduce the regulatory requirements associated with permitting related to critical minerals (e.g., H.R. 2604, H.R. 2637, H.R. 3240, S. 2965), none have passed as of the date of this report. It also does not restrict the export of critical minerals beyond any export restrictions in place due to environmental or national security considerations (15 U.S.C. § 730-774 (2024)).

Table 11 - 2022 USGS Critical Minerals Available in Florida

Aluminum (Al)	**Antimony (Sb)**	**Arsenic (As)**	Barite (Ba)	Beryllium (Be)
Bismuth (Bi)	**Cerium (Ce)**	Cesium (Cs)	**Chromium (Cr)**	**Cobalt (Co)**
Dysprosium (Dy)	**Erbium (Er)**	**Europium (Eu)**	Fluorspar (F)	**Gadolinium (Gd)**
Gallium (Ga)	Germanium (Ge)	Graphite (C)	Hafnium (Hf)	**Holmium (Ho)**
Indium (In)	Iridium (Ir)	**Lanthanum (La)**	**Lithium (Li)**	**Lutetium (Lu)**
Magnesium (Mg)	**Manganese (Mn)**	**Neodymium (Nd)**	**Nickel (Ni)**	Niobium (Nb)
Palladium (Pd)	Platinum (Pt)	**Praseodymium (Pr)**	Rhodium (Rh)	Rubidium (Rb)
Ruthenium (Ru)	**Samarium (Sm)**	**Scandium (Sc)**	Tantalum (Ta)	Tellurium (Te)
Terbium (Tb)	**Thulium (Tm)**	Tin (Sn)	**Titanium (Ti)**	Tungsten (W)
Vanadium (V)	**Ytterbium (Yb)**	**Yttrium (Y)**	Zinc (Zn)	**Zirconium (Zr)**

Table 11 - 2022 USGS Critical Minerals Available in Florida shows federally listed critical minerals, with those available in Florida in bold. Only two of these, titanium and zirconium, are actively mined in Florida today. Other unlisted minerals of interest available in Florida include gypsum, phosphate, potash, and radium. Potash was included in the 2018 list, but not the 2022 list. Most of the listed critical minerals available in Florida are found in industrial byproducts such as coal ash, phosphogypsum, clay storage areas, or oil and gas production byproducts.

The USGS maintains the critical minerals list for Congress and annually reports inventories, production, consumption, and import/export of mineral commodities. Other agencies have developed their own perspectives on mineral criticality as it pertains to their strategic objectives. For example, the Department of Energy (DOE) published its 2023 listing of critical minerals, which contained fourteen (14) minerals from the USGS listing, added two additional, and expanded the scope to include critical *materials* (electrical steel and silicon carbide). The DOE also added a time perspective to mineral criticality by projecting changes in importance to energy and supply risk over time. The DOE criticality matrices can be found below in **Figure 17 - DOE Criticality Matrix - Short Term** and **Figure 18 - DOE Criticality Matrix - Medium Term**. The DOE perspective is limited to the critical needs for energy. Thus, phosphorus is listed as a critical element for lithium-iron-phosphate batteries but shown as having a low importance to energy because of the availability of competing technologies and abundant sources for phosphorus. The main market for phosphorus is as a nutrient additive for agriculture. The risks of running out of phosphorus supply for phosphate fertilizer would make phosphate resources a matter of more serious concern. Here, the major non-US suppliers include countries in North Africa (particularly, Morocco), the Middle East, Russia and China. The finite nature of the US phosphate supply should make phosphate a critical element for domestic food production in a manner not captured in the DOE matrices below.

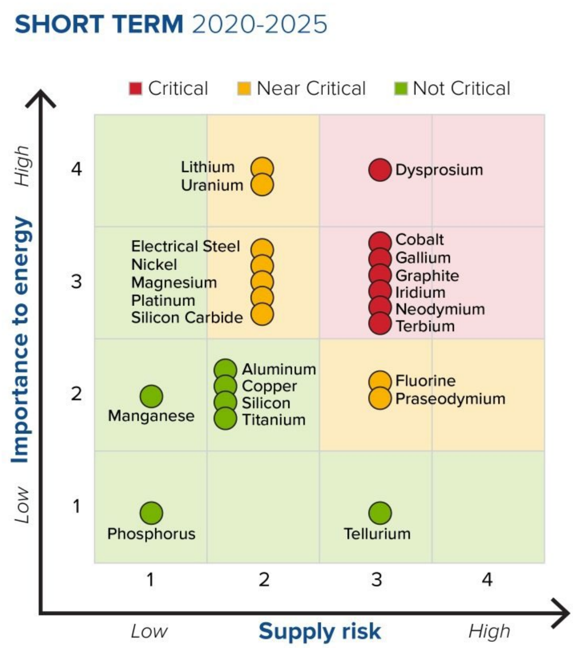


Figure 17 - DOE Criticality Matrix - Short Term

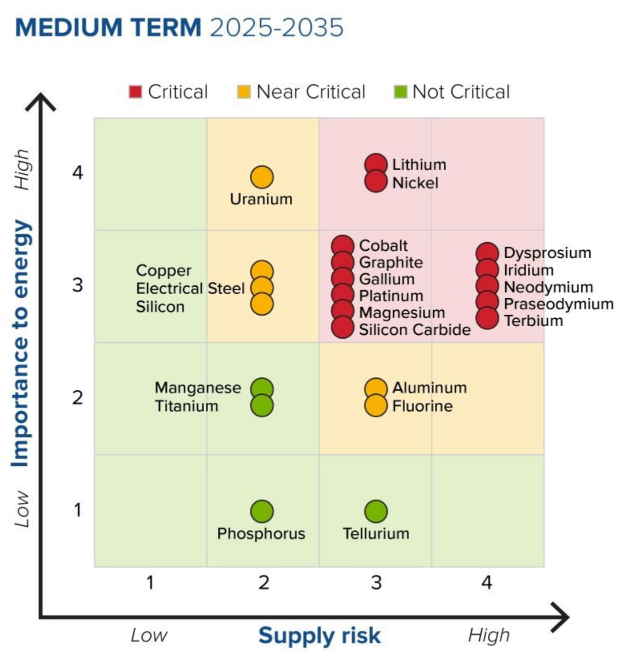


Figure 18 - DOE Criticality Matrix - Medium Term

Other federal agencies with different strategic objectives may similarly have their own perspectives on mineral and material criticality. The Department of Transportation (DOT) has minerals crucial to electric vehicle production it needs to protect. The Department of Defense (DOD) has well documented minerals – especially rare earth permanent magnets - crucial to production of the F-35 jet, Virginia and Columbia class submarines, and unmanned aerial vehicles. Other agencies such as the Department of Agriculture (USDA) or Human and Health Services (HHS) may have similar important raw materials they need to protect to secure their mission. For example, the USDA may advocate for potash and phosphate critical listing as essential for food security. The international supply of these minerals is vulnerable to disruption. The Center should keep tabs on each of these evolving criticality perspectives, especially as they pertain to the production capacity in Florida.

As the fragility of the critical minerals supply chain is further understood through USGS risk matrix preparation, federal governmental agencies outside of the DOI are asking to be better represented in the CML creation to advocate their own supply chain requirements. On June 4, 2024, the House Subcommittee on Energy and Mineral Resources held a legislative hearing to discuss several proposed bills (US Congress 2024). These bills look to solidify the contributions of additional agencies such as the Department of Health and Human Services (HSS) and the Department of Agriculture (USDA) within the CML creation and reevaluation process (US Congress 2024). HR8446 would broaden the USGS list to align with the DOE perspective and include copper, electrical steel, silicon, and silicon carbide. HR 8450 was introduced to propose adding potash and phosphate to the USGS list, and an amendment to the Energy Act of 2020 would have included uranium, phosphate and copper in the definition of critical mineral. HR 6395 has been introduced to require the Secretary of the Interior (the home department of the USGS) to consult with the Secretary of Health and Human Services before designating critical minerals, elements, substances, and materials. Other secretaries for executive agencies such as the USDA and Department of Transportation (DOT) should have similar formal consultation on the listing.

What can the state of Florida do to manage critical minerals at the state level? This should include advocacy to the federal agencies for federal listing as well as state legislative & executive agency actions regardless of federal listing status. Florida should develop its own critical minerals program mirrored after the objectives and mechanisms of the federal program and administered by the FGS. This program would develop and maintain a state critical mineral database, forecast importance and supply risk, and determine officially listed critical minerals for protection.

While state geological surveys or natural resource agencies are common, programs or legislation specific to critical minerals are less common. States that have prioritized critical minerals as a resource typically contain areas identified by the USGS as having mineral systems that could contain critical minerals ("Mineral Systems Map") and/or mining waste tailings that have the potential to contain critical minerals ("USGS Provides"). Given the relatively recent emphasis on domestic production of critical minerals, the active focus throughout these states is generally on resource identification and extraction of minerals specific to their region. Key mechanisms to protect and promote critical minerals from Florida across the supply chain can be identified in examples from other states.

Resource assessment and mapping is a common and primary activity for state programs. Whether pursued independently or in collaboration with USGS, many states are actively mapping new resources ("Earth Mapping") or investigating critical mineral potential in mine waste ("USGS Provides"). In addition to resource mapping, Alaska is taking a more comprehensive approach which includes not only identification of critical mineral resources within the state, but also evaluates the state's location within the supply chain and how the interconnected systems of manufacturing and transportation impact the critical minerals market (Brooks). A Florida critical minerals program could focus on further assessment and mapping of critical resources that could be extracted from mineral systems within the state or recovered from waste streams within Florida. Like Alaska, Florida could go beyond identification of critical mineral locations to consider the manufacturing and transportation systems within the state and how those could be leveraged or improved to promote critical minerals from Florida across the supply chain.

Research and development activities to advance resource extraction and processing are also pursued by some states, often in cooperation with colleges and universities, with a history of mining. A few examples include:

- University of Nevada Reno (Werdann) – Improvement in processing techniques for lithium extraction and supporting a critical minerals processing and research skills are a focus for the Department of Mining and Metallurgical Engineering at UNR.
- Penn State (Pacchioli) – Research is focused on critical mineral extraction from coal mine waste resulting from the state's historic mining activity.
- University of Kentucky (Melanson) – The Strategic Minerals and Recovery Technologies (SMaRT) Center, Center for Applied Energy Research and College of Engineering are conducting research on critical mineral extraction from mine waste and recovery from recycling of minerals.

