Sharon Township Planning Commission

Regular Meeting Agenda

Tuesday, April 11, 2023, 7:00 pm – Sharon Township Hall

1. Call meeting to order
2. Pledge of Allegiance
3. Roll call
4. Approval of the agenda
5. Approval of the minutes from the March 11, 2023 regular meeting
6. Public comment (non-agenda items)
7. Zoning Administrator Report – David Wilson
8. Zoning Board of Appeals Liaison Report – Mike Hobbs
9. Township Board Representative Report – Trudi Cooper
10. Mineral Licensing Board Liaison Report – Justin Smith
11. Public Hearing - EarthWell Retreat Center, LLC – Special Land Use Amendment Application
    A. Motion to open the Public Hearing
    B. Introduction – Megan Masson-Minock
    C. Applicant presentation – Emily Adama, EarthWell
    D. Public Comment
    E. Applicant response to evidence presented – Emily Adama, EarthWell
    F. Township representatives' and members of the public response to the applicant's rebuttal response
    G. Motion to close the Public Hearing
12. Old Business
    A. EarthWell Retreat Center – Special Land Use Amendment Application
    B. Stoneco - Special Land Use Approval for Extraction of Natural Resources – Demonstration of No Serious Consequences
13. New Business - none
14. Public comment
15. Concerns of PC members, Zoning Administrator, Planner, Engineer and Legal Counsel.
16. Action Items
17. Next regular meeting date and time
18. Adjourn

Sharon Township Planning Commission
Regular Meeting Minutes
Tuesday, March 14, 2023, 7:00 pm
Sharon Township Hall

The meeting was **called to order** by Chair Pat Kelly at 7:00 pm.

The **Pledge of Allegiance** was recited.

Roll Call: Members present: Chair Pat Kelly, Vice-Chair Justin Smith, Secretary and Township Board Liaison Trudi Cooper, Commissioner Randy Bradshaw, and Commissioner Mike Hobbs. Members absent: None. Also present were Township Zoning Administrator Dave Wilson, and five members of the public.

Approval of the Agenda: Agenda was approved by unanimous consent.

Public Comment (non-agenda items): Kathy Spiegel, as Deputy Supervisor, will be attending a meeting on March 22, which will include Peter Psarouthakis, Stoneco's president, and Stoneco representative Austin Fisher.

Zoning Administrator Report: Dave Wilson
ZA Wilson processed four new compliances, for a barn, a solar array, a house demolition and a generator. Wilson has also been procuring estimates for a shingle and a metal roof for the Township Hall, which has a leak. Funding for a generator for the Township Hall has been approved by the Board of Trustees. A house on Sharon Hollow Road has been condemned and scheduled for a demolition. Inspection took place, and the process is well underway.

Zoning Board of Appeals: Mike Hobbs
No meeting, no report.

Township Board Representative Report: Trudi Cooper
Cooper reported that at the Board of Trustees meeting held March 2, 2023, the following business was done: a presentation by the Community Resource Center to let Sharon Township residents know the services and programs that they offer; a presentation from Revize, the website developer that will be renewing the Township's website; a motion to allow Supervisor Psarouthakis to draft a letter to legislators in Lansing to address the inaccuracies in a presentation from the gravel mining coalition that was given to certain legislators; the appointment of Kathy Spiegel as Deputy Supervisor; Township Hall rental approval; lawn care contract renewal; motion to approve up to $15,000 for the purchase and installation of a generator at the Township Hall.

Mineral Licensing Board Liaison Report: Justin Smith
No meeting, no report

Old Business:
Stoneco Application for Special Land Use Approval for Extraction of Natural Resources – Demonstration of No Serious Consequences - At Stoneco's request, consideration of the Special Land Use (SLU) application was deferred pending completion of a Stoneco response to input

from the February 15, 2023 Public Hearing and the latest reports from the Township planning and engineering consultants.

Stoneco representative, Austin Fisher also reported via email that Stoneco will file their response by April 5, 2023. Planning Commissioners discussed the timing of Stoneco's expected response and agreed that a minimum of two weeks of review/response time is required for the PC and Township consultants, meaning that the Stoneco response must be received no later than March 27, 2023 for the SLU application to be considered at the April 11, 2023 regular PC meeting. .

Earthwell Retreat Center, LLC Special Land Use Application:
Planner Masson-Minock stated verbally that in her opinion the application is complete. Bradshaw requested that this be confirmed in writing.

Cooper made a motion to deem the application complete and to schedule a Public Hearing for the next Regular Meeting on April 11. Motion seconded by Bradshaw. Motion carried.

Public Comment: None.

Action items: The upcoming Earthwell Public Hearing will be posted on the Township website, in *The Sun Times* and on the Township door. Masson-Minock's written response to Earthwell's application will be forwarded to Planning Commission members.

Adjourn: **Motion** to adjourn by Cooper, **second** by Smith. **Carried** by voice vote. Meeting adjourned at 7:53 pm.

The next regularly scheduled meeting of the Sharon Township Planning Commission is at 7pm on April 11, 2023 at the Sharon Township Hall, unless otherwise notified on the Township website, www.Sharontownship.org.

Minutes submitted by Trudi Cooper, Planning Commission Secretary.

These minutes were approved by majority vote at the ------------, 2023 Sharon Township regular meeting.

Sharon Township
Planning Commission
Notice of Public Hearing

Notice is hereby given that the Planning Commission of Sharon Township will hold a Public Hearing on April 11, 2023 at 7:00 p.m. at Sharon Township Hall, located at 18010 Pleasant Lake Road on the application of Emily Adama of EarthWell Retreat Center, LLC to amend the special land use for a retreat center. The requested amendment includes a temporary caretaker residence, use of the basement of the conference center for staff/caretaker housing, six daytime events of up to 125 people annually, three daytime events of up to 75 people annually, and two 7-day events for up to 25 people. The current special land use permit has a maximum of 25 people per event.

The property is located on the north side of Grass Lake Road, between Sylvan Road and Hashley Road, at 18580 Grass Lake Road in Sharon Township. Parcel ID Number: 15-03-300-013.

A copy of the petitioner's request may be examined at the Township Office during business hours from 9:00 a.m. to Noon, Thursdays. Written comments concerning this request will be received at the Township office from the date of this publication until the date of the Public Hearing.

PLEASE TAKE NOTE: Sharon Township will provide reasonable and necessary auxiliary aids and services to those individuals requiring such upon two weeks prior notice to the Sharon Township Clerk's Office. Phone number (734) 428-9250.

Notice must be published on or before Monday, March 27, 2023

Carlisle | Wortman
ASSOCIATES, INC.
117 NORTH FIRST STREET SUITE 70 ANN ARBOR, MI 48104 734.662.2200 734.662.1935 FAX

Date: April 5, 2023

Special Land Use Amendment For Sharon Township, Michigan

GENERAL INFORMATION

Applicant: Emily Adama

Project Name: Earthwell Retreat Center

Plan Date: March 9, 2023

Location: 18580 Grass Lake Road

Zoning: A-1, General Agriculture

Action Requested: Special Land Use Amendment Review

PROJECT AND SITE DESCRIPTION

The applicant is proposing to amend the Special Land Use permit for a retreat center at this location granted in 2012. The following amendments are proposed:

- Provision of a temporary tiny home caretaker residence;
- Utilization of the basement of the conference center for staff/caretaker housing;
- Six (6) daytime events annually of up to one hundred and twenty-five (125) people;
- Three (3) daytime events annually of up to seventy-five (75) people; and
- Two (2) events annually of up to seven (7) days for weeklong retreat experiences.

