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March 31, 2022

IN THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REQUEST FOR APPROVAL OF ADDITIONAL USES OF PHOSPHOGYPSUM PURSUANT TO 40 C.F.R. § 61.206

Small-scale Road Pilot Project on Private Land in Florida

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CONTENTS

This Petition and supporting risk analysis were developed to comply with requirements of the Environmental Protection Agency (EPA) regulations governing the approval of alternative uses for phosphogypsum (PG) at 40 C.F.R. Part 61 and guidance in the "Applying to EPA for Approval of Other Uses of Phosphogypsum: Preparing and Submitting a Complete Petition under 40 C.F.R. § 61.206, A Workbook" (EPA PG Workbook), and through a series of discussions with EPA staff. This Petition incorporates by reference, The Fertilizer Institute's (TFI) October 2019 Request For Approval Of Additional Uses Of Phosphogypsum Pursuant to 40 C.F.R. § 61.206 (EPA-HQ-OAR-2020-0442-0017), the April 7, 2020 Revised Request (EPA-HQ-OAR-2020-0442-0005), and the associated administrative records for these Requests and includes, Radiological Risk Review (Appendix 9), Monitoring Plan (Appendix 10), Site Map (Appendix 12), and New Wales Stack Data (Appendix 13) and any additional information EPA determines for the administrative record. The methodologies and technical evaluations were informed by this previous work and in coordination with EPA.[1]

This Petition includes the following sections:

Section	Description
Preamble	Definition of Key Terms
I	Overview
II	Petition Request
III	Benefits of Use in PG Road Construction
IV	Conclusion

This Petition is supported by the following information:

Appendix Number	Description
Appendix 1-4, 6, and 8, The Fertilizer Institute October 2019 Petition and the April 7, 2020 Revised Petition and their relevant Appendices are incorporated by reference. Mosaic was a member of the TFI member companies who submitted the October 2019 and April 7, 2020 Petitions. The risk is based on adjusting the risk calculated in October	Appendix 1 from the April 7, 2020 TFI Revised Request for Approval Of Additional Uses Of Phosphogypsum Pursuant to 40 C.F.R. § 61.206 Use in Road Construction Projects Authorized by Federal, State and Local Departments of Transportation or Public Works (April 7, 2020 TFI Revised Petition). This includes the Summary of the Risk

[1] EPA approved TFI's Petition to authorize the removal of PG for use in government road construction projects under certain conditions on October 20, 2020. *See* Notice of Approval of the Request for Other Use of Phosphogypsum by The Fertilizer Institute, 85 Fed. Reg. 66,550, 66,551 (Oct. 20, 2020). The approval was withdrawn, without prejudice, on July 7, 2021, for failure to provide specific information unrelated to the risk assessment. *See* Withdrawal of Approval for Use of Phosphogypsum in Road Construction, 86 Fed. Reg. 35,795 (Jul. 7, 2021).

2019 and April 7, 2020 Petitions to reflect the risk from exposures appropriate for this Small-Scale Mosaic Pilot Study.	Assessment and Metals Screening Report (same as October 2019 Petition submission). Appendix 2: Radiological Risk Assessment in Support of Petition for Beneficial Use of Phosphogypsum (same as October 2019 Petition submission) Appendix 3: Human Health Risk Screening for Metals and Metalloids Appendix 4 4a: Response to EPA Comments on January 16, 2020 and 4b: Responses to Second Set of USEPA Questions on March 6, 2020 – Reclaimer Appendix 6: Policy Navigation Group, Economic Analysis of Phosphogypsum Reuse (December 2019) Appendix 8: Other documents being submitted for the administrative record
Appendix 9	Mosaic Petition – Road Pilot Study – Radiological Risk Review
Appendix 10	Mosaic Petition – Monitoring Plan for the Small-Scale Pilot Road Study
Appendix 11	Site Map- Location of the Road
Appendix 12	New Wales Stack Data

DEFINITION OF KEY TERMS

The basic concepts relevant to this Petition are:

PILOT STUDY CONCEPTS

Small-scale pilot project: is the intermediate step between laboratory testing and full-scale implementation of the alternative use.[2] Because of its small size, both cost, potential doses, and risks will be lower in a small-scale study than in the full-scale implementation of the alternative use. The small-scale study is designed to simulate alternative use conditions as much as possible. At a minimum, a small-scale study will consist of a field test demonstrating

[2] EPA, Applying to EPA for Approval of Other Uses of Phosphogypsum: Preparing and Submitting a Complete Petition Under 40 CFR 61.206: A Workbook, at 9 (2005) [hereinafter EPA PG Workbook], https://www.epa.gov/sites/default/files/2015-05/documents/wrkbk_sub-r_appl_1105.pdf.

how the proposed alternative would function and a control test to generate baseline conditions.[3]

This Petition seeks approval to perform a small-scale pilot study on land owned and controlled by Mosaic of the use of PG in road construction compared to a control area (*see* Appendix 11: Site Map- Location of the Road and Figure 1, Appendix 9: Radiological Risk Review).

The purpose of the small-scale pilot is to demonstrate the range of PG road construction designs that meet the Florida Standard Specifications for Road and Bridge Construction.[4]

Florida road specifications. The Florida Standard Specifications for Road and Bridge Construction contain requirements governing the method or manner of performing work, quantities and qualities of materials, and labor for all Florida Department of Transportation (FDOT) contracts.[5]

RADIATION CONCEPTS

Radioactivity is a measure of the amount of gamma rays, alpha or beta particles, x-rays, or neutrons that disintegrate from a gram of the substance being measured (in our situation, in each gram of PG). The amount of radioactivity in a gram of a substance is measured in curies (Ci) or becquerels (Bq). One curie is 3.7×10^{10} radioactive decays per second, roughly the amount of decays that occur in 1 gram of radium per second. A Bq is one disintegration per second. Historically, scientists originally used units of Ci. The International System of Units (ISU) now uses Bq.

A picocurie (pCi) is one-trillionth of a curie.

1 Bq = 2.70 x 10-11 curies = 27 pCi

Many substances (often naturally occurring substances) are radioactive. Generally, the sources for this explanation include EPA, Radiation Terms and Units, available at https://www.epa.gov/radiation/radiation-terms-and-units; NRC, available at https://www.nrc.gov; MIT News, Explained: rad, rem, sieverts, becquerels A guide to terminology about radiation exposure, available at http://news.mit.edu/2011/explained-radioactivity-0328; National Aeronautics and Space Administration, Radiation Math, available at https://www.nasa.gov.

The Maximum average radium (226) concentration in the PG used in the small-scale pilot study will be 35 pCi/g or less and will be measured at the location where the PG will be removed prior to removal from the stack.

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[3] *Id.*

[4] *See* FLA. DEP'T OF TRANSP , Standard Specifications for Road & Bridge Construction 219, § 200 (Jan. 2022), https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/specbooks/january-2022/january2022-ebook.pdf?sfvrsn=752d1333_4.

[5] *See id.*

EXPOSURE RELATED CONCEPTS

Reasonable Maximum Exposure: An estimate of a conservative exposure case, well above the average case, that is still within the range of possible exposures.

RISK ASSESSMENT AND RISK MANAGEMENT CONCEPTS

The regulatory risk assessment process converts a dose equivalent (in millirem) into an upper bound risk (or probability) of developing fatal cancers. It is based on a regulatory assumption that the dose equivalent may cause harmful effects and as the magnitude of this dose increases or decreases, the risk increases or decreases, in direct proportion, respectively, i.e., linearly (e.g., if the dose is halved, the calculated risk is halved).

The risk assessment submitted as a component of the TFI Petition (April 7, 2020) concluded that an effective dose of 600 millirem corresponds to a risk of 3 in 10,000 (i.e., if all of the protective assumptions are valid, 3 in 10,000 people may develop a fatal cancer). The actual risk is likely to be lower.

An average Radium-226 concentration of 35 pCi/g in PG was proposed in TFI's Petition (and accepted by EPA). This concentration utilized for road construction is well below EPA's safe risk level of 3 in 10,000 and is consistent with the 2019 stack sampling and with prior sampling conducted by EPA. Specifically, the 2019 risk assessment was based on a nominal Radium-226 value of 27 pCi/g, a value based on previous work by the EPA and published information on Radium-226 levels in PG. The 2019 assessment further examined the potential dose to the most exposed receptor (RME), the road construction worker who was estimated to receive a risk of about 0.55 per 10,000 exposed from the Radium-226 in the PG used in road construction. Holding all other factors the same, the potential doses and risks to the RME arising from the use of PG in road construction were also scaled up based on relative concentrations of Radium-226 PG. For example, the 2019 risk assessment discussed the risks to a road construction worker arising from the use of PG containing 35 pCi/g of Radium-226 would be about 0.7 in 10,000 (i.e., 0.5/10,000 x 35/27), compared to the 3 in 10,000 risk level (EPA's safe level) corresponds to an average Radium-226 concentration of 148 pCi/g. Although we are not aware of any PG with average Radium-226 concentrations anywhere near 148 pCi/g, such PG could in principle be used for road construction and still achieve the EPA safe level of a risk of 3 in 10,000. Table 5.1 of the 2019 Risk Assessment and discussion on the broad sampling data demonstrates that PG taken from the stacks is not expected to exceed that limit of 35pCi/g. EPA approved the TFI Petition setting of a maximum average Radium-226 concentration of 35 pCi/g.[6]

The risk assessment for this 2022 Mosaic Petition calculates the risk of the small-scale pilot road study by adjusting the risk determined in the TFI risk assessments to account for the shorter

[6] *See* Notice of Approval of the Request for Other Use of Phosphogypsum by The Fertilizer Institute, 85 Fed. Reg. 66,550, 66,552 (Oct. 20, 2020).

duration of exposure and smaller size of the pilot study (*see* Table 1, below). The radiological risk for the 2022 Mosaic Pilot Study is likely less than 1 in 1 million (*see* Table 2, below).