Florida could continue to leverage existing higher education institutions within the state to partner with industries that have a need for critical minerals originating from Florida. Extraction of certain critical minerals like yttrium and scandium from phosphate would be an example of a target partnership since Florida is the largest United States producer of phosphate (Jaskinski).

Closely related to research and development for critical minerals is the use of **public-private partnerships**. The most common form of public-private partnerships at the state level are associated with higher education and, like research and development, can be used to promote critical minerals across the supply chain. Colleges and universities are key in public-private partnerships as industries seek to advance critical mineral extraction technology. For example, faculty at the Department of Mining and Metallurgical Engineering at the University of Nevada at Reno have collaborations with mining companies focused on critical minerals extraction (Werdann). Penn State collaborates with companies in the energy, waste, and minerals sectors through their Center for Critical Minerals (C^2M) ("Partnerships & Collaborations). Such collaborations have already taken place in Florida ("Florida Startup"; "Center for Rare Earths") and could continue to be used to promote Florida's critical mineral resources across the supply chain as well as promote a critical minerals workforce.

Existing permitting for mining or other extraction activities can be complicated due to the potential for environmental impacts. While there is current interest at the federal level in updating and streamlining the General Mining Act of 1872 (Puko) which focuses on mining

Insights

- Utilizing Industrial Byproducts Maximizes Resource Efficiency
- Comprehensive Data Collection and Monitoring Improves Supply Chain Planning
- Establishing a State-Level Critical Minerals Program Aligns with Federal Initiatives
- Adopting Sustainable Practices and Advanced Technologies Minimizes Environmental Impacts
- Leveraging Public-Private Partnerships and Educational Collaborations Fosters Innovation and Workforce Development
  Expanding Regulatory Efforts Enhances Utilization of Industrial Byproducts and Streamlines Permitting Processes

Questions

- Technical understanding and research questions.
- Systems and policy development questions.
- Stakeholder engagement and collaboration.

federal land, there is no apparent parallel at the state level. Florida could consider existing regulations related to mining, extraction or resource recovering and determine opportunities for **regulatory and permitting streamlining** while still protecting the environment and human health and safety.

6.1 Insights and Questions

This subsection delves into the key insights derived from our analysis of critical minerals in Florida. We will also pose critical questions that arose during our study, highlighting areas requiring further investigation or clarification. This structured approach aims to provide actionable guidance for policymakers, stakeholders, and industry leaders to realize the potential value of market development.

6.1.1 INSIGHT: UTILIZING INDUSTRIAL BYPRODUCTS MAXIMIZES RESOURCE EFFICIENCY

Utilizing industrial byproducts such as phosphogypsum, phosphatic clays, and coal ash maximizes resource efficiency by transforming waste into valuable resources. This approach aligns with the principles of a circular economy, reducing environmental impact and enhancing sustainability. By developing technologies and processes to extract critical minerals from industrial byproducts, Florida can create new revenue streams, reduce waste disposal costs, and minimize environmental hazards. This initiative promotes a more sustainable industrial ecosystem and positions Florida as a leader in innovative resource management.

6.1.2 INSIGHT: COMPREHENSIVE DATA COLLECTION AND MONITORING IMPROVES SUPPLY CHAIN PLANNING

Comprehensive data collection and monitoring are essential for effective supply chain planning in the critical minerals sector. Accurate and timely data enables better forecasting, risk assessment, and strategic decision-making. Establishing a central repository for mineral data at FGS which can be included in the FSU Center data model will facilitate collaboration among stakeholders and support the development of robust supply chain models. This initiative will enhance Florida's ability to respond to market demands, mitigate supply chain disruptions, and optimize resource allocation.

6.1.3 INSIGHT: ESTABLISHING A STATE-LEVEL CRITICAL MINERALS PROGRAM ALIGNS WITH FEDERAL INITIATIVES

Establishing a state-level critical minerals program in Florida aligns with federal initiatives and strengthens the state's position in the national critical minerals strategy. This program would support research, development, and sustainable practices while ensuring regulatory compliance. By mirroring federal programs like the DOE FAST-41, Florida can streamline permitting processes, secure federal funding, and attract private investment. This alignment fosters a cohesive approach to critical mineral management, enhancing economic resilience and national security.

6.1.4 INSIGHT: ADOPTING SUSTAINABLE PRACTICES AND ADVANCED TECHNOLOGIES MINIMIZES ENVIRONMENTAL IMPACTS

Adopting sustainable practices and advanced technologies in the extraction and processing of critical minerals minimizes environmental impacts and promotes long-term resource stewardship. Innovations in beneficiation, chemical processing, and recycling can significantly reduce the ecological footprint of these activities. Florida's commitment to sustainable mining and processing practices not only protects natural ecosystems but also enhances the state's reputation as an environmentally responsible leader in the critical minerals sector. This approach attracts eco-conscious investors and aligns with global sustainability goals.

6.1.5 INSIGHT: LEVERAGING PUBLIC-PRIVATE PARTNERSHIPS AND EDUCATIONAL COLLABORATIONS FOSTERS INNOVATION AND WORKFORCE DEVELOPMENT

Leveraging public-private partnerships and educational collaborations is key to fostering innovation and workforce development in Florida's critical minerals industry. Partnerships between academia, industry, and government can drive technological advancements and provide valuable training opportunities. By fostering collaborations with institutions like FSU, Florida can develop a skilled workforce, promote cutting-edge research, and accelerate the commercialization of new technologies. These efforts support economic growth and ensure the state remains competitive in the global critical minerals market.

6.1.6 INSIGHT: EXPANDING REGULATORY EFFORTS ENHANCES UTILIZATION OF INDUSTRIAL BYPRODUCTS AND STREAMLINES PERMITTING PROCESSES

Expanding regulatory efforts to support the utilization of industrial byproducts and streamline permitting processes is essential for maximizing the economic and environmental benefits of critical minerals. Clear and efficient regulations encourage industry compliance and innovation. By updating Florida's Solid Waste Management Statutes and coordinating with local governments, the state can facilitate the safe and sustainable use of industrial byproducts. This regulatory framework supports industry growth, reduces environmental risks, and promotes resource efficiency.

6.1.7 QUESTIONS: TECHNICAL UNDERSTANDING AND RESEARCH

These questions represent gaps in our insights and highlight areas requiring further investigation. The questions fall primarily within the sphere of concern for The Center and through answering will develop a deeper understanding of the complexities involved with critical minerals market development in Florida.

What specific technologies are needed to improve the extraction of critical minerals from industrial byproducts in Florida? Identifying and developing technologies that can efficiently extract critical minerals from industrial byproducts is essential. Research should focus on innovative methods that maximize yield, reduce environmental impact, and are cost-effective, ensuring these technologies can be implemented at scale in Florida.

How can the efficiency and cost-effectiveness of these extraction technologies be evaluated and improved over time? Continuous evaluation and improvement of extraction technologies are necessary to maintain competitiveness and sustainability. This involves setting benchmarks, conducting regular performance assessments, and incorporating feedback to refine processes, thereby enhancing both efficiency and cost-effectiveness.

What are the potential environmental impacts of extracting critical minerals from Florida's industrial byproducts, and what mitigation strategies can be developed? Understanding the environmental impacts is crucial for sustainable development. Research should identify potential risks and develop mitigation strategies to minimize adverse effects, ensuring that extraction processes align with environmental regulations and best practices.

What additional research is needed to fully understand the mineral content of Florida's industrial byproducts and solid wastes? Comprehensive research is required to map and quantify the mineral content in Florida's industrial byproducts. This involves detailed geological surveys and chemical analyses to identify which byproducts contain valuable minerals and to what extent, guiding future extraction efforts.

6.1.8 QUESTIONS: SYSTEMS AND POLICY DEVELOPMENT

These questions highlight gaps that require formal actions and policy decisions, primarily within the purview of the Florida Legislature and Executive Branch. Addressing these questions will support the development of the critical minerals market in Florida.

What legal or regulatory changes are necessary to support the adoption of sustainable extraction and processing practices for critical minerals in Florida? Legislative and regulatory frameworks need to be updated to facilitate sustainable practices. This includes revising existing laws, creating new regulations that promote environmental stewardship, and removing barriers that hinder the adoption of advanced extraction technologies.

How can Florida create a strategic plan to identify, develop, and regulate new supply sources for critical minerals from industrial byproducts? Developing a strategic plan involves mapping out the entire supply chain, from resource identification to processing and market distribution. This plan should include guidelines for regulatory compliance, incentives for industry participation, and clear objectives for sustainable growth.

What incentives can be implemented to encourage industries to invest in the extraction and processing of critical minerals from Florida's industrial byproducts? Incentives such as tax breaks, grants, and subsidies can stimulate investment in the critical minerals sector. Developing a robust incentive program will attract companies to invest in extraction and processing technologies, fostering industry growth and innovation.

What specific policies or legislative actions are necessary to attract and secure federal funding for innovation and development in Florida's critical minerals sector? Policies and legislative actions should focus on aligning state initiatives with federal priorities to secure funding. This includes lobbying for federal grants, creating matching fund programs, and ensuring that state projects meet the criteria for federal support.

6.1.9 QUESTIONS: STAKEHOLDER ENGAGEMENT AND COLLABORATION

These questions emphasize the importance of engaging key stakeholders and fostering collaboration. They highlight the need for actions that bring attention and exert influence, within the scope of the Florida Legislature and Executive Branch. Addressing these questions will ensure comprehensive stakeholder involvement and support for development of the critical minerals market in Florida.

What partnerships and collaborations are essential for the success of research and development efforts in extracting critical minerals from industrial byproducts? Collaborations with academic institutions, research centers, and private companies are vital for advancing R&D efforts. These partnerships can provide the technical expertise, funding, and resources needed to innovate and improve extraction processes.