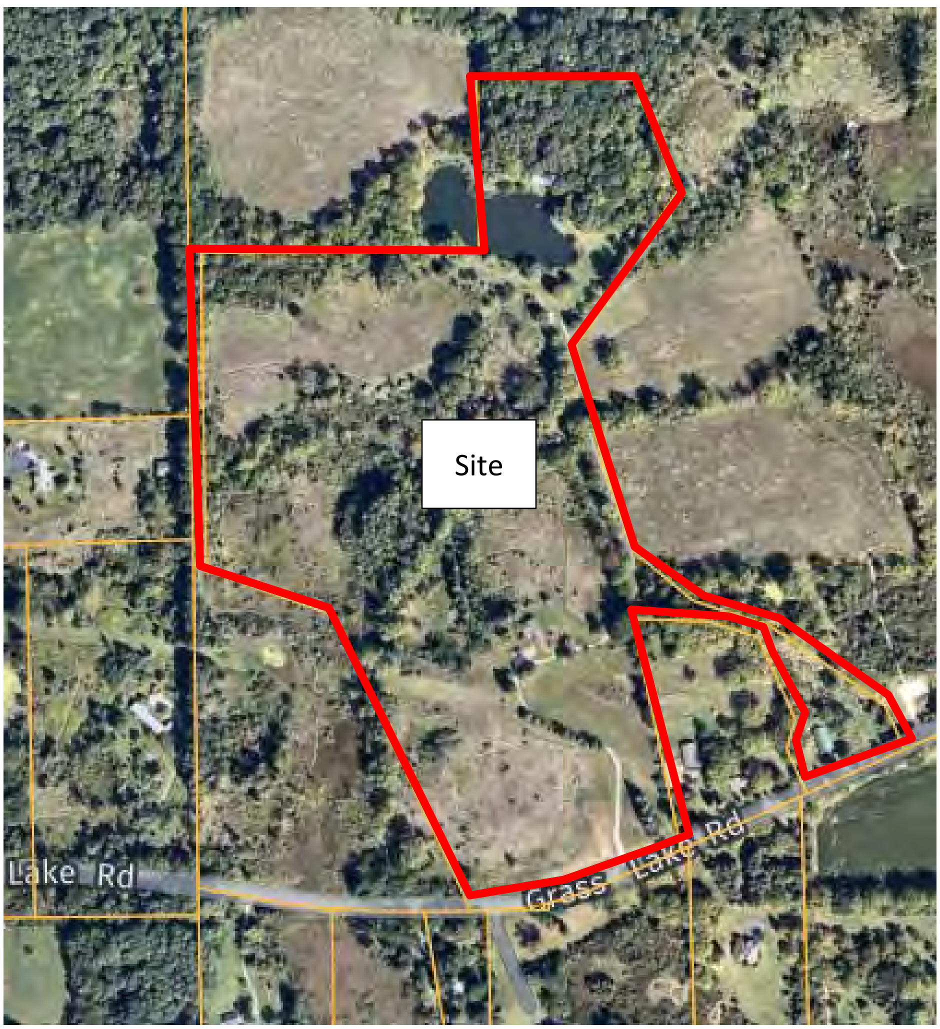
The subject site is zoned A-1, General Agriculture, located on the north side of Grass Lake Road, between Sylvan Road and Hashley Road at 18580 Grass Lake Road, with an area of 40 acres. Retreat centers are special land uses in the A-1 zoning district.

The definition of "Retreat Center" in the Sharon Township Zoning Ordinance is:

> **Retreat Center:** A facility used for professional, educational, or religious conclaves, meetings, conferences, or seminars and which may provide meals, housing and recreation for participants during the period of the retreat or program only, and provided all kitchen facilities are limited to a single centrally located building and not within individual sleeping quarters. This term shall not apply to facilities utilized by the general public for meals or overnight accommodations.

The Chairperson of the Planning Commission and the Township Supervisor, in unanimous agreement, have granted the substitution of a plot plan instead of a site plan for this application, finding that the provision of adequate information for decisions to be made and the requirements of Section 4.04.B are onerous in this case. The Planning Commission makes a recommendation on the special use approval to the Township Board.

Aerial Photograph



Source: NearMap

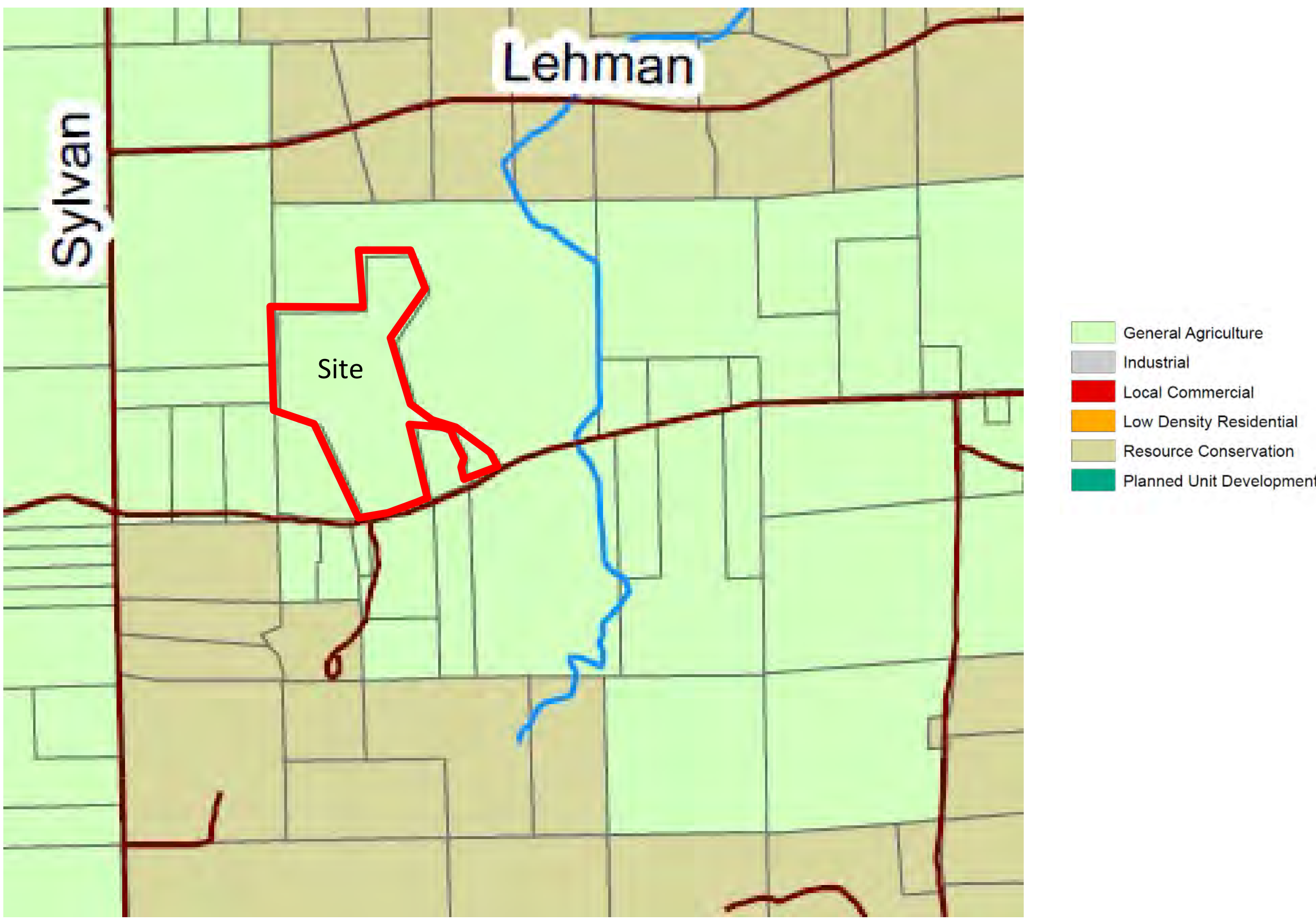
Items to be Addressed: *None.*

NEIGHBORING ZONING AND LAND USE

The zoning, land use and Master Plan designations of the subject site and surrounding properties is provided in Table 1, below:

	Subject Property	North	South	East	West
Zoning	General Agriculture	General Agriculture	General Agriculture	General Agriculture	General Agriculture
Land Use	Retreat Center	Land Preserve	Single Family Agriculture	Land Preserve	Single Family Agriculture
Master Plan	Resource Conservation	Resource Conservation	Resource Conservation	Resource Conservation	Resource Conservation