Table 1 Comparison of Risk Assessment Assumptions and Pilot Study Conditions

	Assumptions in 2019 Radiological Risk Assessment	Conditions in the Pilot Study
PG in roadbed material, by weight	< 50 %	< 50 %
Ra-226 in PG	27 pCi/g (max 35 pCi/g)	<35 pCi/g (The nominal average radium concentration used in the October 2019 and April 7, 2020 TFI risk assessment). The average Radium-226 concentration in 2019 for the New Wales stack was 15pCi/g (Appendix 12). Sampling will be updated prior to removal of PG from any stack for the road project, as required by EPA regulations.
Road base	10 inches	10 inches
PG of the surface asphalt	< 2.25%	none
Thickness of surface asphalt	4-5 inches	4-5 inches
Road length	>> 1mile (5280 feet)	3 x 200 feet
Road width	48 feet (4 lanes)	24 feet (2 lanes)
Residence	> 50 feet from the road	>> 50 feet from the road

Table 2. Application of the 2019 Risk Assessment for the Pilot Road Construction Exposures

Receptors Considered	Exposure Pathways	Applicable to Pilot Road	Basis for Decision	RME Radiation Doses
Truck Driver who delivers PG for road base material to construction site	Gamma radiation	Yes	PG will need to be delivered to the test road construction site	Given the size of the proposed test road, the amount of PG that will be required is much smaller than that required for the 4-lane county road considered in the 2019 risk assessment. A truck driver would be exposed for a period of a few weeks to a month, rather than the 5 years assumed in the 2019 risk assessment, and thus, on this basis alone, the dose (and risk) to the truck driver

Receptors Considered	Exposure Pathways	Applicable to Pilot Road	Basis for Decision	RME Radiation Doses
				transporting PG for the test road would be about 1/60th of that of the dose or about 1.6 mrem for a truck driver worker who works on the Pilot Road. The unavoidable dose from natural background is about 311 mrem and the incremental dose to the RME is negligible compared to dose or risk criteria and a tiny fraction of the natural background dose.
Road Construction Worker who works on roads built exclusively with PG material	Gamma radiation and PG in dust	Yes	Workers who build the test road have potential for exposure to PG	Given the size of the proposed test road, the time to construct the test road is much smaller – a few weeks to a month, rather than the 5 years assumed for construction of the 4-lane county road considered in the 2019 risk assessment. Thus, on this basis alone, the dose (and risk) to the construction worker who works on the test road would be about 1.8 mrem (i.e., about 1/60th of that estimated for the construction worker from the 2019 risk assessment). Also, the average Radium-226 concentration measured in New Wales PG stack in 2019 was 15pCi/g (Appendix 12). The unavoidable dose from natural background is about 311 mrem and hence, he incremental dose to the RME is negligible compared to dose or risk criteria and a tiny fraction of the natural background dose.
Utility worker	Gamma radiation and PG in dust	No	The site is controlled by Mosaic and there is no public access or uncontrolled construction	Not Applicable
Road User (motorist/bicyc	Gamma radiation	No	The site is controlled by	Given the test road is on private land owned by Mosaic, no public use or

Receptors Considered	Exposure Pathways	Applicable to Pilot Road	Basis for Decision	RME Radiation Doses
list) on the PG-constructed road			Mosaic and there is no public access	exposures are expected. Consideration of other road users such as Mosaic workers traveling on the road is possible but would result in dose and exposures much less than those estimated in the 2019 risk assessment considering the PG containing portion of the road would be narrower and shorter than the road assessed in the 2019 risk assessment. The road user dose and exposures in the 2019 risk assessment were already very small, so the dose to the test road user would be negligible compared to dose or risk criteria and a tiny fraction of the natural variation in natural background dose.
Resident Living Near Road	Gamma radiation and PG in dust	No	The radiation levels from the road studied in the 2019 risk assessment decrease rapidly with increasing distance. As the site is controlled by Mosaic and there is no possibility of a residence being constructed closer in proximity than the safe distance established by the 2019 risk assessment. See, TFI April 7,	Not Applicable; the closest residence is over 3miles from the test road location.

Receptors Considered	Exposure Pathways	Applicable to Pilot Road	Basis for Decision	RME Radiation Doses
			2020, Appendix 2.	
At EPA's request, the 2019 risk assessment considered a **reclaimer** scenario, which as discussed in the Petition and the 2019 risk assessment, is not considered as a reasonable maximum exposure (RME) scenario.	Gamma exposure and radon	No	Given the size of the proposed test road and the observation that the test road will be constructed on Mosaic property, a reclaimer scenario is not reasonably plausible.	Not Applicable

I. OVERVIEW

A. INTRODUCTION

PG is a byproduct of phosphate fertilizer manufacturing. Federal regulations, promulgated initially in 1989, require, with limited exceptions, that all PG must be disposed of in stacks or backfilled in phosphate mines. 40 C.F.R. § 61.206(a). Alternative uses of PG may be approved where the EPA Assistant Administrator of the Office of Air and Radiation determines the proposed use is at least as protective of public health, in both the short and long term, as disposal in a stack or mine. 40 C.F.R. § 61.206(a)-(c). This regulatory construct has resulted in the storage of 1.7 billion tons of PG in engineered stacks and the need for new storage capacity at the rate of 46 million tons per year, consuming large quantities of land and in some cases, creating the prospect of negative environmental impacts. Local communities have expressed a desire for beneficial reuse of PG for generating economic development, making land available for other uses and mitigating aesthetic and potential environmental concerns. Meanwhile, PG is widely and safely used in other countries, with significant safe reuse reported in at least 21

countries.[7] Mosaic believes data is now available to support additional alternative uses, including large volume uses such as in road construction, landfill cover, and concrete and cement for construction. EPA's consideration and approval of additional beneficial uses would support Mosaic's sustainability goals of reducing manufacturing waste and greenhouse gas emissions, decreasing the need for virgin materials that require excavation, and potentially reducing the existence or size of stacks as other countries have done.

B. **BACKGROUND**

EPA approved The Fertilizer Institute's April 7, 2020 Revised Request under 40 C.F.R. § 61.206 for use of PG in government road construction on October 20, 2020.[8] Specifically, that approval recognized that PG suppliers may not be the end users and therefore, EPA conditioned the approval to require that the PG supplier and the end user each provide information to EPA about user location and quantity prior to removal from the stack. EPA found TFI's exposure scenarios used for the supporting risk assessment "largely consistent with the EPA's 1992 analysis, as were the overall results."[9] Further, EPA found that TFI's risk assessment "adequately demonstrate[d] that the use of [PG] in road construction will be at least as protective of human health, in the short- and long-term, as stacking."[10]

EPA's approval was challenged by various environmental groups, which also requested EPA to reconsider its approval[11] and EPA withdrew its approval on July 7, 2021.[12] EPA determined that it was premature to approve TFI's request without all of the 40 C.F.R. § 61.206(b) information requirements having been met at the time of the application.[13] EPA's withdrawal was without prejudice to a subsequent request under § 61.206(b). Mosaic's Petition for a small-scale road pilot study is such a request as it contains the information required by 40 C.F.R. § 61.206(b). EPA's approval of this Petition is the next step, necessary to ultimately demonstrate that PG can be beneficially used in Florida road construction.

II. PETITION REQUEST

[7] The Fertilizer Institute, Revised Request for Approval of Additional Uses of Phosphogypsum Pursuant to 40 CFR § 61.206: Use in Road Construction Projects Authorized by Federal, State and Local Departments of Transportation or Public Works, EPA-HQ-OAR-2020-0442-0005 (Apr. 7, 2020).

[8] EPA approved the use of PG in government road construction under specific conditions. 85 Fed. Reg. 66,550 (Oct. 20, 2020).

[9] *Id.* at 66,552.

[10] *Id.*

[11] *Ctr. for Biological Diversity v. EPA*, Case No. 20-1506 (D.C. Cir. Dec. 18, 2020). These same groups submitted, on the same day, a petition seeking EPA reconsideration ostensibly under the Clean Air Act. EPA stated that reconsideration was under its own initiative and pursuant to President Biden's Executive Order 13990 which directs agencies to examine a wide range of actions issued by the previous administration.

[12] *See* Withdrawal of Approval for Use of Phosphogypsum in Road Construction, 86 Fed. Reg. 35,795 (Jul. 7, 2021).

[13] *Id.*

A. Specific Request

This Petition requests EPA approval under 40 C.F.R. § 61.206 to remove PG from a stack for use in a small-scale pilot project conducted with the University of Florida to demonstrate the beneficial use of PG in engineered road base. Laboratory studies conducted by the University support that PG, when appropriately blended with other aggregate or cementitious materials, can meet the performance criteria for engineered road base.

Environmental testing of PG aggregate blends supports that a properly designed and constructed road will meet conventional human health risk criteria sufficient for beneficial use. EPA's approval will be the next step toward developing a safe and economic alternative use for PG.

B. Requirements

1. Components of the Petition

40 C.F.R. § 61.206(b) requires the Petition must be in writing and should address the following:

The name and address of the person(s) making the request:

Patrick Kane
VP Operations Services, North America
Mosaic Fertilizer, LLC
13830 Circa Crossing Drive
Lithia, Fl 33547

A description of the proposed use, including any handling and processing that the phosphogypsum will undergo:

This Petition seeks approval to perform a small-scale pilot study of the use of PG in road construction on land owned and controlled by Mosaic. The purpose of the small-scale pilot is to demonstrate the range of PG road construction designs that meet the Florida Standard Specifications for Road and Bridge Construction. See, Section II for full description.

The location of each facility, including suite and/or building number, street, city, county, state, and zip code, where any use, handling, or processing of the phosphogypsum will take place:

Mosaic New Wales stack, 3095 Hwy 640 W. Mulberry, FL 33860.
See, Appendix 11 Site Map and Appendix 9, Figure 1 for aerial view of the proposed project location.

The mailing address of each facility where any use, handling, or processing of the phosphogypsum will take place, if different from paragraph (b) (3) of this section.

The quantity of phosphogypsum to be used by each facility:

Total amount of PG is estimated to be up to but not more than 500 tons.

The average concentration of Radium-226 in the phosphogypsum to be used:

2019 data for the New Wales stack shows an average of about 15 pCi/g and a maximum of about 19 pCi/g. Based on that data, we can assume the level will be below 35pCi/g. *See*, Appendix 12.

A description of any measures which will be taken to prevent the uncontrolled release of phosphogypsum into the environment:

Mosaic employees will handle all offloading of PG from the stack to trucks used to haul PG to road site. PG will be unloaded to a prepared staging area for mixing with aggregate as described in Section II and Appendix 9. All PG will be handled consistent with FDOT requirements for road construction.

An estimate of the maximum individual risk, risk distribution, and incidence associated with the proposed use, including the ultimate disposition of the phosphogypsum or any product in which the phosphogypsum is incorporated.

See Appendix 9

A description of the intended disposition of any unused phosphogypsum:

Any unused PG will be returned to the stack

The Petition must be "signed and dated by a corporate officer or public official in charge of the facility.":

See Petition, Signature page.