How can educational institutions and industry leaders collaborate to develop a skilled workforce capable of supporting the critical minerals sector in Florida? Developing a skilled workforce involves creating specialized training programs in collaboration with educational institutions and industry leaders. These programs should focus on the technical skills and knowledge required for critical minerals extraction and processing, ensuring a steady supply of qualified professionals.

How can Florida create a strategic communication plan to advocate for the inclusion of specific minerals in the USGS Critical Minerals List? A strategic communication plan should highlight Florida's strengths in mineral resources and extraction capabilities. This includes developing targeted messages, engaging with policymakers and industry stakeholders, and leveraging media to build a compelling case for the inclusion of Florida-specific minerals in the USGS Critical Minerals List.

7 Industries

Legislative Directive

Report the existing and emerging industries that could benefit Florida's economy and environment through the production and processing of rare earths, critical minerals, and industrial byproducts.

Key Questions

What are the existing industries in Florida which produce, process, or consume rare earths, critical minerals, or industrial byproducts?

What are the existing industries outside of Florida which may participate in Florida's economy for rare earths, critical minerals, and industrial byproducts?

What are potential new industries for production, processing, or consumption of rare earths, critical minerals, or industrial byproducts?

How would these existing and emerging industries impact Florida's economy?

What data supports this industrial assessment, and how reliable and comprehensive is this data?

How can the FSU Center improve this data over the next 3-5 years?

In this section, we will explore the industries that can significantly impact Florida through the use of rare earths, critical minerals, and industrial byproducts. We will examine existing operations within Florida, identify potential new entrants from outside the state, and highlight emerging opportunities. Additionally, we will evaluate how these industries can bolster Florida's economy and support environmental sustainability. This analysis will provide data-backed insights and outline ways to enhance this data in the coming years. The insights, questions, and opportunities uncovered will form the basis of our recommendations for maximizing the potential of Florida's rare earths, critical minerals, and industrial byproducts industries.

7.1 Understanding the Supply Chain: A Visual Guide

To demonstrate how companies interact within the supply chain of rare earths, critical minerals, and industrial byproducts, we consider a visual model (**Figure 19 - Rare Earth & Critical Mineral Network Diagram**). The supply chain, value stream, and distributor network for most rare earth, critical minerals, and industrial byproducts value adders is very complex, creating many opportunities to influence existing and future networks for the benefit of the citizens of Florida, stewardship of our natural resources, and the economic health of our corporations. This model aligns with our standard framework, which includes the phases of material acquisition, material processing, manufacturing consumer goods, and consumer goods disposal.

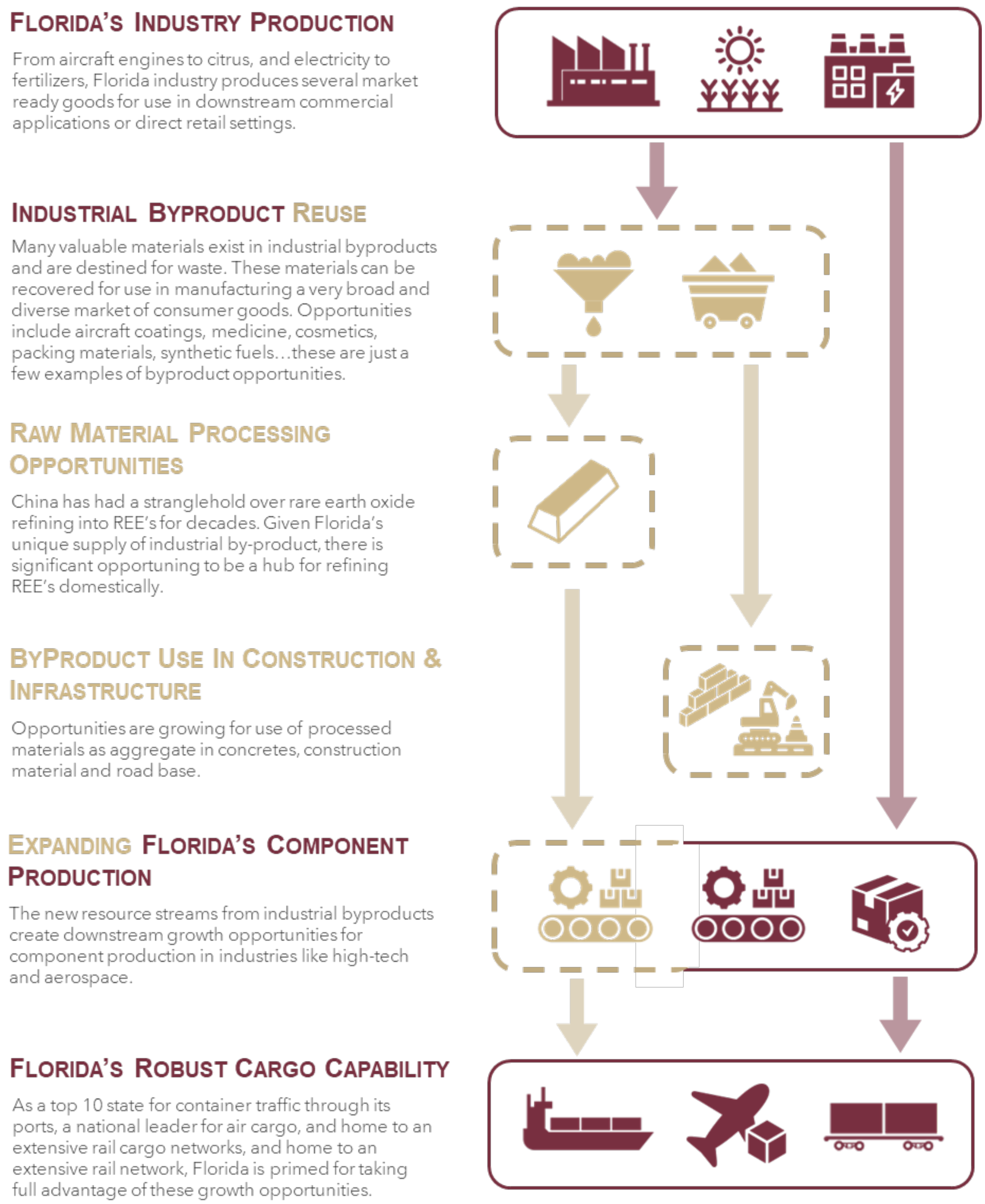


Figure 19 - Rare Earth & Critical Mineral Network Diagram

Figure 19 - Rare Earth & Critical Mineral Network Diagram shows the network of corporate relationships within a typical rare earth or critical mineral supply chain, value stream, distribution network, and waste stream. This model will help you visualize how materials flow from their natural state, through processing and manufacturing, eventually reaching the consumer and finally being disposed of or recycled.

While the visual model focuses on the relationships and flow of materials, several broad factors influencing these processes aren't shown but are critical for understanding the full context of the opportunities within this space. Factors such as proximity to natural resources, supply chain footprint, available land, workforce, tax structure, utilities, logistics, and proximity to customer markets play crucial roles in determining operational efficiency, cost-effectiveness, and overall success. These elements influence each phase from material acquisition to consumer goods disposal, providing a comprehensive view of how companies operate within Florida's economy and environment.

7.2 Emerging Opportunities

Emerging opportunities in the rare earths, critical minerals, and industrial byproducts (RE/CM/IB) space often exist in the form of precisely defined challenges. Once these challenges are addressed, they create a natural space for rapid market growth. A primary challenge in the availability of rare earths is the inefficiency in extraction and processing techniques. Advances in beneficiation, chemical processing, and separation methods are crucial for developing new sources and making production more efficient. Research conducted at Florida State University (FSU) and other institutions focuses on overcoming these barriers by developing innovative technologies. Efficient extraction and processing can transform the availability and cost-effectiveness of rare earth elements, making Florida a hub for these critical resources (Eggert et al.).

These advancements are not akin to curing cancer, a seemingly never-ending pursuit, but are more similar to President Kennedy's 1960s vision to safely take a man to the moon and return him. America, and indeed the world, has never prioritized extraction and processing techniques as a national security-level concern until now.

Results are being proven quickly, such as those publicly published by research centers like Purdue University. Purdue has developed innovative technologies that significantly improve the extraction and purification processes for rare earth elements. These technologies use less power and water, generate near-zero waste, and rely on fewer hazardous chemicals, making them more environmentally friendly. By pursuing research and investing in the commercialization of these pinpoint opportunities, Florida can attract industries and position itself as a leader in environmentally friendly mineral processing. Additionally, the higher extraction yields and purity products offered by these advanced technologies can support Florida's emerging industries, particularly those involved in high-tech products like electric vehicles, wind turbines, and consumer electronics (Purdue News).

The recent federal funding of over $17 million for critical minerals and materials projects demonstrates a commitment to developing domestic capabilities in this sector ("Biden-Harris Administration Invests"). Although these projects are currently based outside Florida, they illustrate the potential for similar initiatives within the state. The projects, which include advanced laboratory and pilot-scale testing for rare earth elements and critical minerals from coal and coal by-products, highlight how federal investments can stimulate research and development. For Florida, this indicates that with an organized and effective team, similar funding could be attracted to support the state's unique RE/CM/IB needs. This could lead to partnerships with existing corporations in Florida and attract new companies specializing in advanced processing techniques and sustainable production processes, enhancing the state's industrial base.

In our analysis of potential new industries in the rare earths, critical minerals, and industrial byproducts space in Florida, we have taken a data-driven approach. This involved analyzing market demand and identifying gaps in the current industry presence within the four standard steps: material acquisition, material processing, consumer product manufacturing, and consumer product waste. By understanding these gaps and the reasons behind them, we have pinpointed opportunities for growth and development.

Market demand emerged as a primary driver for industry development. By examining global and regional trends in demand for rare earths, critical minerals, and industrial byproducts, we identified high-demand sectors such as renewable energy, electric vehicles, and advanced manufacturing as potential growth areas for Florida. Conversely, certain markets demonstrated cooling and are potentially diminishing industry opportunities.

Causes of Current Value Stream Gaps

Upon identifying significant gaps in various steps of the value stream we asked: “Why does this step have opportunity to grow in Florida?” In grouping the answers to this question the data suggested that the gaps were due to one or more of the following factors:

- **Technological Feasibility:** Technological challenges or lack of available technology.
- **Economic Viability:** Economic feasibility of establishing and maintaining operations in Florida.
- **Environmental Impact:** Environmental concerns or regulatory barriers.
- **Regulatory Support:** Adequacy of regulatory support and incentives for these industries.