Zoning Map

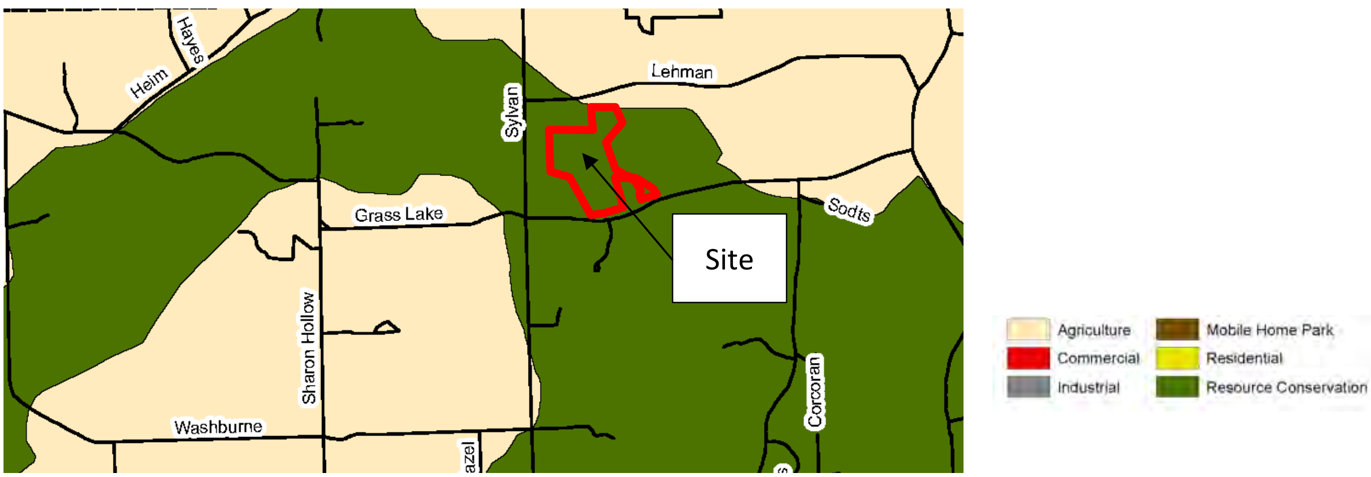


Items to be Addressed: *None*

MASTER PLAN

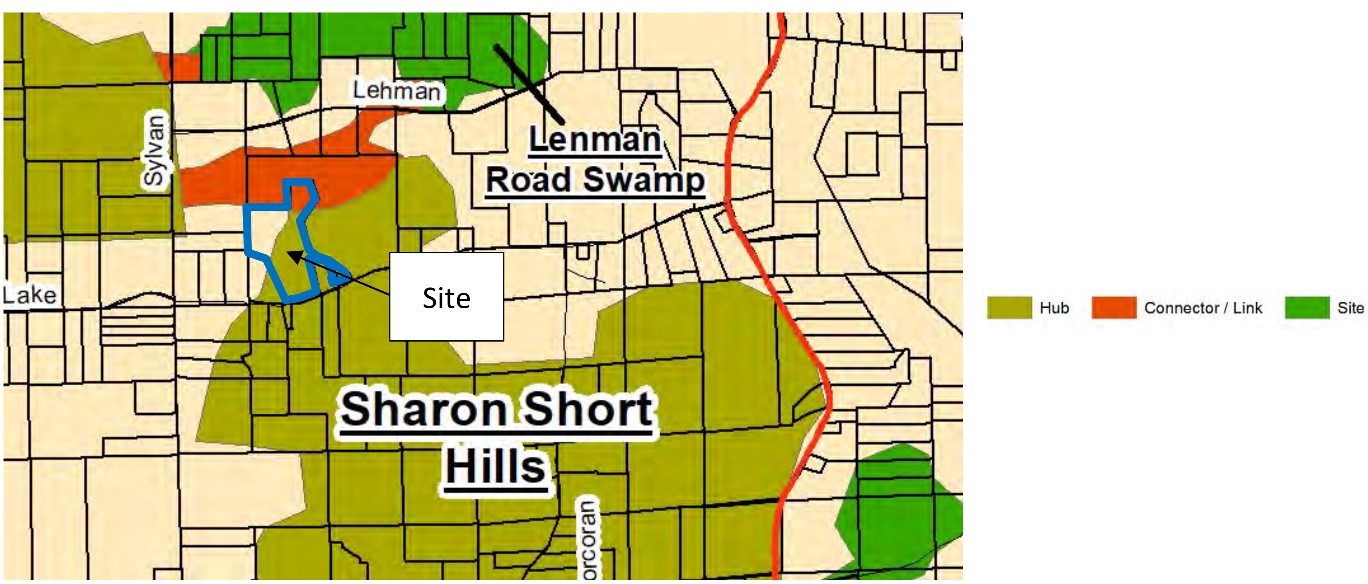
The subject site is planned as Resource Conservation and most of the property is a designated green infrastructure hub and a small portion in the northern part of the property as a connector/link, as shown in the maps below.

Future Land Use Map



Site location is approximate

Green Infrastructure Map



The following aspects of the adopted Master Plan apply to this property:

Vision	Growth and development in Sharon Township are consistent with the natural limitations of the land, the availability and provision of public services, the protection of the Township's natural resources, green infrastructure and rural character, as well as the protection of the natural resources and character of neighboring townships and villages and the green infrastructure of the watersheds in the Township.
Sustainability Goal	Land use, preservation, and development meets the environmental, economic, and social needs of the present residents, businesses, and property owners without compromising the ability of future generations to meet their needs.
Sustainability Objectives	1. Preserve the Township's natural resources and features through a coordinated future land use strategy and related regulations that permit reasonable use of land while prohibiting unnecessary destruction or loss of natural resources or features. 5. Maintain a transportation network throughout the Township that moves vehicular and nonmotorized traffic in a safe and efficient fashion, coordinated with the planned future land use pattern. 6. Discourage high traffic generating land uses and development patterns along road segments until such roads are improvement to accommodate the development. 8. Encourage innovative land development that incorporates the preservation of green infrastructure, open spaces, and the Township's rural character. 9. Separate incompatible land uses by distance, natural features, and/or man-made landscape buffers to screen or mitigate adverse impacts. 13. Provide opportunities for limited expansion of commercial and industrial uses that minimize negative effects upon adjacent land uses, respond to the predominant rural and agricultural character of the community, and are compatible with available public services and infrastructure. 19. Ensure long-term financial viability of the Township tax base while preserving farmland, natural features, and green infrastructure.

Green Infrastructure Goal	Preserve, protect, and enhance the green infrastructure of the Township and the watersheds within its borders including the integrity of the interconnected network of natural areas, wildlife habitats, riparian corridors, and places of biological diversity.
Green Infrastructure Objectives	1. Promote an interconnected green infrastructure system of natural environmental corridors, including streams, wetlands, woodlands, and open fields. 2. Encourage development that actively preserves open spaces. 3. Assure that development does not increase air, noise, land, and water pollution, or degrade land and water resource environments, including groundwater. 4. Limit development intensity in environmentally sensitive areas, particularly the hubs, sites, links, and special features shown on the Green Infrastructure Map. 5. Recognize the special environmental resources and ecosystems and associated development constraints of the green infrastructure hubs of the Mill Creek Headwaters, Sharon Hollow, and the Sharon Short Hills and manage land use intensity, development density and site development practices to protect the environmental integrity of these area. 6. Recognize the high infiltration rates of local soils and the groundwater's vulnerability to contamination and minimize negative effects upon this resource by appropriate development densities and site development practices.

In the description of the Resource Conservation Future Land Use Category, development of land designated Resource Conservation "should be limited to open space and natural resource-based land uses such as farming and wildlife management, and low-density residential development."

Items to be Addressed: *None*

NATURAL FEATURES

The site is surrounded to the east, west and north by the Washtenaw County Clark and Avis Spike Preserve and has the following natural features:

Topography: The site has rolling topography, with the highest point near the frontage on Grass Lake Road, decreasing to the north.

Woodlands: The site has tree rows along the roads and drives on the property and woodlands, particularly in the central and northern parts of the property.

Wetlands: Per the wetland inventory on the MapWashtenaw Parcel viewer, wetlands are on the subject site, concentrated in the central and northern parts of the property. Any proposed activity within the wetlands would require wetlands permits from the Township and from EGLE, if the wetlands are regulated by the State of Michigan.

Waterways: A pond is located in the northern part of the property, which has coastline on both the subject site and the Clark and Avis Spike Preserve.

Floodplains: No floodplains are present on the site.

Groundwater Recharge: The site is within the groundwater recharge area on the Soil Perk/Groundwater Map in the appendix of the Master Plan.

Items to be Addressed: *None*

PARKING

The parking regulations in the Sharon Township Zoning Ordinance require one (1) parking space for every three (3) persons based the occupancy load of an auditorium, theater or assembly hall. When evaluating the parking needs for the event spaces proposed for the Barkham Winery PUD, this standard was used, plus a parking space for each employee on-site during events.

The applicant is proposing events with up to one hundred and twenty-five (125) people and fifty (50) parking spaces. Per the metric cited above, forty-two (42) spaces would be required for events of one hundred and twenty-five (125) people plus a space for each employee on-site at the time of the event. The applicant should provide additional information about the number of staff and where they would park.

In addition, it seems that the 50-vehicle parking area is not on the subject site, but on the Clark and Avis Spike Preserve. At a minimum, the applicant should provide a signed parking agreement with Washtenaw County, documenting this arrangement. In the best case scenario, a cross-access and parking easement would be placed on this portion of the Clark and Avis Spike Preserve.

Finally, it is unclear if the proposed parking area is large enough and has the appropriate surfacing. For the parking area for larger events, we recommend that the applicant submit a scaled layout of the parking area, documenting that fifty spaces with drive aisles of the appropriate size are possible. Also, we recommend consulting the Township Engineer as to whether the number and frequency of proposed parked vehicles could have an adverse impact on groundwater, since this site is a green infrastructure hub and within the groundwater recharge area.

Items to be Addressed: *1.) Applicant provides the number of employees on-site during events and location of employee parking. 2.)Written documentation that a portion of the Clark and Avis Spike Preserve may be used for event parking. 3.) Applicant provides a scaled drawing that shows the area can accommodate 50 vehicles. 4.) Township Engineer approval of parking proposal.*

SPECIAL LAND USE STANDARDS

Section 5.06 lists the general approval standards for all special land use requests. Prior to approving a Special Land Use application, the Planning Commission and Township Board must find that all the general approval standards in italicized text below are met to approve a special land use:

The proposed special use shall be harmonious with and in accordance with the general objectives, intent, and purposes of this ordinance.