2. Scope of the Petition

The scope of this request is described below.

Small-scale pilot road study risk assessment.

The Petition calculates the risk of the small-scale pilot road study by adjusting the risk determined in the October 2019 and April 7, 2020 TFI risk assessments based on the shorter duration of exposure for the pilot study. Mosaic adjusted the exposure times to reflect the exposures for the Pilot Study.

3. The Reasonable Maximum Exposure (RME)

For there to be a risk, there must be exposure. EPA uses a reasonable maximum exposure (RME) metric to assess exposure risk. According to EPA, the "intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures."[14] EPA guidance suggests that each exposure factor used to estimate the

[14] EPA, Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment, 6-3 (2001), https://www.epa.gov/sites/default/files/2015-09/documents/rags3adt_complete.pdf; *see also id.* at 7-1 ("The RME is defined as "the maximum exposure that is reasonably expected to occur within a potentially exposed population."); Interstate Technology Regulatory Council, Decision Making at Contaminated Sites, Issues and Options in Human Health Risk Assessment at 6.1.1 (2015) [hereinafter ITRC Decision Making at

RME should be selected so that the resulting estimate of exposure is consistent with the higher end of the range of plausible exposures. [15]

A National Academy of Science (NAS) Committee reviewing EPA's regulation of technologically enhanced naturally occurring radioactive material (TENORM) recommended that "EPA should use exposure and dose risk assessments that are "reasonably realistic" in developing standards for exposure to the various types of low level naturally occurring radiation.[16] The Committee defined "reasonably realistic" as "not … intended to greatly overestimate or underestimate actual effects for the exposure situation of concern" and EPA agreed with the Committee's recommendations.[17]

The exposure calculations in the Petition use currently accepted radiation modeling methods such as RESRAD and Microshield. EPA also notes that "[i]f "high-end values are chosen for every exposure factor, then the resulting exposure estimate may no longer be consistent with the RME and may exceed the realm of possibility altogether."[18]

The use of reasonable exposure assumptions is supported by the courts, which have long held that exposure assumptions used "must bear some rational relationship" to the actual conditions, and disallowed unduly conservative approaches.[19] For example, a court rejected an EPA failure to demonstrate a rational relationship between a child that eats sludge applied to roadside cemeteries every day for a five- year period and the actual usage regulated by those assumptions.[20]

Scenario-specific exposure assumptions were selected for this analysis in accordance with USEPA guidance and methodology. The exposure assumptions are discussed in Sections II and III in the 2022 Mosaic Petition. *See* Appendix 2 and Table 1 and 2, above.

Contaminated Sites], https://projects.itrcweb.org/risk-3/#6.%20Exposure%20Assessment.htm#6.1.1_Issue_–_Justifying_Site-Specific_Exposure_Factors%3FTocPath%3D6.%2520Exposure%2520Assessment%7C6.1%2520%2520Determining%2520Appropriate%2520Exposure%2520Factors%2520%7C6.1.1%2520Issue%2520%25E2%2580%2593%2520Justifying%2520Site-Specific%2520Exposure%2520Factors%7C_____0, (citing EPA Guidance).

[15] *Id*.

[16] EPA, Report to Congress: Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials, 15 (2000), https://www.epa.gov/sites/production/files/2015-04/documents/402-r-00-001.pdf (describing a National Academy of Sciences report on TENORM).

[17] *Id.*

[18] ITRC Decision Making at Contaminated Sites, *supra* note 14, at 6.1.1.

[19] *See Leather Indus. of Am. v. EPA*, 40 F.3d 392, 405 (D.C. Cir. 1994) (rejecting EPA's use of an extreme assumption of a child eating sludge applied to roadside cemeteries every day for a five-year period).

[20] *Id.*

As described, below, EPA has specifically concluded that a 3 in 10,000 cancer risk is essentially the equivalent to EPA's safe risk management level and is comparable to the existing risks from PG stacks. *See* Appendix 9.[21]

4. <u>The Reasonable Maximum Exposure (RME)</u>

a. **Distance from the road.** Distance from the road and duration of exposure are key considerations in calculating the total dose risk. While the RME is designed to bound these, most people would be located at greater distances and/or experience shorter durations. This is true because the road project will occur on Mosaic's New Wales mine site and there are no residences or offices located in proximity to the location of the road. Thus, actual doses for the populations would be less than those presented here.

b. **Roadbase Mix**. The study road will include an approximately 10-inch base and a 4-inch pavement top layer. PG will be incorporated into the road base materials that currently will include aggregate source materials provided by a FDOT-approved supplier, not to exceed 50% PG by mass.

These ratios are supported by technical evaluations in the previous TFI Petitions and their administrative records. Studies of the road containing PG in Polk County Florida in the 1990s found similar results. *See* TFI 2020 Petition, Appendix 4a: Response to EPA Comments on January 16, 2020. State transportation departments also approve of the range of specific design requirements for PG.

5. <u>Exposure Analysis</u>

The following exposure scenarios (Table 2) were previously evaluated by EPA in the 2019 TFI risk assessment, which is also relied upon in the April 7, 2020 Revised Petition:

- **Truck Driver** who delivers PG for road base material to a construction site for **5 years**;

[21] As did TFI, this Petition uses 5 x 10-7 as a conversion as set forth by the International Commission on Radiological Protection (ICRP) and is consistent with EPA risk assessment procedures. Similarly, the international community has widely adopted the International Atomic Energy Agency (IAEA) determination that 1 millisievert (1 mSv) per year is the acceptable level of radiation exposure (for example, the European Union [EU] regulations). *See* IAEA, Radiation Protection and Management of NORM Residues in the Phosphate Industry, Safety Report Series No. 78, 165 (2013). The IAEA and EU determinations are also based on recommendations from the ICRP. *See, e.g.*, ICRP, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication No. 103, 55, 97 (Table 5), 116 (Table 8) (March 2007). The EPA provides cancer risk factors for uniform whole-body exposures of low-dose gamma radiation to the entire population, and reports an estimated 90% confidence interval for cancer mortality of 2.8 % to 10 % per Gy (2.8×10^{-7} to 10×10^{-7} per mrem). *See* EPA, EPA Radiogenic Cancer Risk Models and Projections for the U.S. Population, EPA 402-R-11-001 (April 2011). For practical purposes for gamma radiation, 1 Gy = 1 Sv = 100 rem = 100,000 mrem. This range is essentially the same dose to risk conversion range derived by ICRP.

- **Road Construction Worker** who builds roads exclusively with PG material for **5 years**;
- **Road User** who routinely commutes on the constructed roadway by vehicle, motorcycle or bicycle for **26 years** (motorist/bicyclist was deemed most conservative);
- **Resident Living Near Road** who resides in a home located 50 feet or more from a PG roadway for **26 years**. To illustrate the amount of exposure reduction with distance, exposure to a resident who resides 20 feet from the PG roadway for **26 years** was also calculated; and
- **Utility Worker** who excavates across a PG roadway during utility maintenance projects and is exposed in a trench for **160 hours in a year**. *See* next subsection for a more detailed description. *See* Appendix 1 for details.
- **Reclaimer Scenario:** Not applicable to this Petition because PG will be remain on the New Wales facility.

These exposure scenarios were selected by TFI based on a review of prior regulatory submissions as well as discussions with EPA personnel, and the best professional judgment of the scientists assisting in the preparation of the Petition.[22] This list includes receptors added at USEPA's request during the working sessions to fully evaluate public health.

6. Converting the Use Dose to Risk

Radiation risk for cancer is calculated as the product of the RME exposure dose for each scenario and the dose to risk conversion factor. The road design features analyzed in the October 2019 and April 7, 2020 TFI Petitions, Appendix 3, Metals Screening Report, and Appendix 4a, Response to EPA Comments on January 16, 2020, were determined to represent RME for all road designs, regardless of the size of the road. That is, the radioactivity levels emitted from the road in using these design assumptions were RME assumptions and did not exceed 3 in 10,000 (Appendix 4a). Thus, the radioactivity exposure risk associated with all other road designs is less than 3 in 10,000.[23] Mosaic's small-scale study road, being only 1200 ft fully constructed, falls well within these acceptable limits. *See* Table 2 above.

7. Groundwater Exposure

[22] Arcadis (a firm specializing in design and consultancy for natural and built assets), Exponent (an engineering and scientific consulting firm), Professor Timothy G. Townsend (whose research topics include recycling of waste-to-energy ash, sustainable landfill design and operation, construction and demolition debris management, beneficial use of waste materials and sustainable materials management) and Mosaic team personnel as needed. Professor Townsend has worked extensively with the Florida Department of Environmental Protection and the Florida Department of Environment. *See* Timothy G. Townsend, *Recent and Current Projects*, https://faculty.eng.ufl.edu/timothy-townsend/research/.

[23] This is an upper bound because, among other reasons, the industry practice recommends similar ratios or less and EPA's 1992 risk assessment used 33.3 percent PG to 66.6 percent soil. *See* Appendix 2; EPA, Potential Uses of Phosphogypsum and Associated Risks, Background Information Document (May 1992) [*hereinafter* "EPA 1992 BID"], https://www.epa.gov/sites/production/files/2015-07/documents/0000055v.pdf. EPA's 1992 BID risk assessment approved the use of PG for agricultural soil amendments as safe. *See id.*

EPA performed extensive modeling of the likely migration of radionuclides from PG in 1992. EPA's risk assessment determined in the 1992 Background Information Document[24] that "no radionuclides are calculated to reach the onsite well via the groundwater pathway" nor are any "radionuclide calculated to reach the off-site river or well via groundwater." The reconstruction of the 1992 EPA assessment surface water calculations performed by SENES in 1998 confirmed EPA's results. Mosaic agrees with these prior assessments and no additional evaluation was deemed necessary. *See* Appendix 10 for a description of the groundwater monitoring plan associated with construction of the pilot road.

8. The Risk Determination and Risk Management Decision

The Petition is accompanied by a Radiological Risk Assessment (Appendix 2 and 9) and the Human Health Risk Screening for Metals and Metalloids (Appendix 3). The scope and approach to these analyses were developed based on the EPA PG Workbook, prior petitions, and a series of working meetings with EPA staff that provided the benefit of EPA input and direction on key elements of the analysis.

To assist in the risk evaluation for this Petition, Mosaic will measure the radioactivity level in the PG from the Mosaic stack used in the small-scale pilot study.