- **Existing Infrastructure:** Availability of necessary infrastructure to support these operations.

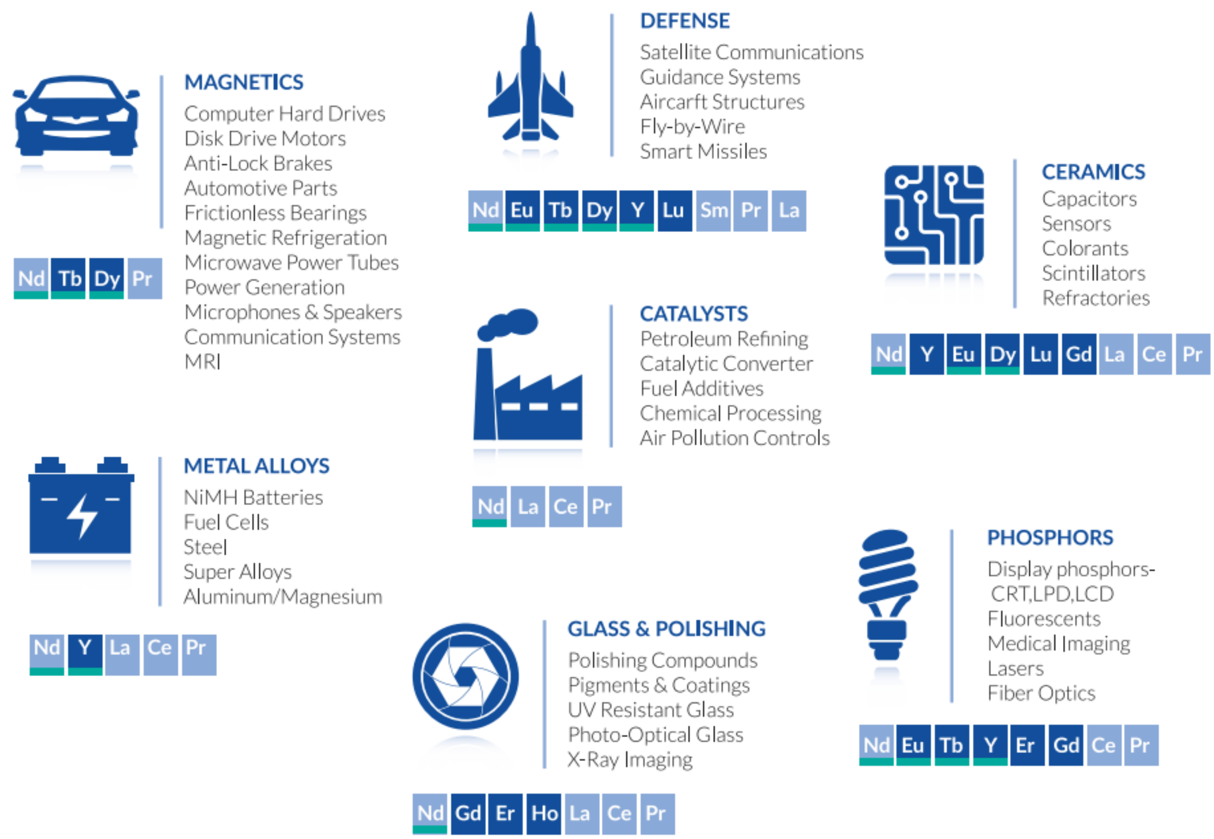


Figure 20 - Rare Earth Element Applications

To evaluate the specific hurdles preventing industry steps from locating in Florida, we:

1. **Identified Roadblocks:** Determined the key factors hindering the establishment of these industries.
2. **Analyzed Solutions:** Explored potential solutions and strategies to overcome these barriers.

By identifying market demand and analyzing the gaps in Florida's current industry presence, we pinpointed opportunities for new industries. Understanding the specific roadblocks and hypothesizing potential reasons for these gaps has helped develop targeted strategies to attract and establish these industries in Florida. This approach ensures that the state can capitalize on its potential, creating economic growth and sustainable development in the rare earths, critical minerals, and industrial byproducts sectors.

Industrial byproducts have valuable reuse opportunities outside the context of rare earth and critical mineral extraction. Some involve processing and extraction of valuable resources, such as radium for medical radiotherapy or purified gypsum for manufacturing. Others involve using industrial byproducts as aggregate or filler material, such as road base, construction aggregate, or landfill cover. The potential advantages of this type of reuse are higher volumes and lower costs. Although reuse as an aggregate material prevents the need for extraction processes, some processing may still be required.

One of The Center's priorities over the next five years is to further develop this data model to inform the opportunities with the most potential for economic and environmental benefits. Once that scope of opportunities is narrowed, an economic impact assessment should be performed to project industry potential and inform funding and investment.

7.3 The Opportunity for Existing Florida Stakeholders

Emerging opportunities are not limited to new investors; they also benefit existing Florida stakeholders. By addressing and overcoming these precisely defined challenges, we invite new investments while opening opportunities for long-time investors in Florida. This approach will not only reduce China's dominance in the REE market but will also achieve it through superior methods that emphasize environmental restoration and renewal.

China's dominance in REE production has often come at the cost of severe ecological damage. By adopting sustainable and environmentally friendly mining practices, Florida can not only match but surpass China's production methods, setting a new standard in responsible REE production (Fernandez).

Phosphogypsum (PG), a byproduct of phosphate fertilizer production, presents significant potential for secondary resource recovery. Utilizing PG can transform it from waste into valuable resources, benefiting industries such as construction and agriculture. Additionally, PG contains trace amounts of REEs, which are critical for high-tech industries. Florida, with its extensive phosphate mining, could develop processes to extract these elements from PG, providing a local source of REEs and supporting the state's economy by reducing reliance on imported materials (Bilal et al.).

The current market dynamics and national security priorities are leading to substantial investments in complete supply chain systems for critical minerals. Florida should leverage this trend by seeking investments that cover the full spectrum of acquisition, processing, manufacturing, and reclamation. Such a comprehensive approach will not only enhance industrial resilience against global supply chain disruptions but also create numerous jobs across various stages of the supply chain. This strategy will contribute significantly to local economic stability and growth, positioning Florida as a leader in advanced industrial ecosystems (Lopez).

Developing REE industries with a focus on environmentally friendly extraction and processing methods can position Florida as a leader in sustainable industrial practices. This can attract businesses and investors interested in green technologies and sustainable resource management. By fostering industries related to REEs, Florida can also contribute to national security by supporting defense-related applications and reducing reliance on foreign REE supplies. This includes the production of critical components used in military and aerospace technologies (Andrews-Speed and Hove).

Collaborating with global leaders in clean energy technology, rather than isolating through tariffs and trade barriers, can foster innovation and reduce costs in green technology. Florida can benefit from such collaborations by integrating best practices and ensuring its production processes meet high environmental standards. By securing diverse sources of raw materials, Florida can position itself as a key player in the global supply chain for critical minerals (Clark).

Investing in education and training programs to build a skilled workforce capable of supporting the production and processing of rare earths and critical minerals is crucial. Florida's economy could greatly benefit by accelerating workforce development in STEM and trade skills. Additionally, by identifying and supporting local businesses involved in the supply chain, Florida can attract federal and private investment, ensuring the stability and growth of these industries (Interagency Task Force).

7.4 Case Studies

7.4.1 MOUNTAIN PASS MINE (CALIFORNIA)

Mountain Pass is an open pit mine in the California desert that once produced the majority of the world's rare earths. Small scale production first began in 1952 and grew until it dominated the market in the 1960s – 1990s. As Chinese production grew in the 1990s, Mountain Pass faced increasing profitability challenges. The facility faced significantly higher environmental compliance costs than Chinese competitors (Standaert). Additionally, the Chinese government's strategy was to gain market share, so they were willing to flood the market and lower prices to establish a monopoly. Mountain Pass became unprofitable and closed in 2002. In 2008 an attempt was made by investors to revive the mining operation, develop local oxide processing, and compete with the Chinese monopoly. This operation eventually failed due to technology failing to meet expectations and a lack of government support, declaring bankruptcy in 2014.

Since reopening in 2017, Mountain Pass Materials is the only working rare earth mine in the US, and it is currently the biggest source of rare earths outside China. Mountain Pass produces 38,500 tons/year of rare earth concentrate, especially high-purity neodymium-praseodymium oxide, a key ingredient in the high strength permanent magnets (Burron). This oxide concentrate is currently shipped to China for processing. In 2020, this operation received $9.6 million from the DOD to contribute towards establishment of light rare earths processing on site ("DOD Announces Awards"). It will soon begin on-site separation and processing of rare earths, consolidating the complex supply chain in one location.

7.4.2 CASE STUDY: PUBLIC-PRIVATE PARTNERSHIP, LYNAS USA + DOD PROJECT (TEXAS)

Since 2020, the Department of Defense has awarded more than $439 million to establish domestic rare earth element supply chains. This includes separating and refining rare earth elements mined in the U.S., as well as developing downstream stateside processes needed to convert those refined materials into metals and then magnets. The DOD's assistant secretary of defense for industrial base policy summarized the department's motivation for investing in this domestic production project: "DOD's recently published National Defense Industrial Strategy will guide the creation of a modernized defense industrial ecosystem. […] Resilient supply chains are essential to this goal. The U.S. can no longer afford to rely on overseas, single-points-of-failure for critical components" (Lopez). The critical nodes of this supply chain the DOD identifies in its five-year investment strategy include sourcing, separation, processing, metallization, alloying, and magnet manufacturing.

Lynas USA was awarded $288 million in funding from the DOD's Manufacturing Capability Expansion and Investment Program (MCEIP). The original $120 million award was announced in June 2022, which has since expanded for additional construction. This funding is supporting a new rare earths processing facility in Seadrift, Texas. The 149-acre site will allow integration of Heavy Rare Earth and Light Rare Earth separation plants with room for additional development of downstream processing. The facility will serve both DOD and commercial customers and is projected to be operational in FY2026 (Leonard; "U.S. DoD Strengthens Support").