The standard can be met if the proposed amendments meet the definition of "retreat center" and sufficient parking is provided. We feel that the caretaker residence, use of the basement of the conference center for staff/caretaker housing, and the weeklong retreat experiences do fall within the scope of the "retreat center" definitions. However, the larger daytime events have the possibility of the use becoming more of an event space, like a banquet hall or the event space allowed in the Barkham Winery PUD. The Township has debated whether to allow event spaces on farm operations in the past and has chosen not to allow "party barn" uses in the past. The applicant has stated in their application that "weddings, celebrations of life, family reunitions, and gatherings related to Earthwell's wellness mission" are among the events that could take place. We feel that with the proper constraints and oversight in the Development Agreement, larger events could be held and remain within the definition of retreat center. However, we highly recommend the Planning Commission give direction as to what those circumstances would be.

If the Planning Commission feels that they need an interpretation of the Zoning Ordinance, the Zoning Board of Appeals makes interpretations. The Township Attorney could also be consulted.

The proposed special use shall be designed, constructed, operated, maintained, and managed so as to be harmonious and appropriate in appearance with the existing or intended character of the general vicinity.

The standard is met for caretaker residence and use of the basement of the conference center for staff/caretaker housing. No additional permanent structures are proposed and the addition of more staff on site can help with the operation of the retreat center in a harmonious fashion with the general vicinity.

We feel that weeklong retreats and larger events can be accommodated on operated, maintained and managed with proper oversight by continuing approvals of events via the development agreement. However, the number and size of the events might be lowered in order maintain the character of the area, which could be impacted by increased and frequent traffic, and the environmental integrity of the area. We recommend consultation with the Township Engineer on the potential groundwater impacts of the proposed parking (size, frequency and lack of surfacing).

The proposed special use shall be served adequately by essential public facilities and services, such as: highways, streets, police and fire protection, drainage structures, refuse disposal, or that the persons or agencies responsible for the establishment of the proposed use shall be able to provide adequately any such service.

The standard is met for caretaker residence and use of the basement of the conference center for staff/caretaker housing. The standard can be met for the other proposed amendments if the events are at the proper size and with oversight.

The proposed special use shall not be hazardous or disturbing to existing or future neighboring uses.

The standard is met for caretaker residence and use of the basement of the conference center for staff/caretaker housing. Again, at the proper scale and with oversight, we feel larger events can be managed to not be hazardous or disturbing to existing or future neighboring uses. However, adequate parking must be provided.

The proposed special use shall not create excessive additional requirements at public costs for public facilities and services.

The standard is met. The use would not create excessive additional requirements for public facilities and services.

Items to be Addressed: *Direction from the Planning Commission as to the proper size, scale and oversight for larger events.*

RECOMMENDATIONS

Based upon our review, we recommend that Planning Commission ask the applicant for more information on:

1. The number of employees on-site during events and location of employee parking.
2. Written documentation that a portion of the Clark and Avis Spike Preserve may be used for event parking.
3. Scaled drawing that shows the area can accommodate 50 vehicles.

The Planning Commission should give direction to the applicant or recommendations to the Township Board regarding the following:

1. Proper size and scale of larger events; and
2. Oversight of events in revised development agreement.

If the Planning Commission chooses to recommend approval to the Township Board, we recommend the following conditions be attached:

1. Sufficient parking is provided;
2. Township Engineer approval of parking area;
3. Written documentation that a portion of the Clark and Avis Spike Preserve may be used for event parking; and
4. Township Attorney approval of a revised development agreement.

Respectfully submitted,

Megan A. Masson-Minock

CARLISLE/WORTMAN ASSOC.,INC
Megan Masson-Minock, AICP
Principal

EarthWell Retreat Center Special Use Permit Amendment Application
Parking Detail
April 6, 2023

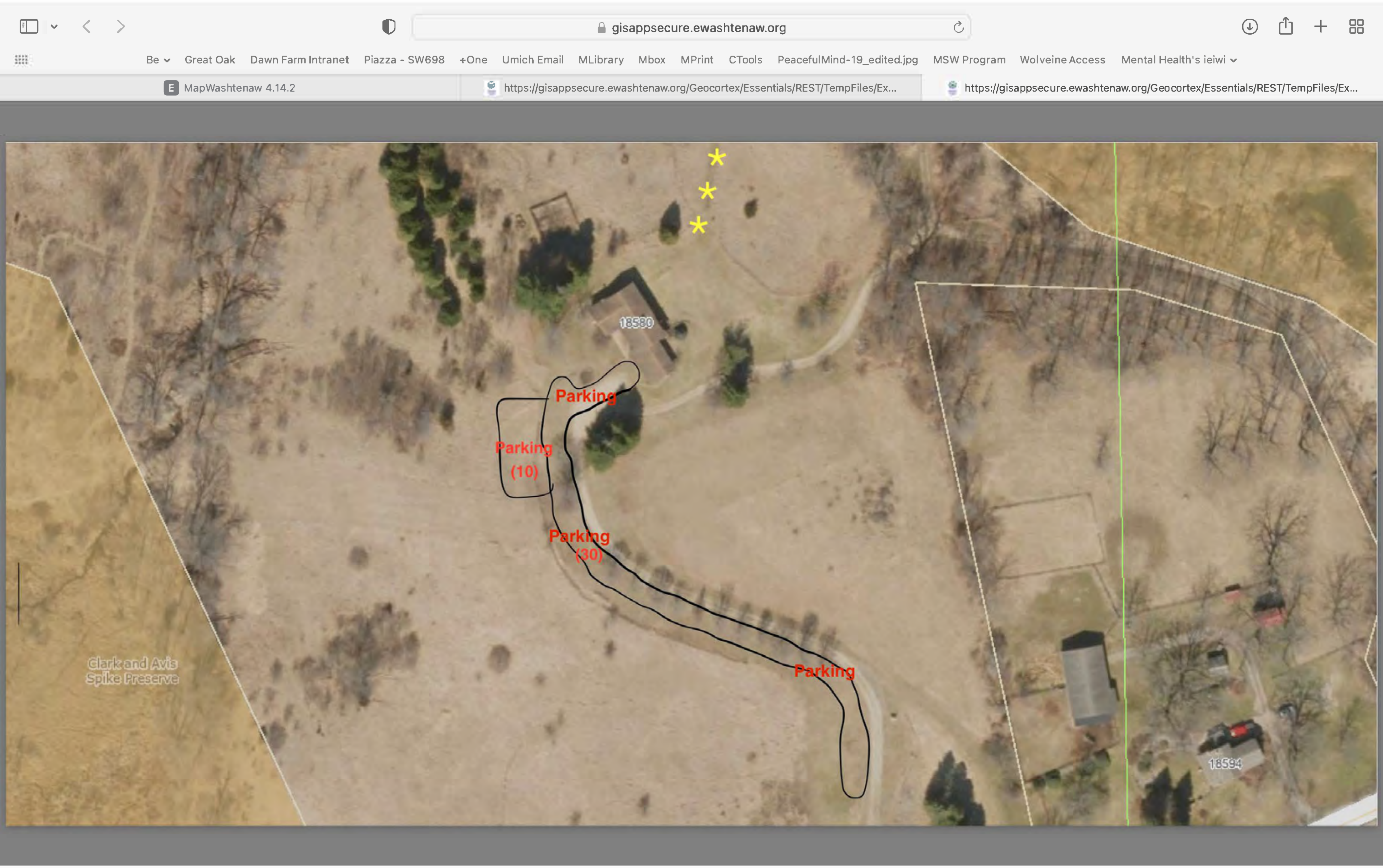
See attachments "EarthWell Event Parking A" and "EarthWell Event Parking B"
The numbers in parenthesis indicate how many cars we would park in that location.

EarthWell Event Parking Plan:

EarthWell Staff will be onsite during event arrivals to direct traffic and parking.

Parking area "A" will be filled with the first 15-30 cars (depending on event size) and anyone staying overnight. Golf carts will be used by EarthWell staff to bring people to event space by pond as needed, otherwise walking signs to the pond are visible.