Appendix 2 contains a summary of Radium-226 concentrations from prior Petitions and the general scientific literature. Results reflect that average radiation levels from the composite samples taken from all stacks do not exceed: (a) the average concentration Radium-226 concentration of 35 pCi/g) and (b) more importantly, the 148 pCi/g Radium-226 concentration corresponds to the 3 in 10,000 risk management level that EPA has designated as safe.

Key points of the Radiological Risk Assessment (*See* Tables 1 and 2, above, and Appendix 9) demonstrate that PG can be used at a cancer risk level well below 3 in 10,000 for the small-scale pilot road construction study for the following reasons:

- All RMEs resulting from the widespread use of PG in road construction in the 2020 TFI Petition were accepted by EPA and correspond to a risk of less than the 3 in 10,000 lifetime cancer risk--the risk level that EPA has determined to be safe for alternative PG uses--and well below natural background exposure (*See* Summary Table 1, and the Petition's Risk Assessment summarizing the risks from each of the exposure scenarios calculated for this Petition).
- Most actual exposures are less than those received by the RME and hence the associated average risk would also be lower (Appendix 4a: Response to the EPA Question on January 16, 2020). For example, the risk is lower for workers who are not exposed for the same duration or as directly as the RME scenarios. The analysis also shows that the risks for the residential RME scenario are much lower than for the construction worker, truck driver, and

[24] EPA 1992 BID, *supra* note 22 at 4-31, 4-34.

road user. In each case, most of the exposed population have a dose that is lower than the RME dose (*See* Appendix 4a: Response to EPA Comments on January 16, 2020).

- The exposure and risk for a small-scale pilot study are by definition lower than the exposures and risk for use of PG in governmental roads (*See* Table 1).
- Risk from other toxic or hazardous constituents is likely to be negligible, consistent with the findings of the TFI Human Health Risk Screening for Metals and Metalloids (Appendix 3).

EPA also requested that TFI perform screening analyses of the potential impact of PG ingestion on road construction workers and potential metals leaching on ground and surface water quality. Thus, these screening assessments were performed and appear in Appendix 3.

9. Florida Beneficial Use Requirements

The Florida Department of Environmental Protection (FDEP) regulates beneficial use under Florida Administrative Code (FAC) 62-701 and Part IV of Chapter 403 Florida Statutes, Solid Waste Management Act.[25] Industrial by-products are regulated as solid waste unless otherwise exempted.[26] Industrial by-products are defined as: "[m]aterials that have a demonstrated recycling potential, can be feasibly recycled, and have been diverted or removed from the solid waste stream for sale, use, or reuse and consider such wastes as construction and demolition debris, ash residue, waste tires, used oil, and compost.[27] For FDEP approval of PG for beneficial use, Mosaic must show that the proposed use will not cause ground water or surface water contamination and will not pose an unacceptable human health risk.[28] Mosaic will seek that approval after EPA's approval of this Petition.

Florida is required to: "[e]ncourage recycling and resource recovery as a source of energy and materials, including in road construction. [29] FDOT Standard Specifications Section 200 dictate how various materials may be used, based on strength and stiffness considerations, permeability, and stability, among other factors.[30]

[25] FLA. ADMIN. CODE § 62-702; FLA. STAT. § 403.7045(1).
[26] FLA. ADMIN. CODE § 62-701.200(51).
[27] *Id.*
[28] FLA. DEP'T OF ENV'T PROT., Beneficial Uses of Wastes and Old Landfills (Oct. 29, 2019), https://floridadep.gov/waste/permitting-compliance-assistance/content/beneficial-uses-wastes-and-old-landfills.
[29] FLA. STAT. § 403.704(6).

[30] FLA. DEP'T OF TRANSP., Standard Specifications for Road & Bridge Construction 219, § 200 (Jan. 2022) https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/specbooks/january-2022/january2022-ebook.pdf?sfvrsn=752d1333_4.

Therefore, after EPA authorizes use of PG in a small-scale study pilot project, the Florida DOT will have a clear path under Florida law to consider whether the PG – aggregates test blends can meet FDOT performance criteria.[31]

10. Information and Certifications Required to Implement EPA Determination

The purpose of the study is to demonstrate the beneficial use of PG as an ingredient in engineered road base to support an application for beneficial use of PG in roads with the Florida Department of Environmental Protection (FDEP). As the regulator of beneficial use of waste products in Florida, any use of PG as road construction material must be approved by FDEP. [32] For FDEP approval, Mosaic must show that the proposed use will not cause ground water or surface water contamination and will not pose an unacceptable human health risk.[33] With these goals in mind, Mosaic contracted with Timothy Townsend, PhD, University of Florida to develop a demonstration project study design. The road is planned at the location of an existing road at the Mosaic New Wales facility, 3095 Hwy 640 W. Mulberry, FL 33860. As explained in the study design, Mosaic will construct a 1,200 ft. section of paved road, consisting of six 200 ft. sections. Three sections will incorporate PG into the road base in various mixes, between 30%-50% PG by mass. The other three sections will be designated as control sections.[34] PG will only be placed below an asphalt layer and no PG will be used in the paving layer itself. The road will be constructed consistent with FDOT testing protocols.[35] and include a 10-inch base layer and a 4-inch pavement layer. The study will employ U.S. EPA's Leaching Environmental Assessment Framework (LEAF) testing where appropriate and U.S. EPA's Industrial Waste Management Evaluation Model (IWEM) will be used in fate- and -transport modeling.[36] The PG will come from Mosaic's New Wales stack, approximately one half mile away. 2019 sampling data supports PG from the New Wales stack is well within the 15pCi/g – 35pCi/g range. Prior to removal, Mosaic will measure the average Radium-226 concentration in the location in the stack from which the PG will be removed, consistent with requirements of 40 CFR §61.207. In addition, Mosaic will comply with the certification requirements at § 61.208 and the records requirements at § 61.206 (c)-(d) and § 61.209.

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[31] The Florida DOT is required to encourage the use of products and materials with recycled content in its road construction programs and to continually update its bid procedures and specifications to encourage the use of such products and materials. *See* FLA. STAT. § 336.044(4).

[32] *See* FLA. ADMIN. CODE § 62-701.100.

[33] *See* FLA. DEP'T OF ENV'T PROT., Beneficial Uses of Wastes and Old Landfills (Oct. 29, 2019), https://floridadep.gov/waste/permitting-compliance-assistance/content/beneficial-uses-wastes-and-old-landfills.

[34] *See* Figure 1, Study Plan, for aerial view.

[35] *See generally* FLA. DEP'T OF TRANSP., Standard Specifications for Road & Bridge Construction (Jan. 2022), https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/programmanagement/implemented/specbooks/january-2022/january2022-ebook.pdf?sfvrsn=752d1333_4.

11. Disposition of Unused PG

There is unlikely to be any unused PG. If any PG is unused, it will be placed back on the stack.

12. Monitoring

There are several monitoring/sampling studies performed in the past, which are part of the existing administrative records, including sampling associated with the TFI Petitions. Separately, environmental testing and risk assessment, including soil, groundwater, PG leachability and fate-and-transport modeling will be conducted as required by FDEP and FDOT for the road specification and beneficial use approvals under the contract with the University of Florida, *See* Appendix 10 Monitoring Plan.

III. BENEFITS OF USE OF PG IN ROAD CONSTRUCTION

The benefits of using PG in road construction outweigh storage in stacks. With 1.7 billion tons of PG currently stacked throughout the U.S. and approximately 46 million tons of PG produced per year in the United States, existing practices are creating environmental, land use and viewshed concerns. EPA's approval of a small-scale pilot road will demonstrate that PG, when appropriately blended with other aggregate or cementitious materials, can meet the performance standards required for engineered road base.

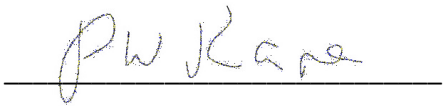
IV. Conclusion

Mosaic's request that the use of PG in a small-scale pilot road project should be deemed approved, as meeting the criteria set for at 40 C.F.R. § 61.206. Such approval constitutes final agency action under the Clean Air Act, 42 U.S.C. 7607 (b)(1), and the Administrative Procedures Act, 5 U.S.C. Section 704. Under established legal precedents, an agency approval conditioned on specified requirements "mark[s] the consummation of the agency's decision making process"[37] and determines the "rights or obligations" of relevant parties, with "direct and appreciable legal consequences."[38] The approval process outlined above satisfies these legal prerequisites.

[37] *Whitman v. Am. Trucking Ass'ns*, 531 U.S. 457, 478 (2001) (quoting *Bennett v. Spear*, 520 U.S. 154, 178 (1997)).
[38] *Bennett,* 520 U.S. at 178 (*quoting Chi. & S. Air Lines, Inc. v. Waterman S.S. Corp.*, 333 U.S. 103, 113 (1948)).

SIGNATURE PAGE

I, Patrick Kane, am Vice President of Operations Services, North America for Mosaic Fertilizer, LLC. Mosaic Fertilizer owns and operates the New Wales phosphogypsum (PG) stack, located at 3095 Hwy 640 W. Mulberry, FL 33860, the source of the PG that will be used for construction of the proposed small-scale pilot road project. I am signing on behalf of Mosaic Fertilizer who prepared this Petition in consultation with Timothy Townsend, PhD, University of Florida.



Patrick Kane

Vice President, Operations Services,
North America, Mosaic Fertilizer, LLC.

March 31, 2022

Appendix 9

Mosaic Petition – Road Pilot Study – Radiological Risk Review

Privileged and Confidential, Attorney-Work Product

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Keith.Nadaskay@mosaicco.com

Date: 18 March 2022
Our Ref: 30108102
Subject: Phosphogypsum – Road Pilot Study – Radiological Risk Review

Dear Mr. Nadaskay,

As background information related to a petition for the use of phosphogypsum (PG) in the construction of a pilot test road (Pilot Road) on Mosaic's New Wales facility near Mulberry Florida, Arcadis is providing this letter to document a review of predicted radiological risks, related to this proposed use.

In preparing this overview of potential radiological risks associated with the development of the proposed Pilot Road, Arcadis has considered previously completed risk assessments related to PG use in roads and how these previous risk assessments relate to the proposed project.