The material source for this processing plant will initially be a mine and processing facility in Australia, but the Texas facility will be able to accept future sources when they become available. The Heavy Rare Earths separation plant will be the first of its kind outside China.

The MCEIP has also invested $10 million to explore the development of extraction technology and alternative sources of rare earth minerals from coal ash, acid mine drainage, and other waste streams.

7.4.3 CASE STUDY: INDUSTRIAL POTENTIAL IN FLORIDA / WASTE STREAM SUSTAINABLE RE-USE, CITRUS AGRICULTURE

Another industry in Florida with significant byproduct reuse opportunities is agriculture and food goods processing. The citrus fruits sector of the industry contributed nearly $7 billion to Florida's economy in 2021, producing nearly 260,000 tons of fresh fruit and 2.4 million tons of processed citrus products (University of Florida; United States Department of Agriculture). This sector and beneficial reuse opportunities are demonstrated in **Figure 21 - Citrus Byproduct Diagram**. This offers a clear example of the numerous opportunities to expand byproduct

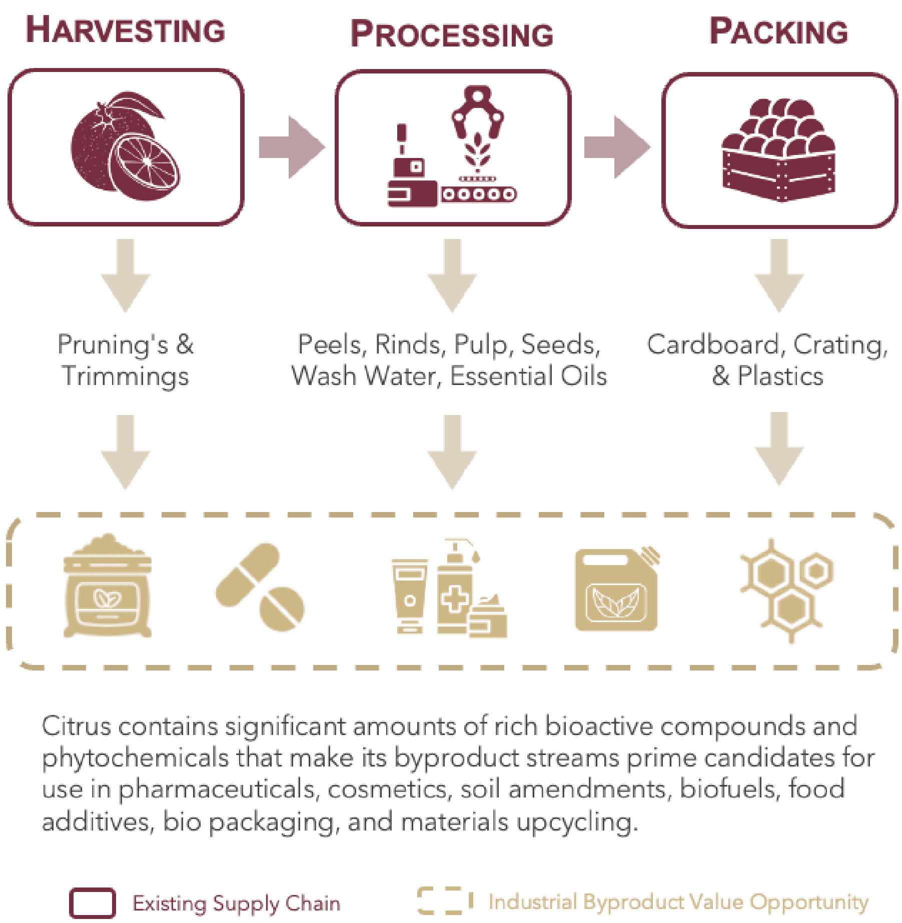


Figure 21 - Citrus Byproduct Diagram

reuse across every link of the supply chain.

Citrus fruits are rich sources of bioactive compounds, creating opportunities for use in many industries. As a potent source of phytochemicals, citrus peels can be reused and incorporated into pharmaceuticals, food additives, cosmetics, and bio-absorbent techniques (Suri, Singh, and Nema 2022). This point is significant due to the large volume of citrus waste that is produced from processing output from goods like fruit juice. A large part of the fresh fruit mass becomes waste in the form of peels, seeds, pomace, and wastewater, with peels alone composing nearly 40-50% of the fresh fruit weight. Given that close to 90% of processed citrus in Florida goes to juice, which could equate to close to 1 million tons of citrus peel waste annually, relative to 2021 production (Verma, Rakesh, et al.).

Research into cost-effective and innovative strategies for extracting bioactive compounds from citrus byproducts could create a new byproduct stream, directly supporting other industrial sectors in manufacturing. Not only would a new byproduct stream directly support other industrial sectors in manufacturing, but—just as in the expansion of domestic REE processing—the citrus waste process sector could add an entire new value stream, creating jobs, and new capital opportunities for Florida investment.

7.5 Insights and Questions

This subsection delves into the key insights derived from our analysis of potential value for existing and new industries by developing rare earth, critical minerals, and industrial byproduct reuse systems in Florida. We will also pose critical questions that arose during our study, highlighting areas requiring further investigation or clarification. This structured approach aims to provide actionable guidance for policymakers, stakeholders, and industry leaders to navigate the identified industry opportunities.

Insights

- Florida Can Capture China Market Share by Focusing on Greater Natural Resource Stewardship
- Utilizing Phosphogypsum (PG) Transforms Waste into Valuable Resources
- Investing in Complete Supply Chain Systems Enhances Industrial Resilience
- Investing in Workforce Development Supports Industry Growth
- Forming Public-Private Partnerships Enhances Supply Chain Stability
- Repurposing Citrus Byproducts Creates New Economic Opportunities
- Federal Funding Drives Innovation and Industrial Growth
- Diversifying Supply Sources Boosts Economic Security

Questions

- Technical understanding and research questions.
- Systems and policy development questions.
- Stakeholder engagement and collaboration

7.5.1 INSIGHT: INVESTMENTS IN TECHNICAL EXTRACTION AND PROCESSING CHALLENGES ACCELERATES GROWTH ACROSS THE VALUE STREAM

Improving extraction and processing techniques for rare earth elements can transform their availability and cost-effectiveness. Research at institutions like FSU is crucial in overcoming these barriers and positioning Florida as a leader in this sector.

7.5.2 INSIGHT: FLORIDA CAN CAPTURE CHINA MARKET SHARE BY FOCUSING ON STEWARDSHIP OF NATURAL RESOURCES

By adopting sustainable and environmentally friendly mining practices, Florida can surpass China's production methods. This not only reduces dependency on China but also sets a new standard in responsible REE production.

7.5.3 INSIGHT: UTILIZING PHOSPHOGYPSUM (PG) TRANSFORMS WASTE INTO VALUABLE RESOURCES

Phosphogypsum, a byproduct of phosphate fertilizer production, can be transformed from waste into valuable resources. Utilizing PG for secondary resource recovery benefits industries such as construction and agriculture and provides a local source of REEs, reducing reliance on imports.

7.5.4 INSIGHT: INVESTING IN COMPLETE SUPPLY CHAIN SYSTEMS ENHANCES INDUSTRIAL RESILIENCE

Investing in the full spectrum of critical minerals supply chains—from acquisition to reclamation—enhances industrial resilience and creates numerous jobs. This comprehensive approach contributes to local economic stability and growth.

7.5.5 INSIGHT: INVESTING IN WORKFORCE DEVELOPMENT SUPPORTS INDUSTRY GROWTH

Investing in education and training programs to build a skilled workforce is crucial. Accelerating workforce development in STEM and trade skills will support the production and processing of rare earths and critical minerals, benefiting Florida's economy.

7.5.6 INSIGHT: FORMING PUBLIC-PRIVATE PARTNERSHIPS ENHANCES SUPPLY CHAIN STABILITY

Forming public-private partnerships can secure investments and enhance the stability and growth of local businesses involved in the critical minerals supply chain. This approach ensures a resilient and efficient supply chain system.

7.5.7 INSIGHT: REPURPOSING CITRUS BYPRODUCTS CREATES NEW ECONOMIC OPPORTUNITIES

Citrus byproducts can be repurposed into valuable resources for various industries. Developing cost-effective strategies for extracting bioactive compounds from citrus waste can create new value streams and economic opportunities in Florida.

7.5.8 INSIGHT: FEDERAL FUNDING DRIVES INNOVATION AND INDUSTRIAL GROWTH

Federal funding for critical minerals and materials projects can drive innovation and development in Florida's RE/CM/IB sector. Leveraging these funds can stimulate research and attract new companies to the state, enhancing the local industrial base.

7.5.9 INSIGHT: DIVERSIFYING SUPPLY SOURCES BOOSTS ECONOMIC SECURITY

Developing a diversified supply chain for rare earths and critical minerals can enhance economic security and resilience. Florida can reduce its reliance on foreign imports by establishing local sources and processing capabilities, contributing to national security and economic stability.

7.5.10 QUESTIONS: TECHNICAL UNDERSTANDING AND RESEARCH

These questions represent gaps in our insights and highlight areas requiring further investigation. The questions fall primarily within the sphere of concern for The Center and through answering will develop a deeper understanding of the existing and emerging industries that could benefit Florida's economy and environment through the production and processing of rare earths, critical minerals, and industrial byproducts.

What specific technologies are needed to improve extraction and processing efficiency in Florida, and how can these technologies be effectively implemented? Identifying and implementing advanced technologies is crucial for enhancing extraction and processing efficiency, thereby increasing the availability and cost-effectiveness of rare earth elements in Florida.

What are the most efficient methods for extracting rare earth elements from phosphogypsum, and what are the potential environmental impacts and mitigation strategies? Understanding and developing efficient extraction methods for rare earth elements from phosphogypsum, along with strategies to mitigate environmental impacts, is essential for sustainable industry practices.

What are the most promising uses for citrus byproducts in various industries, and what infrastructure and technologies are needed to efficiently process and repurpose these byproducts? Exploring the potential uses of citrus byproducts and the required infrastructure and technologies for processing them can create new economic opportunities and value streams for Florida.