Parking area "B" will be utilized primarily for handicap parking, those with mobility challenges, and drop-off location for food, tent, flowers, decorations, etc. Parking area "B" will be utilized for overflow parking after Parking area "A" has reached capacity.
We have solar ground lights that light a walking path from the pond to the Common House, so those whose cars are near the Common House can safely walk to their cars on a lighted path, not using the driveway where cars will be exiting.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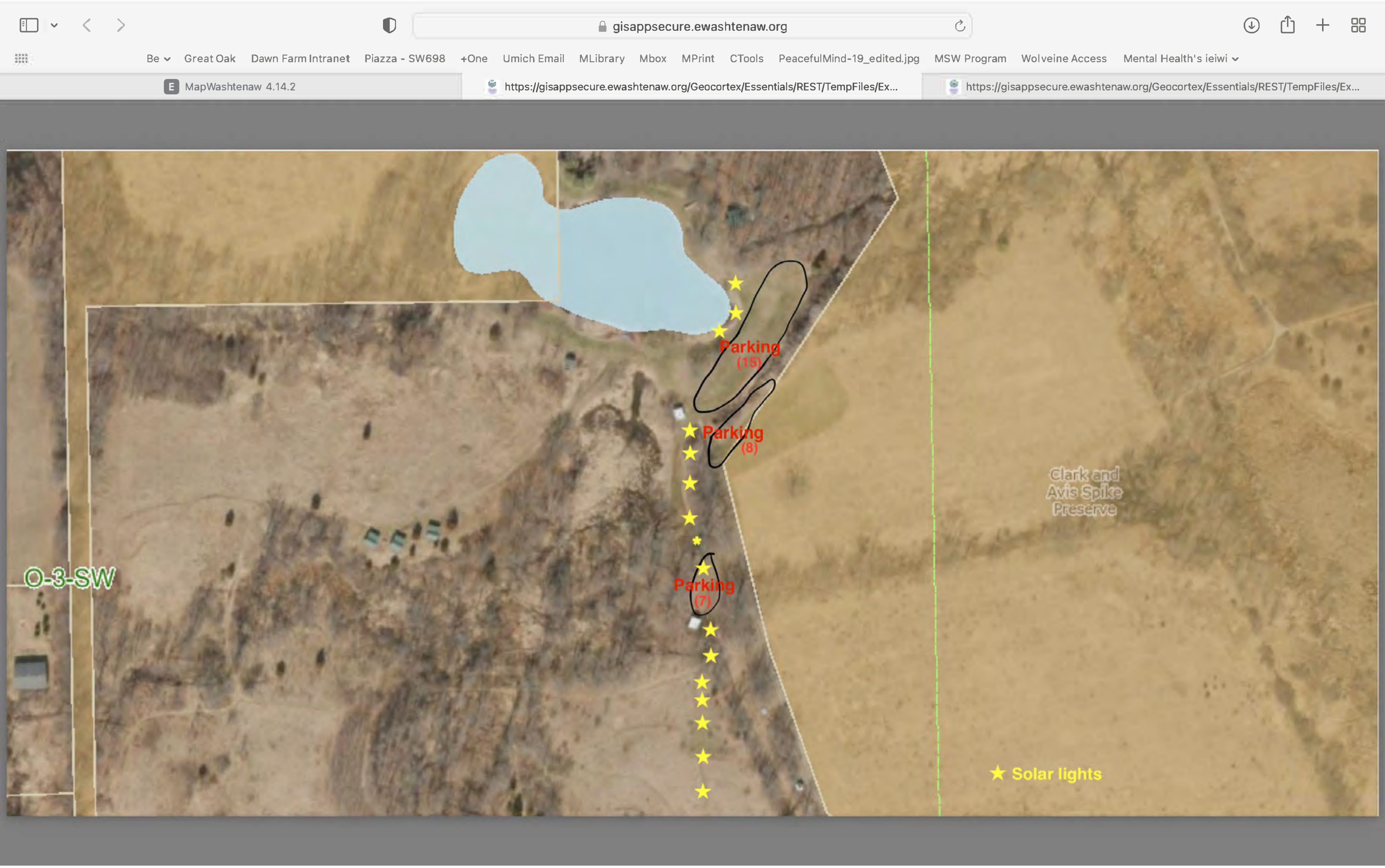
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Clark and Avis Spike Preserve
★ Solar lights

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ASSOCIATES, INC.
117 NORTH FIRST STREET SUITE 70 ANN ARBOR, MI 48104 734.662.2200 734.662.1935 FAX

Date: March 6, 2023

Special Land Use for Extraction of Natural Resources Based on Determination of No Very Serious Consequences For Sharon Township, Michigan

GENERAL INFORMATION

Applicant: Stoneco of Michigan

Project Name: 19024 Pleasant Lake Road

Plan Date: December 13, 2022

Location: 19139, 19024, 17020 Pleasant Lake Road
Parcel ID Numbers: 15-27-100-001, 15-26-200-002, 15-26-200-001, 15-23-300-002, 15-23-200-002, 15-22-400-005

Zoning: A-1, General Agriculture District

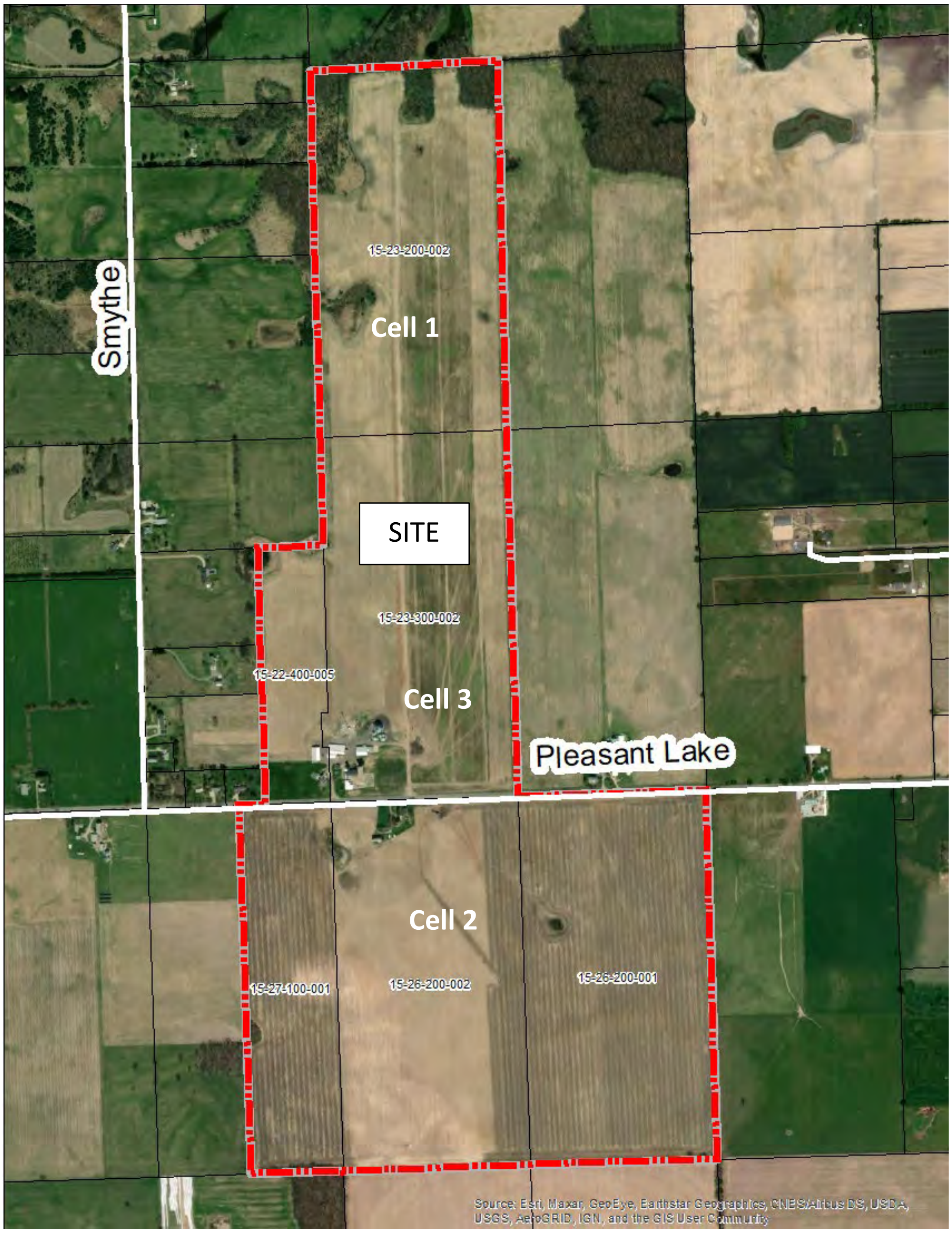
Action Requested: Special Land Use for Extraction of Natural Resources based on Determination of No Very Serious Consequences

PROJECT AND SITE DESCRIPTION

The applicant is proposing a sand and gravel mining operation on five (5) parcels on both sides of Pleasant Lake Road. The applicant has stated that material would be transferred between the northern and southern properties with conveyors running under Pleasant Lake Road, subject to approval by the Washtenaw County Road Commission. The proposed hours of operation are Monday through Saturday, 7:00 a.m. to 6:00 p.m., with sales year round and production processing during a nine-month season, generally March to November, with no operations on

Sundays or legal holidays. The proposed gravel mining operation is expected to produce 1.5 million tons annually.

Aerial Photograph of the Subject Site



Wet and dry excavation methods are proposed. The dry excavation would use dozers, excavators, loaders, water trucks, haul trucks, feed bins, and conveyors. The wet excavation would use excavators, draglines, dredges, water trucks, haul trucks, loaders, feed bins, and conveyors.