SUMMARY STATEMENT

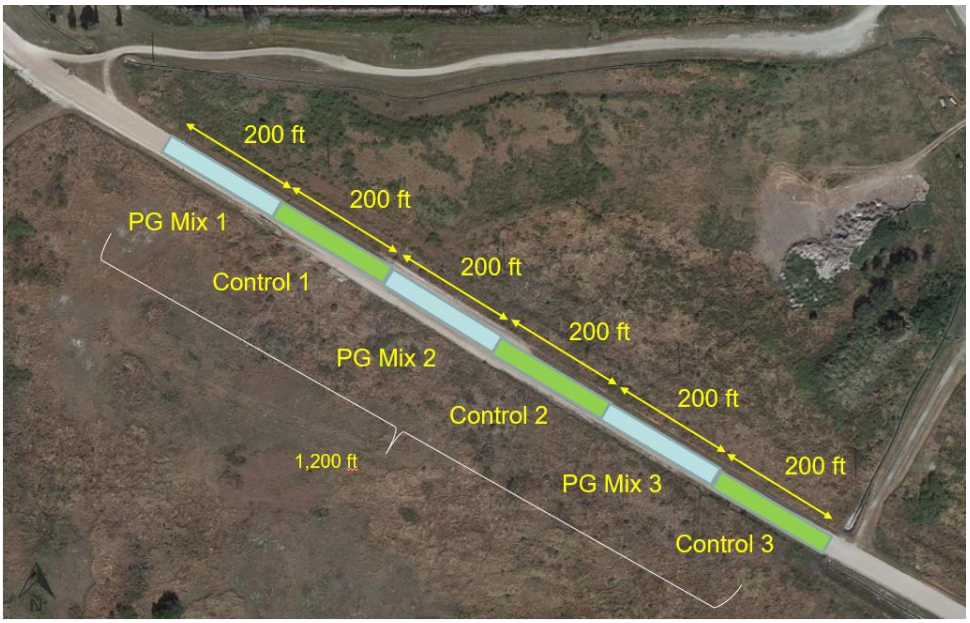
In summary, the anticipated doses and risks potentially arising from the Pilot Road project are predicted to be much smaller than those estimated from the previous PG risk assessments.

In the following sections, each of the potentially relevant exposure pathways is reviewed and considered in context of the previously completed calculations. Comments on each pathway are provided for closer review, as they relate to the petition for the Pilot Road.

PROPOSED ROAD DESIGN

Mosaic Fertilizer, LLC plans to construct a 1,200-ft section of paved road at their New Wales Facility in Mulberry, Florida. This construction project will demonstrate further the beneficial use of PG as an ingredient in engineered road bases. Laboratory research conducted at the University of Florida over the past two years supports that PG, when appropriately blended with other aggregate or cementitious materials, can meet the performance standards required for engineered road base. Figure 1 illustrates the planned location of the pilot project road.

Figure 1. Aerial View of the Proposed Pilot Project Road (1200 ft) with PG-aggregate Road Bases and Respective Control Segments (200 ft each)



The road will be constructed at the location of an existing road at the New Wales Facility. The road will be constructed outside of the current PG stacking operations in an area of reclaimed mine land. The existing road materials will be removed during construction.

A contractor will construct a 1,200-ft section of road consisting of six 200-ft sections. In three of these 200-ft sections, PG will be incorporated into the road base[1]. No PG will be used as part of the other three sections (the control sections); however, the radioactivity (in particular, the Ra-226 content) of the local aggregates used in the Pilot Road will be measured. Road base containing PG will only be placed below an asphalt pavement layer and no PG will be used in the paving layer itself.

Roadway design is currently underway, but conceptually the road will be constructed following standard Florida Department of Transportation (FDOT) practices and include a 10-inch base layer and a 4-inch pavement layer.

Three types of road base mix designs will be tested. In Mix design 1, PG will be blended with limerock (LR) sourced from an FDOT approved aggregate supplier (for B01 aggregate). In Mix design 2, PG will be blended with recycled concrete aggregate (RCA) sourced from a FDOT approved aggregate supplier (for B12 aggregate). The sources of the LR and RCA aggregates will be aggregate suppliers in the Tampa, FL area. Samples of these materials have been obtained and are currently being tested[2] as part of 3rd test mix design development. Mix design 3 will include PG (no more than 50%), sand, and Type I portland cement.

[1] The blending is assumed to be at the site of the Pilot Road but could potentially, be preblended.
[2] Including Ra-226 content.

The source of the PG will be a gypstack at the Mosaic New Wales facility (which was sampled as part of the TFI Petition.) The 2019 test data showed an average Radium 226 content of about 15 pCi/g. The PG to be used in the construction of the road will be sampled for Radium-226 content. PG is anticipated to be incorporated into the mix designs in the range of 30% to 50% by mass.

Preconstruction Testing

Mosaic is currently working with the University of Florida to design the roadway, develop construction drawings, and monitor the performance of the Pilot Road. The mix designs are being developed based on previous testing, using the materials identified for this project, and following standard FDOT testing protocols. Prior to finalizing the design, test results will be discussed with FDOT, and the mix designs will be revised as necessary. Environmental testing and risk assessment includes measurements of total concentrations of PG constituents, leachable concentrations of PG constituents, fate-and-transport modeling, and an assessment of potential radiation doses to those potentially affected.

Once appropriate EPA and Florida Department of Environmental Protection (FDEP) approvals and permits have been obtained, Mosaic will hire a contractor to construct the Pilot Road. PG will be provided to the contractor in a staging area near the construction site.

The PG and sand will be mixed by rotary tiller prior to adding cement; if possible, the entire 10-in thickness of the base will be processed at once. Otherwise, the base will be laid in two 5-in courses, scarifying the bottom layer before placing the second. After mixing cement into the base, water will be added and mixed with a rotary mixer and the base will be thoroughly compacted within 30 minutes. After the base is shaped and finished, an emulsified asphalt curing solution will be applied at 0.25 gallons per square yard. The sand-cement and PG-sand-cement bases will be left to cure for a minimum of three days before paving.

All sections will be covered by a 4-in layer of hot mix asphalt pavement as specified in Section 330 of the FDOT Standard Specifications for Road and Bridge Construction. Any remaining excavated PG not used as part of the construction project will be returned by Mosaic to the gypstack.

As part of pilot project construction, groundwater monitoring wells will be installed. The monitoring well network is still under design, but the conceptual plan is to locate groundwater well(s) upgradient and downgradient of the Pillot Road at suitable locations.

Baseline conditions will be established for the area of the Pilot Road.

The Pilot Road will be monitored before and during construction, and for at least six months. Prior to construction, background water quality samples obtained from the groundwater monitoring wells will be analyzed for a suite of constituents, including radionuclides. Additionally, soil samples will be collected from the area adjacent to the road (top 12 inches of soil). The soil samples will be analyzed for parameters typically associated with PG and stack operations including radionuclides.

During construction, contractors will be equipped with personal gamma dosimeters (likely Optically Stimulated Luminescence (OSL)). In addition, passive radon detectors will be placed around the location of proposed Pilot Road, as well as three background stations away from the Mosaic site. During mixing of PG, air monitoring including measurement of key radionuclides, will be performed proximate to the site of mixing.

The details of the proposed Pilot Road are as follows:

- Road width is 24 feet
- 10-inch road base thickness
- Density
  - PG-LR Base 126 lb/ft^3
  - PG-RCA Base 121.1 lb/ft^3
  - PG-Sand-Cement base: 115.3 lb/ft^3 (to be confirmed)
- Total Amount of PG Used: 337 tons
- Asphalt pavement – 4-inch thickness and does not contain PG.

Table 1 illustrates factors that would be considered in the fate and transport modelling and the radiation risk assessment.

Table 1. Comparison of Risk Assessment Assumptions and Pilot Study Conditions

	Assumptions in 2019 Radiological Risk Assessment	Conditions in the Pilot Study
PG in roadbed material, by weight	< 50 %	< 50 %
Ra-226 in PG	27 pCi/g [3]	<27 pCi/g
Road base	10 inches	10 inches
PG of the surface asphalt	< 2.25%	none
Thickness of surface asphalt	4-5 inches	4-5 inches
Road length	>> 1mile (5280 feet)	3 x 200 feet
Road width	48 feet (4 lanes)	24 feet (2 lanes)
Residence	> 50 feet from the road	>> 50 feet from the road

REVIEW OF RADIOLOGICAL EXPOSURE CALCULATIONS

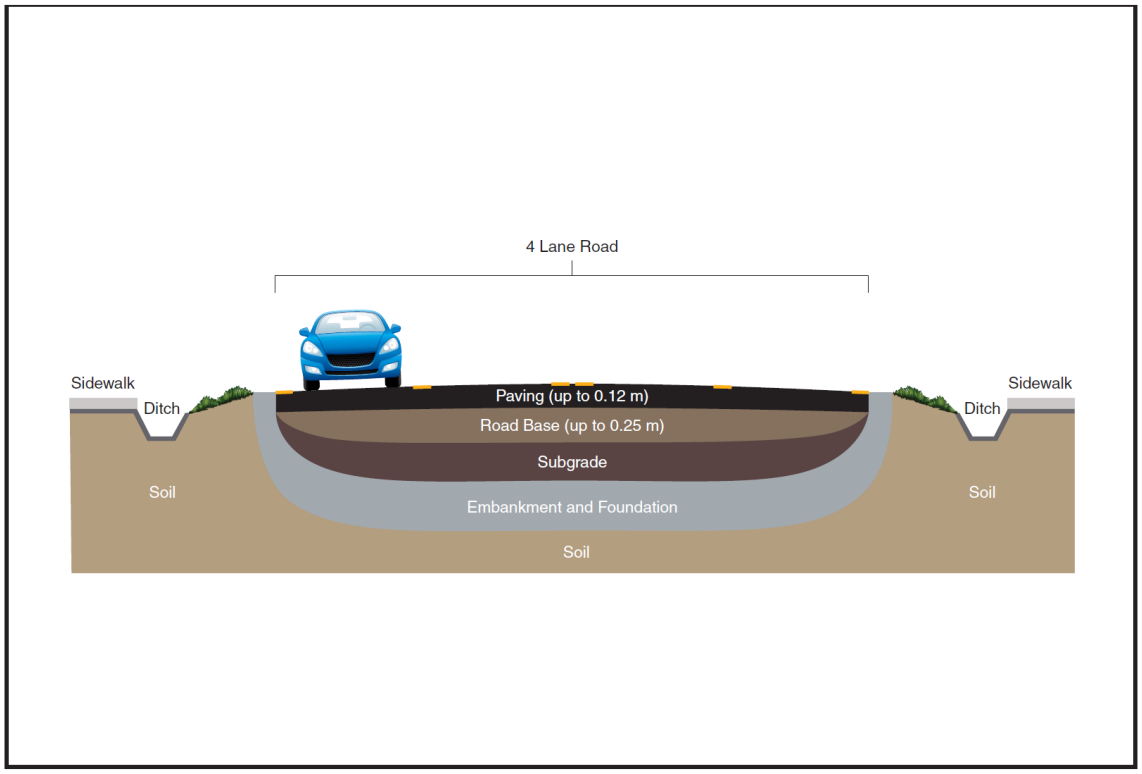
The 2019 Risk Assessment

The 2019 risk assessment performed in support of a TFI Petition for Re-use of PG as road construction considered use of PG as road base when mixed (at or less than 50%) with other materials such as soil, sand or aggregate. As shown in Figure 2, road base is a supporting layer of material ~0.25 m in thickness beneath the pavement and above underlying soil and fill. It serves to provide resiliency to the road. The 2019 risk assessment considered that PG may also be used in a smaller fraction (~2.25%) as part of the surface pavement. The design of new roads as depicted in Figure 2 affects potential for exposures by creating a degree of isolation of the base layer from the