What specific research and development projects should Florida prioritize to align with federal funding opportunities? Prioritizing R&D projects that align with federal funding opportunities will help Florida attract investments and drive innovation in the RE/CM/IB sectors.

7.5.11 QUESTIONS: SYSTEMS AND POLICY DEVELOPMENT

These questions highlight gaps that require formal actions and policy decisions, primarily within the purview of the Florida Legislature and Executive Branch. Addressing these questions will support the full understanding of existing and emerging industries that could benefit Florida's economy and environment through the production and processing of rare earths, critical minerals, and industrial byproducts.

What specific STEM and trade skills are most needed to support the RE/CM/IB industries in Florida, and how can educational institutions align with these needs? Determining the necessary skills and aligning educational programs to meet industry needs will ensure a well-prepared workforce capable of supporting the growth of RE/CM/IB industries in Florida.

What are the specific supply chain steps that need enhancement in Florida's critical minerals sector, and how can Florida create incentives for companies to invest in complete supply chain systems within the state? Enhancing supply chain steps and creating incentives for investment will strengthen Florida's position in the critical minerals market and boost economic resilience.

How can Florida position itself to attract more federal funding for critical minerals projects, and what specific research and development projects should be prioritized? Positioning Florida to attract federal funding involves identifying and prioritizing R&D projects that align with national priorities and demonstrate the state's potential for innovation and growth.

How can Florida develop a strategic plan to diversify its supply sources effectively? Creating a strategic plan for supply source diversification will enhance Florida's economic security and reduce dependence on foreign imports.

7.5.12 QUESTIONS: STAKEHOLDER ENGAGEMENT AND COLLABORATION

These questions emphasize the importance of engaging key stakeholders and fostering collaboration. They highlight the need for actions that bring attention and exert influence, within the scope of the Florida Legislature and Executive Branch. Addressing these questions will ensure comprehensive stakeholder involvement to support existing and emerging industry development through the production and processing of rare earths, critical minerals, and industrial byproducts.

What models of public-private partnerships have been successful in similar industries, and how can Florida facilitate the formation and success of such partnerships in the RE/CM/IB sector? Identifying successful models and facilitating partnerships will drive investment and innovation in Florida's RE/CM/IB industries.

How can Florida create incentives for companies to invest in complete supply chain systems within the state, and how can Florida's educational institutions and training programs be aligned with industry needs to support these investments? Developing incentives and aligning educational programs with industry needs will attract investments and ensure a skilled workforce to support the growth of the RE/CM/IB sectors.

8 Recommendations

Legislative Directive

Report any proposed actions that could be taken by the Florida Legislature and Executive Branch agencies to facilitate the achievement of identified economic and environmental benefits.

Key Questions

What are the barriers to development of Florida's potential as a production center for rare earths, critical minerals, and industrial byproducts?

What information do legislators, regulators, and investors need that the FSU Center can develop?

What role can the FSU Center perform to help overcome these barriers to development?

What can the State of Florida do to align with federal rare earths and critical minerals strategies and maximize the beneficial outcomes of those strategies for the people, environment, and economy of Florida?

What actions could the Florida Legislature and Executive Branch agencies take to overcome the identified barriers and facilitate the achievement of the identified benefits?

Developing domestic rare earth and critical minerals production is strategically and economically valuable, but many challenges hinder growth and investment. The supply chain complexity requires coordinated efforts across diverse industries, and dependence on China for any portion of the supply chain prohibits a healthy, independent domestic industry. Companies are hesitant to invest in this space due to Chinese control of the market price of commodities and services. This lack of free market competition has been used to keep prices artificially low to make short-term profitability impossible and private investment unattractive. As evidenced by the past twenty years of development, the free market alone will not compete with the well-established and heavily subsidized Chinese industry.

Florida has significant potential to be a production center for these valuable resources and the high-tech industries that depend on them. There are many actions at the state government level which can help overcome these barriers and support a significant domestic production industry. First and foremost, legislators, regulators, executive agencies, industry, and investors all need more comprehensive data to understand this dynamic market and make informed decisions. The Center has initiated this process (as evidenced by this report) and should be tasked with developing and publishing this data model for stakeholders in collaboration with critical supporters and at the direction of the legislature. The Center should also be funded with a multi-year strategic plan to continue research in industrial byproduct processing and pursue further research to address the most promising opportunities, such as radium, rare earth, and critical mineral extraction. As the hub for this research and data model, The Center should also serve the role of advisor to stakeholders to help them navigate and leverage funding sources for market development.

Outside the context of The Center, the State Legislature can also identify and assess legal and regulatory barriers. Based on the framework and opportunity presented in this report, the State Legislature should perform a regulatory audit to review these barriers and identify mechanisms to support this economic and environmental opportunity. The State of Florida can also support legislation and initiatives to align with federal strategy, such as creation of a state critical minerals program.

Florida is a large state with a unique combination of circumstances which offer potential to its future growth: rare and critical natural resources, a strong industrial economy, and a growing, highly educated work force. Due to the properties of large stores of industrial byproducts, Florida is positioned not only to capitalize on a significant market, but also reduce environmental liabilities and meet sustainability and resilience strategy goals. This opportunity to fill a strategic need is currently being acted upon by the states of California and Texas, and by Australia, and other allies of the United States. Florida can capitalize on its advantage through a comprehensive and collaborative approach which encourages investment and industry.

With America's growing dependance for products that are reliant on a supply chain dominated by China, the Florida legislature recognized the State's need and potential to become a national leader in critical and rare earth minerals production when it created The Center for Rare Earths, Critical Minerals, and Industrial Byproducts. Over the last two years, The Center's research has been able to provide solutions to realize that vision and create a clear path forward. This path will lead the State of Florida to becoming a national leader in mineral development which will benefit the people of Florida, protect Florida's natural resources, and provide Florida with economic prosperity and security.

The Center's approach is to examine each key step in Florida's mineral resource supply chain, identifying gaps to fill, barriers to overcome, and opportunities to take advantage of on the way to making Florida a national leader. This will be an evolving process as The Center collects data and the mineral markets continue to evolve. Therefore, The Center will create an annual report that will update the legislature on The Center's findings and offer recommendations to both remove barriers and make investments that will advance critical mineral development in the State of Florida.

8.1 Recommendations

8.1.1 ADVOCATE FOR NATIONAL CRITICAL MINERAL LISTING AND DEVELOP A STATE-SPECIFIC PROGRAM

This recommendation involves a two-pronged approach: advocating for the inclusion of key Florida minerals in the National Critical Minerals List and developing a state-specific program to mirror federal initiatives such as the DOE FAST-41.

The Center recommends engaging with the Department of the Interior, Florida Geological Survey (FGS), and Florida's Congressional delegation to advocate for the inclusion of key Florida minerals in the National Critical Minerals List in alignment with Florida's strategic objectives. This advocacy should emphasize a comprehensive understanding of criticality which considers the needs of each federal executive agency and their state counterparts. It should also emphasize the economic importance, supply chain vulnerability, and national security implications of these minerals. A consistent and targeted advocacy effort, including meetings and presentations, would be beneficial in communicating the strategic value of these minerals to federal decision-makers.

Additionally, The Center recommends directing the FGS to develop a Florida Critical Minerals Program that mirrors the federal program and existing state-level programs and includes initiatives such as the DOE FAST-41 program. This program would build on the USGS program at the state level, including development of a comprehensive inventory with forecasting. This program should consider Florida's unique economy, industry, and natural resources to identify minerals critical to long-term prosperity. This program would establish specific timelines and milestones for environmental review and permitting processes. It would also include providing grant funding through state agencies similar to those offered by the Department of Energy, Department of Defense, Department of Commerce, and Environmental Protection Agency. This funding, with appropriate oversight and quality control, would support research, development, and sustainable practices. The program should involve key stakeholders, including state and local government agencies, industry leaders, academic institutions, and environmental groups, to ensure comprehensive development and implementation aligned with Florida's strategic goals. Pursuing and winning federal grant money is a crucial aspect of this program, with potential funding sources including:

- **Department of Energy:** Funding for research and development of advanced mining technologies, processing methods, and recycling techniques, as well as projects that enhance the supply chain security of critical minerals.
- **Department of Defense:** Support for stockpiling critical minerals essential for national defense and for domestic production of materials crucial for the defense and energy sectors.

- **Department of Commerce:** Grants to communities affected by disruptions in the supply chain to stimulate economic recovery and growth, and initiatives to expand domestic and international markets for U.S.-produced critical minerals.
- **Environmental Protection Agency (EPA):** Grants for sustainable mining practices, reducing environmental impacts, and improving reclamation efforts.

8.1.2 DEVELOP AND MAINTAIN THE FLORIDA RARE EARTH, CRITICAL MINERAL, AND INDUSTRIAL BYPRODUCT DATA REPOSITORY

Create and maintain a comprehensive repository data for informed decision-making related to the objectives of the Florida State University (FSU) Center for Rare Earths, Critical Minerals, and Industrial Byproducts. The Center will pursue targeted scientific research, serve as a collaboration hub for stakeholders, and develop the comprehensive data these stakeholders need to make informed decisions. This repository will include scientific research, a master directory of state and federal programs and funding opportunities, Florida natural resources and industrial byproduct inventories and forecasting, environmental and economic analysis as presented in this report, and industrial supply chain data. The State of Florida has untapped deposits of critical resources, an expanding industrial base that produces industrial byproducts, and all the assets that can make Florida a key component in the national supply chain of mineral resources. Collecting and monitoring data and policy on these areas will allow for the development of forecasting models that can catapult FSU and the State of Florida into becoming a key part of this critical national industry.

The Center will maintain the insights and questions developed to understand and leverage the data repository. This effort requires continuously updating and refining this list as new information and data become available, ensuring it remains relevant and comprehensive. The Center will address these insights and questions through existing recommendations and, where necessary, develop new recommendations or initiatives. Additionally, The Center will report back to the Legislature periodically, identifying opportunities to leverage these insights for the benefit of Florida and providing answers to the questions to better inform Legislative and Executive branch decision-makers.