Sand and stone processing are proposed. Conveyors will move material from excavation sites to the proposed plant. The plant will then screen, sort, wash and blend material to make salable products. The washing will be supplied from a freshwater pond on site near the plant, and process water will be sent to a slurry or settling pond. All water will be transported using pumps. Stone processing will utilize the same techniques as sand processing, as well as crushing. In their narrative submitted in September 2022, the applicant indicated that they intend to move the processing plant from their Zeeb Road operation to the subject site when the Zeeb Road operation closes.

The reclamation plan, which shows how the site will be restored after the extraction operation ceases, proposes three lakes and conceptual end uses of agriculture or a wetlands/waterfowl habitat conservation area. With 43 percent of the 391.8 acres proposed as waterbodies, an end use of agriculture is unlikely.

The subject site is zoned A-1, General Agriculture. The site has an area of 398.11 acres. The Comstock Drain notches into the northwest corner of the site. A pipeline surrounded by an easement for Panhandle Eastern Pipeline Company and Standard Oil Company runs along the southern property line. In their application dated September 2022, the applicant stated that the setback distance from the existing natural gas pipelines are subject to change based on final easements.

The site currently contains single-family residences and farm operations on both sides of Pleasant Lake Road, with a lease area for a cellular tower on one of the parcels north of Pleasant Lake Road. The applicant is requesting that the residential uses and the cellular tower use continue for the duration of the mining operation and that agricultural uses continue on land that is not being actively mined or used for the processing plant. Agriculture and single-family dwellings are permitted by right in the A-1 Zoning District. The cellular tower use is operating under a previously granted special land use permit. Sand and gravel mining operations are a special land use in the A-1 Zoning District, subject to the provisions of Section 5.12 of the Sharon Township Zoning Ordinance.

The proposed haul route is Pleasant Lake Road between the site and M-52, with seventy-five percent (75%) of the truck traffic arriving and departing from north on M-52 and twenty-five percent (25%) of the truck traffic from the south on M-52.

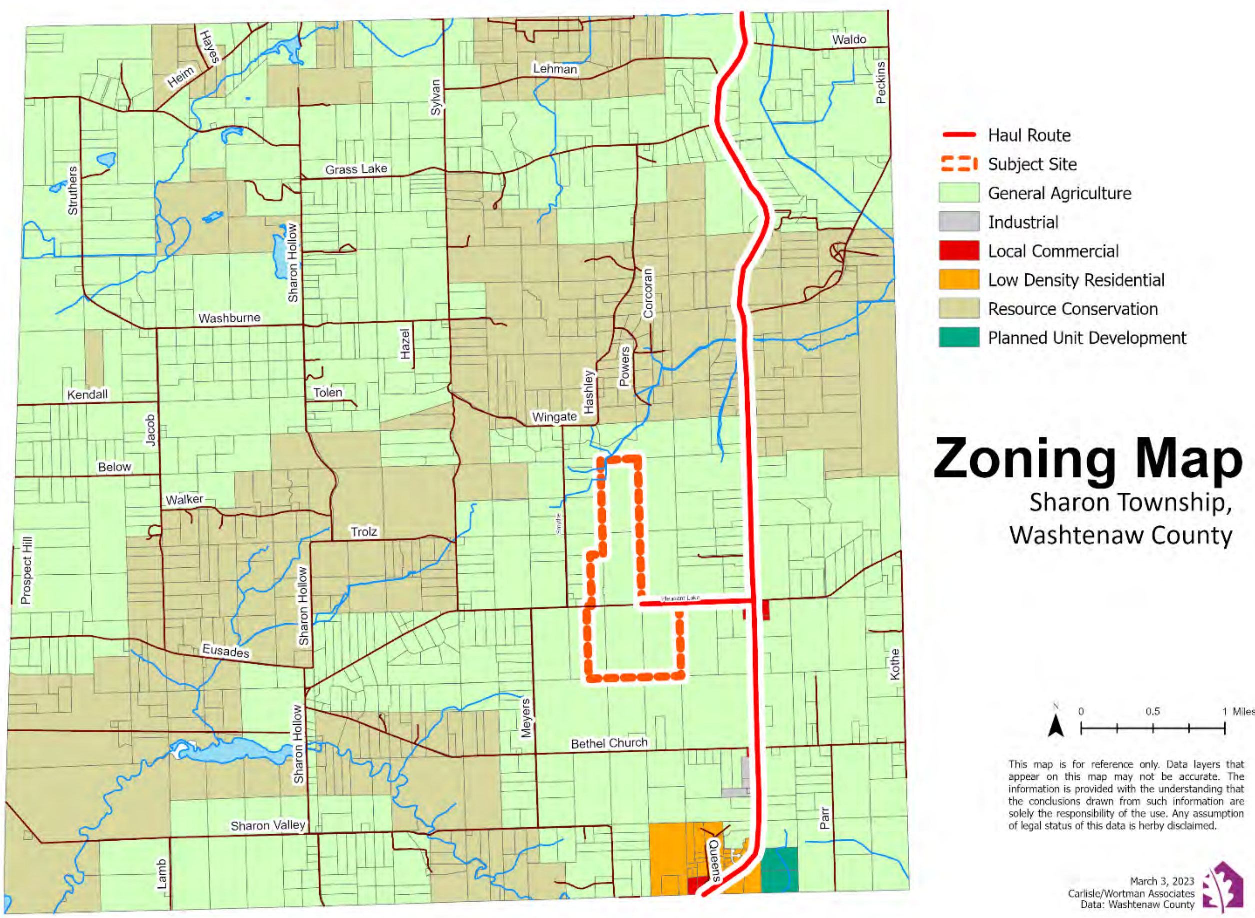
The applicant is requesting a special land use permit based on the determination of no very serious consequences, per Section 5.12.C of the Sharon Township Zoning Ordinance. This is our third review of their special land use application.

Items to be Addressed: *Finalization* of *setback distance from the existing natural gas pipelines and easements.*

NEIGHBORING ZONING AND LAND USE

The zoning, land use and Master Plan designations of the subject site and surrounding properties is provided in table below. The site and haul route are shown on the Zoning Map, as well.

	Subject Property	North	South	East	West
Zoning	General Agriculture (A-1)	General Agriculture (A-1)	General Agriculture (A-1)	General Agriculture (A-1)	General Agriculture (A-1)
Land Use	Single-Family Agriculture Cellular Tower	Agriculture	Agriculture	Single-Family Agriculture	Single-Family Agriculture
Master Plan	Agriculture Resource Conservation	Resource Conservation	Agriculture	Agriculture	Agriculture Resource Conservation



Items to be Addressed: *None*

MASTER PLAN

Sharon Township adopted an update to their Master Plan on October 1, 2020. In that document, all maps were updated using the most recent data. The following items from the Master Plan's Vision, Goals and Objectives are relevant to this application:

Vision Growth and development in Sharon Township are consistent with the natural limitations of the land, the availability and provision of public services, the protection of the Township's natural resources, green infrastructure and rural character, as well as the protection of the natural resources and character of neighboring townships and villages and the green infrastructure of the watersheds in the Township.

Sustainability Goal Land use, preservation, and development meets the environmental, economic, and social needs of the present residents, businesses, and property owners without compromising the ability of future generations to meet their needs.

Sustainability Objectives

1. Preserve the Township's natural resources and features through a coordinated future land use strategy and related regulations that permit reasonable use of land while prohibiting unnecessary destruction or loss of natural resources or features.

9. Separate incompatible land uses by distance, natural features, and/or man-made landscape buffers to screen or mitigate adverse impacts.

17. Maintain and protect the historic and architectural resources in the Township.

19. Ensure long-term financial viability of the Township tax base while preserving farmland, natural features, and green infrastructure.

Sustainability Policies

XI. Continually monitor local attitudes toward the acquisition of public land for recreational facilities or other public facilities and take appropriate planning and capital improvement actions to acquire and development such land should a demonstrated need arise.

Green Infrastructure Goal

Preserve, protect, and enhance the green infrastructure of the Township and the watersheds within its borders including the integrity of the interconnected network of natural areas, wildlife habitats, riparian corridors, and places of biological diversity.

Green Infrastructure Objectives

2. Encourage development that actively preserves open spaces.
3. Assure that development does not increase air, noise, land, and water pollution, or degrade land and water resource environments, including groundwater.
8. Maintain and preserve land identified as suitable for mineral extraction of the production of mineral deposits, including but not limited to sand and gravel. Allow development of these resources only in a manner compatible with the Township's environment, green infrastructure, and character.

Green Infrastructure Policies

VI. Limit mineral extraction to areas that meets, at a minimum, the following criteria: are a source for sand and/or gravel; are in an area(s) of large land parcels, such as 40 acres or larger; are in close proximity to an all-season road that may be used as a haul route or, alternatively, located in close proximity to a hard surface road that may be upgraded and used as a haul route; are located to maximize distance from large concentrations of residences; and do not contain environmentally sensitive and/or endangered species of plants and/or animals, irreplaceable natural features and are not wetlands.