[3] The 2019 risk assessment was based on a nominal radium-226 value of 27 pCi/g, a value based on previous work by the EPA and published information on radium-226 levels in PG. The 2019 risk assessment further considered the potential doses and risks to the RME for other concentrations of Radium-226 in PG. Although we are not aware of any PG with average Ra-226 concentrations anywhere near 148 pCi/g, such PG could in principle be used for road construction and still achieve the EPAs safe level of a risk of 3 in 10,000.

environment. This limits direct contact by the community and also limits contact of PG with surface and groundwater isolated within the base layer. The constructed road also eliminates exposure to road users from alpha and beta radiation and affords a degree of radiation shielding from gamma radiation for people using the road for driving or for nearby residents. The asphalt layer in the proposed Pilot Road, offers a similar protection.

Figure 2. Illustrated Cross-section of the Road Assessed in the 2019 Risk Assessment



In the 2019 risk assessment, five relevant and appropriate exposure scenarios were defined based on knowledge of how exposures might occur to workers and the public from using PG in road construction. The five exposure scenarios were defined, including receptors who would reasonably be expected to receive a dose either during or after construction (Table 2). These receptors include the truck driver hauling PG to the road construction site or the concrete production facility, the construction worker building the road, the resident living near the road both during and after construction and the road user, including a driver and bicyclist. In addition, a worker who spends time working on a buried utility in a trench cutting through the road and road base was assessed.

As discussed in the 2019 risk assessment, a variety of potential exposure pathways were reviewed and those potentially resulting in a non-negligible dose were selected[4]. These included direct radiological exposure from the volumes of material with PG, and ingestion and inhalation of fugitive dust. Table 2 presents the receptors, exposure

[4] Various authors have reviewed the potential doses arising from the use of PG in road construction, among them, the EPA in their BID (EPA 1992). Exposure pathways other than those discussed in this report were shown by EPA to have doses and risks an order of magnitude or more below those discussed in this report.

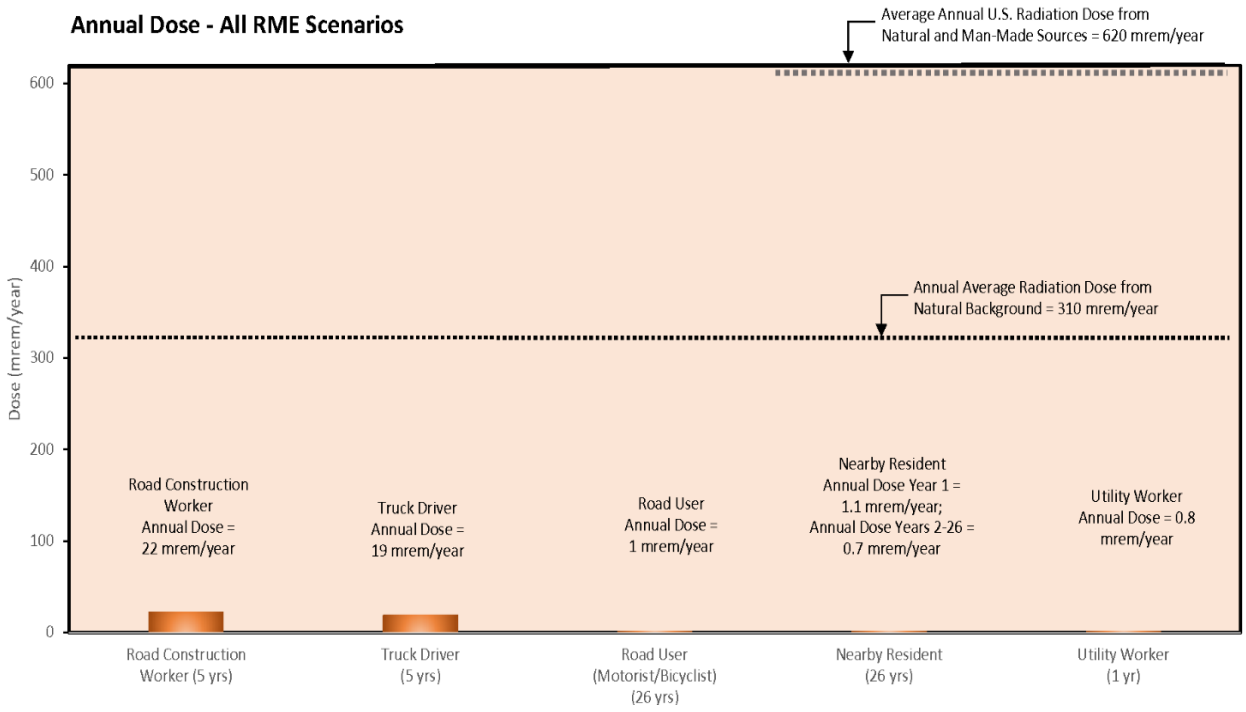
scenarios, and type of exposure. Figure 2 shows graphical depictions of these exposure scenarios. No other pathway was determined as viable or might result in a non-negligible dose.

Table 2. Exposures, Receptors and Complete Exposure Pathways

Exposure Scenario	Exposure	Exposure Pathway
Truck driver-PG to construction site)	Gamma radiation	Direct external exposure
Road Construction Worker	Gamma radiation & PG dust	Direct external exposure Inhalation /Incidental ingestion of dust
Utility worker	Gamma radiation & PG dust	Direct external exposure Inhalation /Incidental ingestion of dust
Road User (bicycle or auto)	Gamma radiation	Direct external exposure
Nearest Resident	Gamma radiation & PG dust	Direct external exposure Inhalation /Incidental ingestion of dust

Figure 3 shows the estimated annual doses for each of the receptors considered in the 2019 risk assessment.

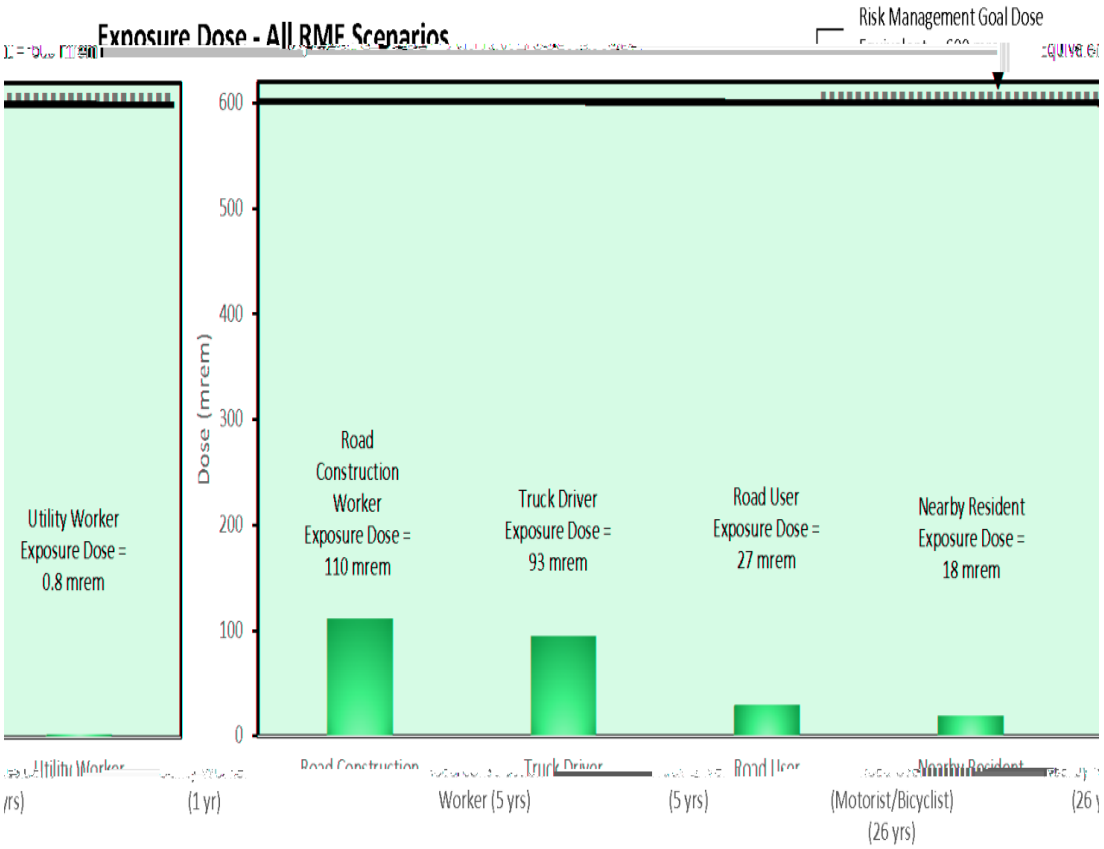
Figure 3. Estimated Annual Doses and Annual Background



As illustrated in Figure 3, all of the doses are small and a small fraction of the dose from unavoidable natural background.

Figure 4 shows the total exposures and risks from the 2019 risk assessment.

Figure 4. Estimated Total Doses and Risk



The information in Figure 4 demonstrates that the cumulative (over time) doses and risks from use of PG as road base are small, well below EPAs risk level and small compared to the unavoidable dose from natural background.