As a collaboration hub, The Center will coordinate with legislators, regulators, executive agencies, industry leaders, investors, and academic institutions to continuously evolve the data model to meet changing needs in the state. The Center will facilitate ongoing stakeholder engagement through regular meetings, workshops, and roundtable discussions to foster a collaborative environment for addressing key issues and opportunities in the sector.

Based on the data and forecast modeling, create a 5-year Critical Mineral Supply Chain Development and Investment Plan. This plan will start with the source of the critical mineral and continue through the supply chain to the end user, identifying the state's strengths, weaknesses, opportunities, and threats. The extraction of rare earth elements (REEs) and other minerals from existing industrial byproducts has the most potential to expand Florida's production capacity. The methods for extraction of REEs are growing more efficient as the Center's technology and research advances. These efforts should be supported at the state level through dedicated funding and milestone mapping. Coordination with private partners to determine the most cost-effective and environmentally secure methods will be crucial in the early stages. Additionally, The Center will act as an advisor to stakeholders, helping them navigate and leverage funding sources for market development.

8.1.3 CREATE A STATE CRITICAL MINERALS FUND AND INVESTIGATE THE OPPORTUNITIES FOR REINVESTING AND REINVIGORATING DOMESTIC REO PROCESSING

The Center recommends creating a State Critical Minerals Fund and investigating opportunities for reinvesting and reinvigorating domestic rare earth oxide (REO) processing in Florida. This initiative positions Florida to become a hub for producing REOs from industrial byproduct extraction and invest in establishing itself as the domestic hub for REO processing. Currently, REOs mined domestically in the United States are shipped abroad, primarily to China, for processing into usable rare earth elements (REEs). The recent push for domestic processing capabilities is evidenced by the Department of Defense (DOD) contract awarded to MP Materials in February 2022 to build a facility for processing REOs at the Mountain Pass mine in California. Additionally, in Texas, Lynas Rare Earths announced in 2023 that the DOD is increasing its investment in an REO processing facility from $120 million to $138 million.

Given the growing concern around dependence on China, especially for high-tech applications, state leaders should advocate for bringing in federal dollars to develop the REO processing industry in Florida. Together with mining industries that hold large rare earth resources, Florida's strategic advantages include four major ports, three international cargo-capable airports in central Florida, and access to the CSX Transportation rail network, making it well-positioned to become a major part of a fully vertically integrated supply chain for REEs. Creating a fund that can match or supplement federal and private investments is essential for making capital investments in Florida. Stakeholders involved include state leaders, federal agencies, industry leaders, and local government bodies. The timeline for implementation involves initial advocacy and fund establishment phases, followed by continuous investment and development efforts.

8.1.4 EXPAND RESEARCH FUNDING FOR PROCESSING & VALORIZING INDUSTRIAL BYPRODUCTS

The Center recognizes one of the key barriers for realizing Florida's potential for a large production and processing economy in this space is the extraction and processing of industrial byproducts. Significant progress has been made, but continued laboratory research and pilot projects remain before investment and growth can be realized. The Center recommends investment into these research projects, as targeted and prioritized by the greatest opportunities for economic and environmental benefits for Florida.

To support this initiative, it is essential to allocate funds for researching the most efficient and effective methods for rare earth element (REE) extraction and byproduct processing. The scope of research considered should include the many beneficial re-use opportunities in the scope of the Center's legislative directive. This includes many different sources and valorization of various constituents of the byproducts, not limited to rare earth extraction and separation. By doing so, Florida can maximize the potential of these byproducts and bring extraction and application resources to market. The stakeholders involved should include state and local government agencies, research institutions, industry leaders, and environmental groups. The implementation timeline should allow for initial research and development, followed by pilot projects and full-scale deployment.

8.1.5 EXPAND REGULATORY EFFORTS TO SUPPORT STATE & FEDERAL PERMITTING TO EXPAND BENEFICIAL USE OF INDUSTRIAL BYPRODUCTS

The Center recommends the state perform a regulatory audit of the current and evolving regulatory framework affecting industrial byproduct and solid waste reuse opportunities. This audit would identify any state and federal regulatory frameworks that do not reflect the potential for sustainable re-use of byproducts as an asset. Pathways for beneficial reuse must include development of technologies that ensure that development of these opportunities does not compromise environmental health and safety. This audit should also consider mechanisms to recognize the potential for reduction of environmental impact and liability through these re-use opportunities. Realization of Florida's potential requires maintaining the public trust and protecting long-term interests of Florida's people and natural resources. While private companies and industry stakeholders are already requesting expanded rulemaking, state advocacy is essential to influence these changes. Florida's advocacy should emphasize the economic, domestic security, and environmental benefits of transforming industrial "wastes" into reusable resources in the light of new technology.

8.2 Alignment and Value Realization of Recommendations

8.2.1 ADVOCATE FOR NATIONAL CRITICAL MINERAL LISTING AND DEVELOP A STATE-SPECIFIC PROGRAM

Insights the Recommendation Will Act On

- Establishing a Domestic Supply Chain Enhances Economic and National Security
- Federal Funding for Innovation and Development Drives Economic Growth
- Diversifying Supply Sources Boosts Economic Security
- Investing in Complete Supply Chain Systems Enhances Industrial Resilience
- Investing in Workforce Development Supports Industry Growth
- Forming Public-Private Partnerships Enhances Supply Chain Stability
- Establishing a State-Level Critical Minerals Program Aligns with Federal Initiatives
- Leveraging Public-Private Partnerships and Educational Collaborations Fosters Innovation and Workforce Development

Questions the Recommendation Will Answer

- How can the impact of federal funding on innovation and economic growth in Florida's rare earth elements and critical minerals sector be measured and reported?
- What specific policies or legislative actions are necessary to attract and secure federal funding for innovation and development in Florida's rare earth elements and critical minerals sector?
- How can Florida create a strategic plan to identify, develop, and regulate new supply sources for critical minerals, and how can Florida diversify its supply sources effectively?
- What specific research and development projects should Florida prioritize to align with federal funding opportunities, and how can Florida position itself to attract more federal funding for critical minerals projects?
- How can Florida create incentives for companies to invest in complete supply chain systems within the state, and how can Florida's educational institutions and training programs be aligned with industry needs to support these investments?
- What models of public-private partnerships have been successful in similar industries, and how can Florida facilitate the formation and success of such partnerships in the RE/CM/IB sector?
- How can Florida create a strategic communication plan to advocate for the inclusion of specific minerals in the USGS Critical Minerals List?

RE/CM/IB Systems Positively Impacted: This recommendation will positively impact the entire RE/CM/IB system, including Material Acquisition and Material Processing by streamlining the permitting process and supporting advanced technologies, fostering the growth of domestic processing capabilities and ensuring environmental standards and economic viability.

Value that will be Realized: This recommendation will realize value across the three lenses: it will benefit the People of Florida by creating jobs and improving living standards, enhance the Stewardship of Natural Resources by promoting sustainable practices, and boost Economic Prosperity and Security by attracting federal funding, fostering innovation, and creating a robust and resilient supply chain for critical minerals.

8.2.2 DEVELOP AND MAINTAIN THE FLORIDA RARE EARTH, CRITICAL MINERAL, AND INDUSTRIAL BYPRODUCT DATA REPOSITORY

Insights the Recommendation Will Act On

- Establishing a Domestic Supply Chain Enhances Economic and National Security
- Federal Funding for Innovation and Development Drives Economic Growth
- Implementing Sustainable Practices Minimizes Environmental Impacts
- Advancing Recovery Technologies Promotes Sustainability and Economic Viability
- Diversifying Supply Sources Enhances Economic Security
- Strategic Cooperation and Partnerships Foster Technological Innovation
- Robust Feedback Mechanisms Enhance Decision-Making for Environmental Impact
- Developing Domestic Processing Capabilities is Key to Achieving Environmental Goals
- Florida Can Capture China Market Share by Focusing on Greater Natural Resource Stewardship
- Utilizing Phosphogypsum (PG) Transforms Waste into Valuable Resources
- Investing in Complete Supply Chain Systems Enhances Industrial Resilience
- Investing in Workforce Development Supports Industry Growth
- Forming Public-Private Partnerships Enhances Supply Chain Stability
- Repurposing Citrus Byproducts Creates New Economic Opportunities
- Comprehensive Data Collection and Monitoring Improves Supply Chain Planning
- Utilizing Industrial Byproducts Maximizes Resource Efficiency
- Leveraging Public-Private Partnerships and Educational Collaborations Fosters Innovation and Workforce Development
- System Leveling Can Significantly Reduce Environmental Impacts
- Focusing on High-Density Resource Acquisition Improves Efficiency and Environmental Outcomes
- Advances in Extraction Technology are Essential for Environmental Progress
- Positioning FSU as a National Research Hub Will Drive Economic and Environmental Benefits

Questions the Recommendation Will Answer

- How can the impact of federal funding on innovation and economic growth in Florida's rare earth elements and critical minerals sector be measured and reported?

- What research is needed to identify the most promising areas for federal investment in Florida's rare earth elements and critical minerals sector, and how can Florida position itself to attract more federal funding?
- How can the effectiveness of sustainable practices and advanced recovery technologies in reducing environmental impacts be measured and reported in Florida's rare earth elements and critical minerals sector, and what specific metrics will be used?
- What additional research is needed to fully understand the mineral content and long-term environmental benefits of Florida's industrial byproducts and solid wastes?
- What are the most promising recovery technologies for extracting rare earth elements and critical minerals from unconventional sources, and how can these technologies be implemented in Florida?
- How can potential new supply sources for critical minerals within Florida and its regions be identified and evaluated?
- What data and metrics are essential for creating robust feedback mechanisms to monitor environmental impacts?
- What specific technologies are needed to improve extraction and processing efficiency in Florida, and how can these technologies be effectively implemented?
- What specific research and development projects should Florida prioritize to align with federal funding opportunities?
- What are the most efficient methods for extracting rare earth elements from phosphogypsum, and what are the potential environmental impacts and mitigation strategies?
- What are the most promising uses for citrus byproducts in various industries, and what infrastructure and technologies are needed to efficiently process and repurpose these byproducts?
- How can Florida develop a strategic plan to diversify its supply sources effectively?
- How can Florida create incentives for companies to invest in complete supply chain systems within the state, and how can Florida's educational institutions and training programs be aligned with industry needs to support these investments?
- What models of public-private partnerships have been successful in similar industries, and how can Florida facilitate the formation and success of such partnerships in the RE/CM/IB sector?
- What partnerships and collaborations are essential for the success of research and development efforts in extracting critical minerals from industrial byproducts?
- How can educational institutions and industry leaders collaborate to develop a skilled workforce capable of supporting the critical minerals sector in Florida?
- What specific environmental factors in Florida's ecosystem need to be considered in tailored impact assessments?
- What additional research is needed to fully understand the unique environmental dynamics of Florida?