VII. Maintain provisions for mineral extraction including sand and gravel within the Zoning Ordinance and Mineral Extraction Ordinance.

Farmland Preservation Goal

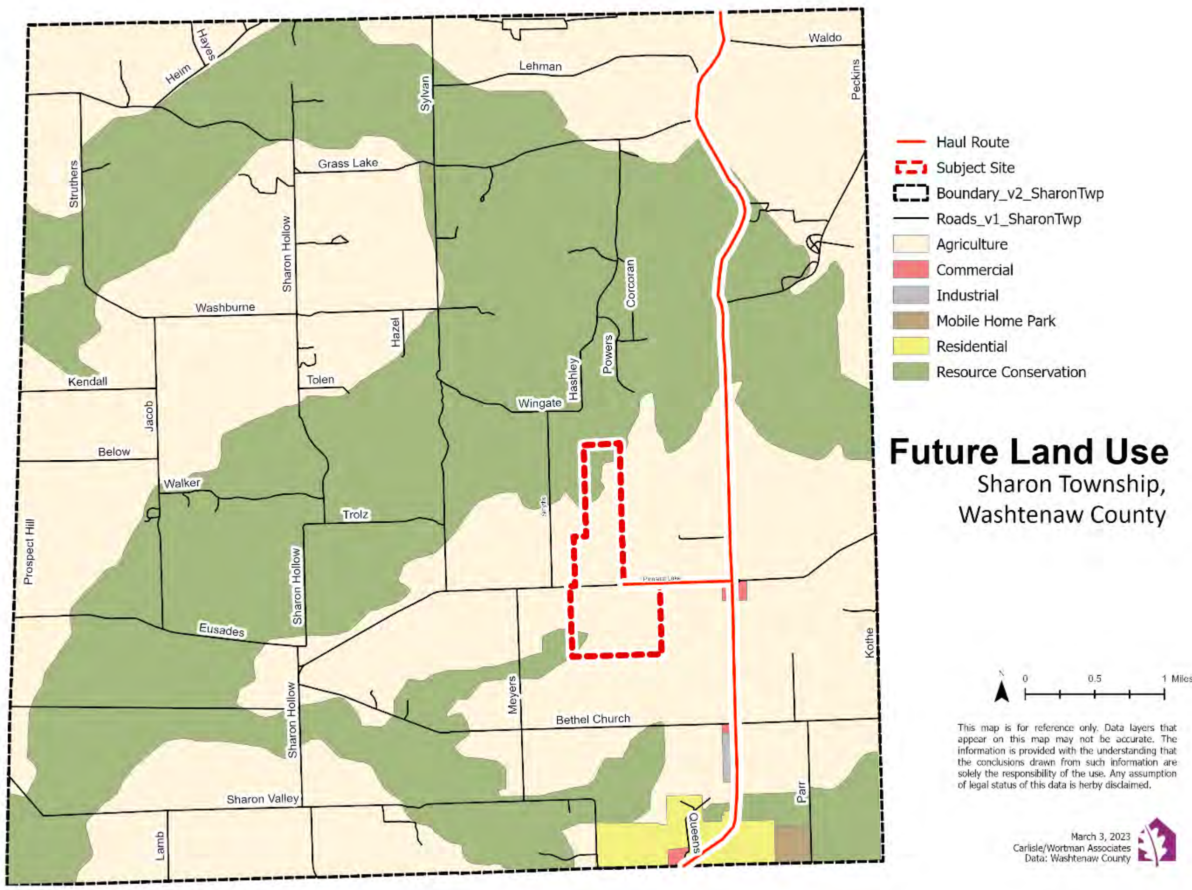
Encourage the continuation of local farming operations and the long-term protection of farmland resources.

Farmland Preservation Objectives

1. Protect areas considered appropriate for farming and implement zoning provisions that complement and sustain local farming interests.

2. Minimize conflicts and nuisance problems (destruction of crops, complaints about legitimate day-to-day farming operations, etc.) in designated agricultural areas by limiting the encroachment of incompatible land uses.

The subject site and surrounding properties are planned mainly for agriculture, with pockets of land planned for resource conservation in the northwestern and southwestern corners of the site, as shown in the map below.



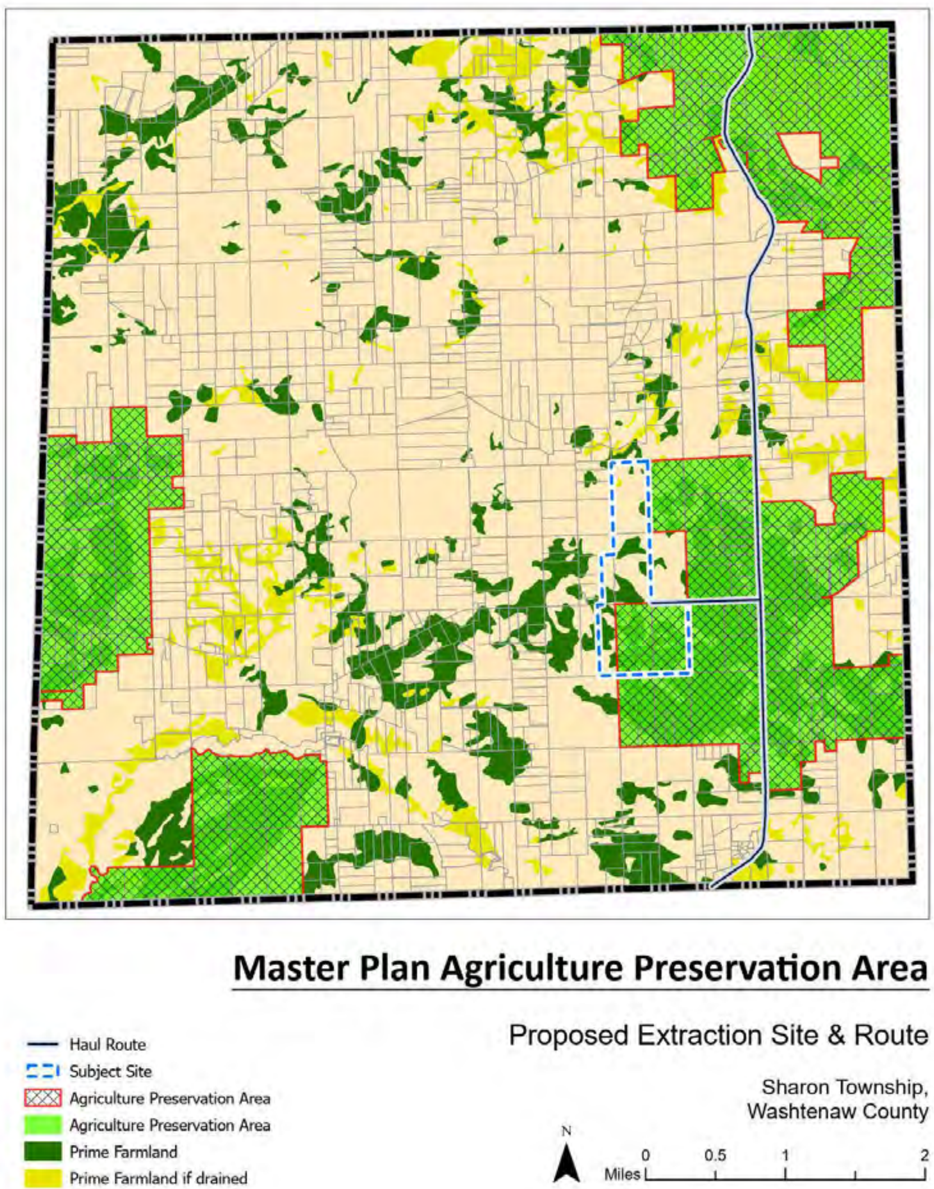
The intent of the Agricultural Future Land Use Designation is to “encourage the long-term protection of the farmland resources and provide opportunities for low-density residential development that preserves the community's overall rural character, natural resources, and open spaces.”[1] The primary land use is agriculture, and the minimum lot size is ten (10) acres.

The Resource Conservation Future Land Use Designation is “is characterized by an array of conditions that require a strong conservation theme”, include “abundant and sensitive natural resources including woodlands, wetlands, and steep slopes”, and “provide special opportunities

[1] Sharon Township Master Plan, adopted on October 1, 2020, page 29.

for passive recreation and contribute to the Township's overall rural character." The intended future land uses "should be limited to open space and natural resource-based land uses such as farming and wildlife management, and low-density residential development."[2]

In addition, as shown in the map below, the subject site either abuts or is within the Agricultural Preservation Area designated in the Master Plan and the haul route goes through two of the four areas in the Township with the Agricultural Preservation Area designation.