It should be noted that the 2019 risk assessment was based on a nominal radium-226 value of 27 pCi/g, a value based on previous work by the EPA and published information on radium-226 levels in PG. The 2019 risk assessment further examined the potential dose to the most exposed receptor (RME), the road construction worker who was estimated to receive a risk of about 0.55 per 10,000 from the Radium-226 in the PG used in road construction. With all other factors the same, the potential doses and risks to the RME arising from the use of PG in road construction can be scaled on the basis of relative concentrations of radium-226 in PG. For example, discussed in the 2019 risk assessment, the risks to a road construction worker arising from the use of PG containing, for example, 35 pCi/g[5] of radium-226 would be about 0.7 in 10,000 (i.e., 0.5/10,000 x 35/27).

Potential Doses and Risks from the proposed Pilot Road

Table 3 considers the applicability of the 2019 risk assessment exposure scenarios for the proposed Pilot Road at Mosaic. The table also provides a preliminary comment on the magnitude of the expected exposure relative to the previous estimates.

[5] Although we are not aware of any PG with average Ra-226 concentrations anywhere near 148 pCi/g, such PG could in principle be used for road construction and still achieve the EPAs safe level of a risk of 3 in 10,000.

Table 3. The 2019 Risk Assessment for the Pilot Road Construction Exposures

Receptors Considered	Exposure Pathways	Applicable to Pilot Road	Basis for Decision	RME Radiation Doses
Truck Driver who delivers PG for road base material to construction site	Gamma radiation	**Yes**	PG will need to be delivered to the test road construction site	Given the size of the proposed test road, the amount of PG that will be required is very much smaller than that required for the 4-lane county road considered in the 2019 risk assessment. The truck drivers would be exposed for a period of a few weeks to a month, rather than the 5 years assumed in the 2019 risk assessment, and thus, on this basis alone, the dose (and risk) to the truck driver transporting PG for the test road would be about 1/60th of that of the dose or about 1.6 mrem for a truck driver worker who works on the Pilot road. The unavoidable dose from natural background is about 311 mrem and the incremental dose to the RME is negligible compared to dose or risk criteria and a tiny fraction of the natural background dose.
Road Construction Worker who works on roads built exclusively with PG material	Gamma radiation and PG in dust	**Yes**	Workers who build the test road have potential for exposure to PG	Given the size of the proposed test road, the time to construct the test road is very much smaller – of the order of a few weeks to a month, rather than the 5 years assumed for construction of the 4-lane county road considered in the 2019 risk assessment. Thus, on this basis alone, the dose (and risk) to the construction worker who works on the test road would be about 1.8 mrem (i.e., about 1/60th of that estimated for the construction worker from the 2019 risk assessment) The unavoidable dose from natural background is about 311 mrem and hence, he incremental dose to the RME is negligible compared to dose or risk criteria and a tiny fraction of the natural background dose.
Utility worker	Gamma radiation and PG in dust	**No**	The site is controlled by Mosaic and there is no public access or uncontrolled construction	Not Applicable

Receptors Considered	Exposure Pathways	Applicable to Pilot Road	Basis for Decision	RME Radiation Doses
Road User (motorist/bicyclist) on PG-constructed roads	Gamma radiation	**No**	The site is controlled by Mosaic and there is no public access	Given the test road is on the Mosaic site, no public use or exposures are expected. Consideration of other road users such as Mosaic workers travelling on the road is possible but would result dose and exposures much less than those estimated in the 2019 risk assessment considering the PG containing portion of the road would be narrower and shorter than the road assessed in the 2019 risk assessment. The road user dose and exposures in the 2019 risk assessment was already very small, so the dose to the test road user would be negligible compared to dose or risk criteria and a tiny fraction of the natural variation in natural background dose.
Resident Living Near Road	Gamma radiation and PG in dust	**No**	The radiation levels from the road studied in the 2019 risk assessment decrease rapidly with increasing distance. As the site is controlled by Mosaic and there is no possibility of a residence being constructed nearby the site of the test road	Not Applicable
At EPA's request, the 2019 risk assessment considered a **reclaimer** scenario, which as discussed in the Petition and the 2019 risk assessment, is not considered as a reasonable maximum exposure (RME) scenario	Gamma exposure and radon	**No**	Given the size of the proposed test road and the observation that the test road will be constructed on Mosaic property, a reclaimer scenario is not reasonably plausible.	Not Applicable

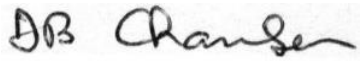
CONCLUSIONS

This review discussed that the Pilot Road is proposed to be at a size and scale that is a fraction of the road examined in detail in the 2019 TFI petition for PG use in roads. Consequently, it was shown that any potential exposures dose and risk related to the use of PG in the Pilot Road will be substantially smaller than the exposures dose and risk estimated for the 2019 TFI petition. In addition, some of the exposure (receptor) scenarios have been shown to not be applicable to this proposed use, effectively eliminating that potential risk.

The 2019 TFI petition showed that the total risk would be well below accepted risk criteria. Through this review and comparison, it can clearly be seen that the total risk associated with the use of PG in the Pilot Road can reasonably be expected to be well below the risk calculated for the 2019 TFI petition and by extension an even smaller fraction of the acceptable risk criterion.

Sincerely,

Arcadis Canada Inc.



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Appendix 10

Mosaic Petition – The Monitoring Plan for the Small-Scale Pilot Road Study

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Date: 31 March 2022
Our Ref: 30108102
Subject: Phosphogypsum – Road Pilot Study – Proposed Monitoring Plan

Dear Mr. Nadaskay,

As background information related to a petition for the use of phosphogypsum (PG) in the construction of a pilot test road (Pilot Road) on Mosaic's New Wales facility near Mulberry Florida, this document provides a review of proposed environmental monitoring, related to this proposed use.

INTRODUCTION

Mosaic Fertilizer, LLC plans to construct a 1,200-ft section of paved road at their New Wales Facility in Mulberry, Florida. This construction project will demonstrate further the beneficial use of PG as an ingredient in engineered road bases. Laboratory research conducted at the University of Florida over the past two years supports that PG, when appropriately blended with other aggregate or cementitious materials, can meet the performance standards required for engineered road base.

Furthermore, environmental testing of PG aggregate blends supports that a properly designed and constructed road will meet conventional human health risk criteria sufficient for beneficial use. The pilot project described here serves as a next step in developing safe and economic recycling options for PG in Florida.

PILOT PROJECT DESCRIPTION

Figure 1 illustrates the planned location of the pilot project road. The road will be constructed at the location of an existing road at the New Wales Facility. The road will be constructed outside of the current PG stacking operations in an area of reclaimed mine land. The existing road materials will be removed during construction.

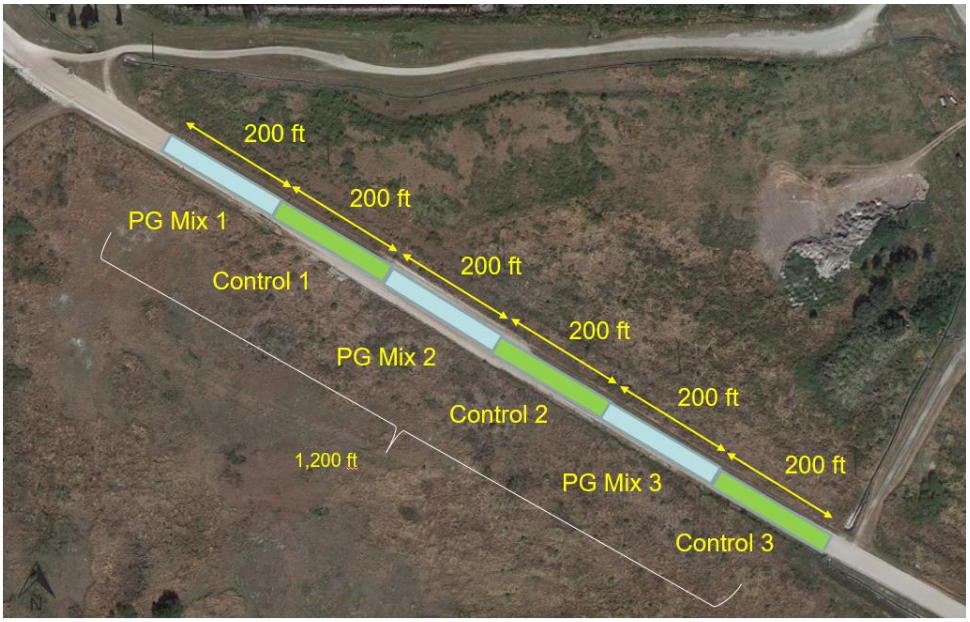
A contractor will construct a 1,200-ft section of road consisting of six 200-ft sections. In three of these 200-ft sections, PG will be incorporated into the road base[1]. No PG will be used as part of the other three sections (the control sections); however, the radioactivity (in particular, the Radium 226 content) of the local aggregates used in

[1] The blending is assumed to be at the site of the Pilot Road but could potentially, be preblended.

the Pilot Road will be measured. Road base containing PG will only be placed below an asphalt pavement layer and no PG will be used in the paving layer itself.

Roadway design is currently underway, but conceptually the road will be constructed following standard Florida Department of Transportation (FDOT) practices and include a 10-inch base layer and a 4-inch pavement layer.

Figure 1. Aerial View of the Proposed Pilot Project Road (1200 ft) with PG-aggregate Road Bases and Respective Control Segments (200 ft each)



Three types of road base mix designs will be tested. In Mix design 1, PG will be blended with limerock (LR) sourced from an FDOT approved aggregate supplier (for B01 aggregate). In Mix design 2, PG will be blended with recycled concrete aggregate (RCA) sourced from a FDOT approved aggregate supplier (for B12 aggregate). The sources of the LR and RCA aggregates will be aggregate suppliers in the Tampa, FL area. Samples of these materials have been obtained and are currently being tested[2] as part of 3rd test mix design development. Mix design 3 will include PG (no more than 50%), sand, and Type I portland cement.

The source of the PG will be a gypstack at the Mosaic New Wales facility, which is approximately one-half mile from the pilot road site. (This stack was previously sampled as part of the TFI Petition.) The 2019 test data showed an average Radium 226 content of about 15 pCi/g, however the requested 35 pCi/g is adequate to cover any unexpected variations. An additional round of sampling for Radium 226 content will take place prior to the initiation of construction. PG is anticipated to be incorporated into the mix designs in the range of 30% to 50% by mass.

[2] Including Radium-226 content.