- What are the current technological gaps in the extraction of REs, CMs, and IBs, and which technologies need to be developed or improved to enhance extraction efficiency?
- What measures and adaptations are needed to ensure and facilitate system leveling across all RE/CM/IB operations in Florida?
- What are the potential economic impacts of system leveling on local businesses and communities?
- How can existing environmental impact assessment frameworks be adapted to better fit the unique characteristics of Florida's ecosystem?
- What investments are necessary to establish domestic processing facilities for REs, CMs, and IBs in Florida?
- What model needs to be developed to generate feedback on the elimination and amelioration of environmental impacts through focused high-density resource acquisition and resource recovery/reuse?
- How can policies and incentives be structured to support the development of domestic processing capabilities?
- How can stakeholder engagement be enhanced to incorporate local knowledge into environmental assessments effectively?
- What partnerships and collaborations are essential for the success of the research hub at FSU, and what are the potential economic impacts of establishing this hub?
- What specific data and feedback mechanisms are needed to enhance decision-making for environmental impacts, and how can they be implemented effectively within existing government structures?
- How can high-density resource acquisition be incentivized through policy measures?
- What specific STEM and trade skills are most needed to support the RE/CM/IB industries in Florida, and how can educational institutions align with these needs?

RE/CM/IB Systems Positively Impacted: This recommendation will positively impact the entire RE/CM/IB system, including Material Acquisition, Material Processing, Manufacture of Consumer Goods, and Consumer Goods Disposal, by improving efficiency, sustainability, and supply chain planning. Additionally, it will provide a structured approach to leveraging insights and addressing key questions through ongoing research, policy recommendations, and stakeholder collaboration.

Value that will be Realized: This recommendation will realize value across the three lenses: it will benefit the People of Florida by creating jobs and improving living standards, enhance the Stewardship of Natural Resources by promoting sustainable practices, and boost Economic Prosperity and Security by fostering industry growth, reducing reliance on foreign imports, and guiding stakeholders through funding and market development. By ensuring that The Center continuously manages and addresses the evolving list of insights and questions, Florida can maintain its leadership in rare earths, critical minerals, and industrial byproducts, driving long-term economic and environmental benefits.

8.2.3 CREATE A STATE CRITICAL MINERALS FUND AND INVESTIGATE THE OPPORTUNITIES FOR REINVESTING AND REINVIGORATING DOMESTIC REO PROCESSING

Insights the Recommendation Will Act On

- Establishing a Domestic Supply Chain Enhances Economic and National Security
- Federal Funding for Innovation and Development Drives Economic Growth
- Advancing Recovery Technologies Promotes Sustainability and Economic Viability
- Utilizing Industrial Byproducts Maximizes Resource Efficiency
- Establishing a State-Level Critical Minerals Program Aligns with Federal Initiatives
- Leveraging Public-Private Partnerships and Educational Collaborations Fosters Innovation and Workforce Development

Questions the Recommendation Will Answer

- What specific policies or legislative actions are necessary to attract and secure federal funding for innovation and development in Florida's rare earth elements and critical minerals sector?
- How can Florida create incentives and a favorable regulatory environment for industries to adopt sustainable practices and advanced recovery technologies in the extraction and processing of rare earth elements and critical minerals?
- How can Florida create a strategic plan to identify, develop, and regulate new supply sources for critical minerals?
- What specific technologies are needed to improve extraction and processing efficiency in Florida, and how can these technologies be effectively implemented?
- What partnerships and collaborations are essential for the success of research and development efforts in extracting critical minerals from industrial byproducts?
- How can Florida create incentives for companies to invest in complete supply chain systems within the state, and how can Florida's educational institutions and training programs be aligned with industry needs to support these investments?

RE/CM/IB Systems Positively Impacted: This recommendation will positively impact the entire RE/CM/IB system, including enhanced acquisition of raw materials and industrial byproducts for REO production, development of domestic processing capabilities to refine REOs into usable rare earth elements, increased availability of domestically processed REOs for high-tech applications, and potential for improved recycling and reuse of REOs, reducing waste and environmental impact.

Value that will be Realized: This recommendation will realize value across the three lenses: it will benefit the People of Florida by creating jobs and improving living standards, enhance the Stewardship of Natural Resources by promoting sustainable practices, and boost Economic Prosperity and Security by attracting federal funding, fostering innovation, and creating a robust and resilient supply chain for critical minerals.

8.2.4 EXPAND RESEARCH FUNDING FOR PROCESSING & VALORIZING INDUSTRIAL BYPRODUCTS

Insights the Recommendation Will Act On

- Implementing Sustainable Practices Minimizes Environmental Impacts
- Advancing Recovery Technologies Promotes Sustainability and Economic Viability
- Establishing a Domestic Supply Chain Enhances Economic and National Security
- Federal Funding Drives Innovation and Industrial Growth
- Investing in Complete Supply Chain Systems Enhances Industrial Resilience
- Investing in Workforce Development Supports Industry Growth
- Forming Public-Private Partnerships Enhances Supply Chain Stability
- Diversifying Supply Sources Boosts Economic Security
- Utilizing Industrial Byproducts Maximizes Resource Efficiency
- Adopting Sustainable Practices and Advanced Technologies Minimizes Environmental Impacts
- Leveraging Public-Private Partnerships and Educational Collaborations Fosters Innovation and Workforce Development

Questions the Recommendation Will Answer

- What technologies are currently available or need development to effectively process high-density materials?
- How can the effectiveness of sustainable practices in reducing environmental impacts be measured and reported in Florida's rare earth elements and critical minerals sector, and what specific metrics will be used?
- What additional research is needed to understand the long-term environmental benefits of sustainable practices in Florida's rare earth elements and critical minerals sector?
- What specific policies or legislative actions are necessary to attract and secure federal funding for innovation and development in Florida's rare earth elements and critical minerals sector?
- How can Florida create incentives for companies to invest in complete supply chain systems within the state, and how can Florida’s educational institutions and training programs be aligned with industry needs to support these investments?

- How can Florida create a strategic plan to identify, develop, and regulate new supply sources for critical minerals?
- How can Florida create incentives and a favorable regulatory environment for industries to adopt sustainable practices and advanced recovery technologies in the extraction and processing of rare earth elements and critical minerals?
- What specific technologies are needed to improve extraction and processing efficiency in Florida, and how can these technologies be effectively implemented?
- What partnerships and collaborations are essential for the success of research and development efforts in extracting critical minerals from industrial byproducts?
- What are the most efficient methods for extracting rare earth elements from phosphogypsum, and what are the potential environmental impacts and mitigation strategies?

RE/CM/IB Systems Positively Impacted: This recommendation will positively impact the entire RE/CM/IB system, including enhanced acquisition of raw materials and industrial byproducts for REO production, development of domestic processing capabilities to refine REOs into usable rare earth elements, increased availability of domestically processed REOs for high-tech applications, and potential for improved recycling and reuse of REOs, reducing waste and environmental impact.

Value that will be Realized: This recommendation will realize value across the three lenses: it will benefit the People of Florida by creating jobs and improving living standards, enhance the Stewardship of Natural Resources by promoting sustainable practices, and boost Economic Prosperity and Security by fostering industry growth and reducing reliance on foreign imports.

8.2.5 EXPAND REGULATORY EFFORTS TO SUPPORT STATE & FEDERAL PERMITTING TO EXPAND USE OF INDUSTRIAL BYPRODUCTS

Insights the Recommendation Will Act On

- Establishing a Domestic Supply Chain Enhances Economic and National Security
- Implementing Sustainable Practices Minimizes Environmental Impacts
- Establishing a Domestic Supply Chain Enhances Economic and National Security
- Implementing Sustainable Practices Minimizes Environmental Impacts
- Utilizing Phosphogypsum (PG) Transforms Waste into Valuable Resources
- Repurposing Citrus Byproducts Creates New Economic Opportunities
- Expanding Regulatory Efforts Enhances Utilization of Industrial Byproducts and Streamlines Permitting Processes
- Utilizing Industrial Byproducts Maximizes Resource Efficiency

Questions the Recommendation Will Answer

- What specific legal or regulatory changes are needed to promote the adoption of sustainable practices in the extraction and processing of rare earth elements and critical minerals in Florida?
- How can Florida create a strategic plan to identify, develop, and regulate new supply sources for critical minerals?
- How can Florida effectively engage key stakeholders, including local communities, industry leaders, environmental groups, and federal agencies, in the development of a domestic supply chain for rare earth elements and critical minerals?
- How can Florida create incentives for companies to invest in complete supply chain systems within the state, and how can Florida's educational institutions and training programs be aligned with industry needs to support these investments?
- What specific policies or legislative actions are necessary to attract and secure federal funding for innovation and development in Florida's rare earth elements and critical minerals sector?
- How can Florida create incentives and a favorable regulatory environment for industries to adopt sustainable practices and advanced recovery technologies in the extraction and processing of rare earth elements and critical minerals?

RE/CM/IB Systems Positively Impacted: This recommendation will positively impact the entire RE/CM/IB system, including Material Acquisition by enhancing the sourcing of raw materials and industrial byproducts, Material Processing by facilitating the refinement of these byproducts into usable materials, Manufacture of Consumer Goods by increasing the availability of sustainably sourced materials, and Consumer Goods Disposal by promoting the recycling and reuse of industrial byproducts, thereby reducing waste and environmental impact.

Value that will be Realized: This recommendation will realize value across the three lenses: it will benefit the People of Florida by creating jobs and improving living standards, enhance the Stewardship of Natural Resources by promoting sustainable practices, and boost Economic Prosperity and Security by fostering industry growth and reducing reliance on foreign imports.

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