PRECONSTRUCTION TESTING

Mosaic is currently working with the University of Florida to design the roadway, develop construction drawings, and monitor the performance of the Pilot Road. The mix designs are being developed based on previous testing, using the materials identified for this project, and following standard FDOT testing protocols. Prior to finalizing the design, test results will be discussed with FDOT, and the mix designs will be revised as necessary. Environmental testing and risk assessment includes measurements of total concentrations of PG constituents, leachable concentrations of PG constituents, fate-and-transport modeling, and an assessment of potential radiation doses to those potentially affected. See Mosaic 2022 Petition, Appendix 9.

As part of the pilot study, U.S. EPA's Leaching Environmental Assessment Framework (LEAF) testing will be employed where appropriate and U.S. EPA's Industrial Waste Management Evaluation Model (IWEM) will be used in fate and transport modeling.

Table 1 illustrates factors that would be considered in the fate and transport modeling and the radiation risk assessment.

Table 1. Comparison of Risk Assessment Assumptions and Pilot Study Conditions

	Assumptions in 2019 Radiological Risk Assessment	Conditions in the Pilot Study
PG in roadbed material, by weight	< 50 %	< 50 %
Ra-226 in PG	35 pCi/g [3]	<35 pCi/g
Road base	10 inches	10 inches
PG of the surface asphalt	< 2.25%	none
Thickness of surface asphalt	4-5 inches	4-5 inches
Road length	>> 1mile (5280 feet)	3 x 200 feet
Road width	48 feet (4 lanes)	24 feet (2 lanes)
Residence	> 50 feet from the road	>> 50 feet from the road

PILOT CONSTRUCTION

Once appropriate EPA and Florida Department of Environmental Protection (FDEP) approvals and permits have been obtained, Mosaic will hire a contractor to construct the Pilot Road. PG will be provided to the contractor in a staging area near the construction site.

[3] The initial calculations in the 2019 risk assessment were based on a nominal radium-226 concentration in PG of 27 pCi/g, a value based on previous work by the EPA and published information on radium-226 levels in PG. The 2019 risk assessment further considered the potential doses and risks to the RME for various other concentrations of radium-226 in PG. Although we are not aware of any PG with average Ra-226 concentrations anywhere near 148 pCi/g, such PG could in principle be used for road construction and still achieve the EPA's safe level of a risk of 3 in 10,000. The 2019 petition was submitted for approval using a reasonable upper bound concentration of radium-226 in PG of 35 pCi/g.

The PG and sand will be mixed by rotary tiller prior to adding cement; if possible, the entire 10-in thickness of the base will be processed at once. Otherwise, the base will be laid in two 5-in courses, scarifying the bottom layer before placing the second. After mixing cement into the base, water will be added and mixed with a rotary mixer and the base will be thoroughly compacted within 30 minutes. After the base is shaped and finished, an emulsified asphalt curing solution will be applied at 0.25 gallons per square yard. The sand-cement and PG-sand-cement bases will be left to cure for a minimum of three days before paving.

All sections will be covered by a 4-in layer of hot mix asphalt pavement as specified in Section 330 of the FDOT Standard Specifications for Road and Bridge Construction. Any remaining excavated PG not used as part of the construction project will be returned by Mosaic to the gypstack.

MONITORING

As part of pilot project construction, groundwater monitoring wells will be installed. The monitoring well network is still under design, but the conceptual plan is to locate groundwater well(s) upgradient and downgradient of the Pilot Road at suitable locations.

Baseline conditions will be established for the area of the Pilot Road.

The Pilot Road will be monitored before and during construction, and for at least six months after construction. Prior to construction, background water quality samples obtained from the groundwater monitoring wells will be analyzed for a suite of constituents, including radionuclides. Additionally, soil samples will be collected from the area adjacent to the road (top 12 inches of soil). The soil samples will be analyzed for parameters typically associated with PG and stack operations including radionuclides.

During construction, contractors will be equipped with personal gamma dosimeters (likely Optically Stimulated Luminescence (OSL)). In addition, passive radon detectors will be placed around the location of proposed Pilot Road, as well as three background stations away from the Mosaic site. During mixing of PG, air monitoring including measurement of key radionuclides, will be performed proximate to the site of mixing.

After construction is completed, the geotechnical performance of the roadway will be monitored following recommendations provided by the FDOT. In addition, a gamma scan of the road surface will be performed on each of the road sections. In this respect, it is anticipated that these data will also provide proof of concept for future radiation risk assessments for roads constructed with PG.

Table 2 summarizes the monitoring to be conducted prior, during and after construction of the Pilot Road.

Table 2. Proposed Environmental Monitoring for Pilot Road Construction and Operation

Type of Monitoring	Description / Parameters	Timing / Duration
Personal gamma dosimeters - Construction Workers - Truck Drivers	Likely Optically Stimulated Luminescence (OSL)	Throughout construction period
External gamma radiation measurements	On and beside the Pilot Road	Baseline – prior to construction; During construction – prior to application of asphalt layer; After construction – operational period
Groundwater Monitoring	Located up and down gradient with respect to groundwater flow; Evidence of leachate from PG; Radioactivity concentrations; Other constituents of potential concern	Baseline – prior to construction; After construction – operational period for at least six months.

CLOSING

If you have any questions regarding this document or the proposed monitoring plan, please feel free to contact me.

Sincerely,

Arcadis Canada Inc.

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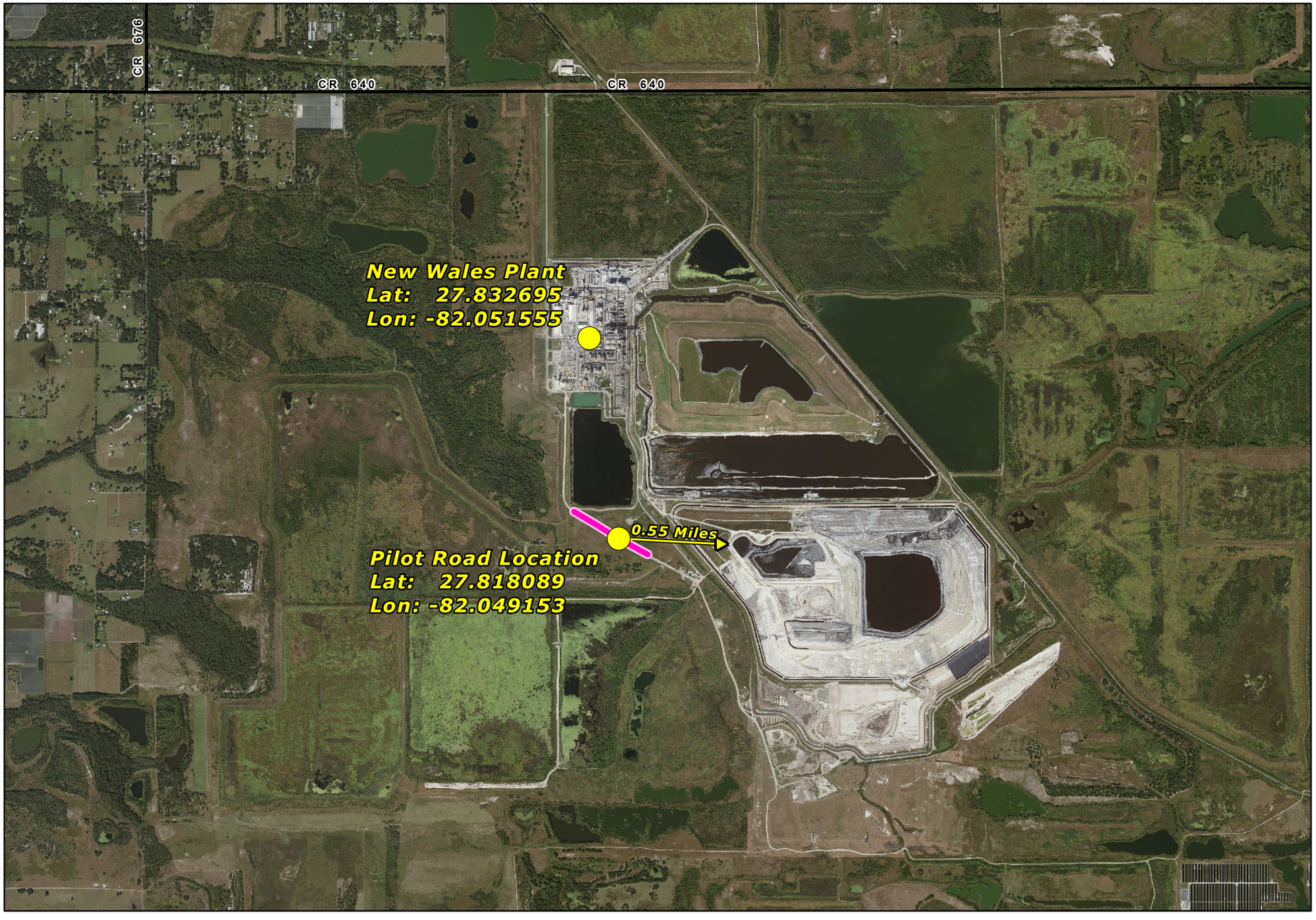
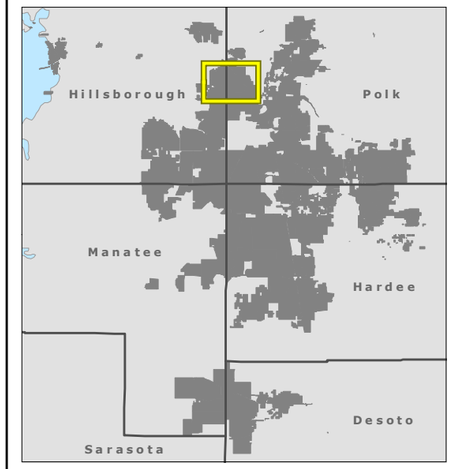
Appendix 11

Site Map – Location of the Road

New Wales Pilot Road



Location Key



Legend

- Points of Interest
- Pilot Road Project
- Distance to Stack
- Major Roads

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Appendix 12

New Wales Stack Data

New Wales Radium Ra-226 - September 2019 in pCi/g	
Sample 1	16.6
Sample 2	17.3
Sample 3	17.5
Sample 4	19.3
Sample 5	10.3
Sample 6	18.6
Sample 7	10.4
Sample 8	11.0
Sample 9	13.8
Sample 10	15.3
Average	15.01
Median	15.95

News Wales Gamma Results – September 2019 in microR/hr	
Avg Gamma @ Surface	51
Avg Gamma 1m Above Surface	44