[2] Sharon Township Master Plan, adopted on October 1, 2020, page 33.

Land in the four Agricultural Preservation areas was selected for the following reasons:

1. The parcels of land within each of the 4 areas are contiguous.
2. Nearly all the parcels in the areas are zoned A-1, Agriculture; the remainder are zoned R-C, Resource Conservation.
3. Most of the tillable land is currently farmed.
4. Most of the designated areas do not have significant areas of natural features.
5. These four (4) areas contain the township's prime agricultural soils.

The current extraction operations in Sharon Township are not in the Agricultural Preservation Area.

In the Planning Issues chapter, the Master Plan recognizes the need for sand and gravel extraction and the potential impacts. In that section, the Master Plan states:

> *"Sand and gravel are important construction materials especially for new developments and roadways. Some of these deposits in Sharon Township are commercially recoverable. Numerous sand and gravel extraction businesses are operating in Washtenaw County, including one active pit in Sharon Township. As these resources elsewhere are consumed, Sharon Township may be faced with additional gravel extraction pressures. Several hundred vacant acres are owned by extractive businesses in the northeast portion of the Township. Extraction of sand and gravel from the Sharon Short Hills has the potential to cause irreparable damage to the environment, including adverse effects on recreational and scenic land, water quality, agricultural soils, woodlands, wildlife habitat, and roadways.*
>
> *Despite their negative effects, mineral extraction operations can be revenue producing entities for the Township. Although mineral extraction is often considered a property right and is not prohibited, it is subject to regulation that can mitigate the negative effects. Currently, Sharon Township allows mineral extraction as a Special Use in both the resource conservation and agricultural districts subject to the Township's Mineral Extraction Ordinance."*[3]

Items to be Addressed: *None*

NATURAL FEATURES

The site has the following natural features:

Topography: The site has fairly level topography, gradually increasing in topography from north to south. By the nature of the proposed use, the topography

[3] Sharon Township Master Plan, adopted on October 1, 2020, page 18.

would drastically change, with the creation of three lakes on site proposed in the reclamation plan.

Woodlands: The site has woodlands along the northern border of Cell 1, the northeastern border Cell 1, a smaller stand of trees on the portion of Cell 2 near Pleasant Lake Road, and portions of larger woodlands on the eastern and southern borders of Cell 2. The mining plan shows fencing either just outside the edge of the woodlands and tree stands on site or slightly encroaching.

Wetlands: Six (6) wetland areas are on site, three (3) of which are regulated by the State of Michigan and the other wetlands are subject to the regulations in the Sharon Township Wetlands Ordinance. No development is proposed within the wetland areas. Any proposed activity within the wetlands would require wetlands permits from the Township and from EGLE, if the wetlands are regulated by the State of Michigan.

Waterways: The Comstock Drain traverses through the northwest corner of Cell 3. The wetland shown as "Wetland 1" on the mining plan is associated with the drain. No disturbance or development is proposed for the drain or the associated wetland.

Floodplains: No floodplains are present on the site.

Soils: Per the environmental impact assessment submitted, the soil on the site consists of primarily silt or loam (Class B), with sandy clay loam (Class C) in the eastern corner of the site and sandy clay (D/A) in the western corner.

Per maps from Washtenaw County, prime farmland soils are on all parcels of the subject site, with a concentration of prime soils in Cell 2.

Items to be Addressed: *None*

TRAFFIC & TRUCK WAITING AREAS

In the traffic study submitted by the applicant, the daily traffic on June 8, 2022 was:

- 6,652 vehicles on M-52, north of Pleasant Lake Road for two-way traffic; and
- 2,873 vehicles on Pleasant Lake Road, west of M-52 for two-way traffic.

We defer to the Township Engineer for confirmation of accuracy of the traffic study.

The proposed extraction operation is expected to generate up to fifteen (15) daily trips for employees and between 150-175 two-way truck trips on average and up to 300-330 two-way truck trips on peak days. The peak days are anticipated to occur three to four times a year.

The traffic study estimated traffic to come in the following waves:

Wave	Time of Day	Average Vehicle Trips	Peak Vehicle Trips
Employee Arrival	Before 7:00 a.m.	10-15	10-15
Wave #1	6:30-7:30 a.m.	30	45
Wave #2	9:30-10:30 a.m.	20	35
Wave #3	2:30-3:30 p.m.	20	35
Hours after Wave #3	3:30 – 6:00 p.m.	--	67*
Employee Departure	6:00 p.m.	10-15	10-15

* Estimate using the average of 26.8 trucks per hour for 2.5 hours per estimate on page 9 of the Traffic Impact Study prepared by Midwestern Consulting, dated July 20, 2022.

The traffic impact in terms of vehicle trips would be similar to the entire site being developed as 10-acre residential lots. Assuming that with infrastructure and preservation of natural features only eighty-five percent of the site would be developable, an estimated thirty-three lots could be created. Using the daily trip generation of 9.43 trips per dwelling unit for single-family detached housing from the 11th edition of the Institute of Transportation Engineers Trip General Manual, a housing development would generate 311.19 trips per weekday. However, the majority of those vehicles would not be trucks, would not idle on site, and likely not run on diesel gas. The peak traffic hours would also be markedly different, more in line with the existing land uses in the vicinity of the proposed site and along the haul route.

The school bus routes for Manchester Community Schools on the haul route are listed in the table below. The bus stops which occur during the waves of truck traffic are in bold, italicized font.

Route & Bus Number	Stop #	Time	Location
Route 2, Bus #18, AM	1	6:16 AM	7255 M-52
	2	***6:17 AM***	***7743 M-52***
	35	***7:36 AM***	***8932 M-52***
	36	7:37 AM	8940 M-52
	37	7:40 AM	10590 M-52
	38	7:41 AM	M-52 & Sharon Hills Lane
Route 2, Bus #18, PM	***1***	***3:20 PM***	***9534 M-52***
	2	***3:24 PM***	***7743 M-52***
	4	***3:30 PM***	***7679 M-52***
	5	3:31 PM	7255 M-52
	6	3:33 PM	6711 M-52
	38	4:44 PM	8932 M-52

Route & Bus Number	Stop #	Time	Location
	39	4:45 PM	8940 M-52
	40	4:48 PM	10590 M-52
	41	4:49 PM	M-52 & Sharon Hills Lane
Route 5, Bus #23, PM	***7***	***3:18 PM***	***W. Pleasant Lake Road and M-52***

Per an email from the Chelsea School District Transportation Director, the Chelsea School District has a bus stop on M-52 between Scio Church and Grass Lake Road. In previous years, Chelsea School District buses had additional stops along this portion of M-52.

The applicant has noted that staging and waiting space for up to one hundred and twenty-nine (129) trucks will be available. With a peak wave of forty-five (45) trucks anticipated by the applicant, the proposed site layout will have more than adequate room for trucks to wait and be loaded.

Items to be Addressed: *Confirmation of the accuracy of the traffic study by the Township Engineer.*

COMPLIANCE WITH ZONING AND MINERAL LICENSING DESIGN STANDARDS

The Mining Plan meets the setbacks and design standards in Section 5.12 of the Zoning Ordinance and Section 2.8 of the Mineral Extraction Ordinance as follows:

Standard	Requirement	Proposed	Complies
Mining area minimum setback from the nearest public roadway or adjoining property line	200 feet	250 feet	Yes
Minimum setbacks of equipment used for screening and crushing from			
Nearest public roadway	300 feet	300+ feet	Yes
Nearest adjoining non-residential property line	200 feet	300 feet	Yes
Nearest residential property line	400 feet	400 feet	Yes
Nearest residential dwelling on adjacent property	500 feet	500 feet	Yes
Perimeter of site to internal roads	150 feet	200 feet	Yes
Perimeter of the site to all stockpiles and processing equipment	300 feet	300 feet	Yes
Stockpile maximum height above the grade of the area situated between the stockpile and adjoining property	25 feet	25 feet	Yes

Standard	Requirement	Proposed	Complies
Screening of active mining area and processing equipment	Not visible from adjacent residential or public road	45 foot maximum height for processing equipment in the narrative, but not on mining plans	Yes
Maximum grade for side slopes on restoration contour map			
Active extraction area perimeter	1:3 feet	1:4 feet	No, but complies with Mineral Extraction Ordinance
Banks adjacent to submerged areas	1:5 feet	1:4 feet	Yes

The Mining Plan meets the setbacks and design standards in Section 2.8 of the Mineral Extraction Ordinance as follows:

Standard	Requirement	Proposed	Complies
Mineral Extraction Ordinance Section 2.8			
Minimum setbacks of fixed machinery and equipment and buildings from			
Any lot line	250 feet	250 feet	Yes
Any existing residence	500 feet	< 500 feet	No
Minimum setbacks of extraction, processing, loading, weighing, stockpiling or other operations or equipment storage or repair			
Any road-right-of-way	250 feet	250 feet	Yes
Any other property boundary	250 feet	250 feet	Yes
Any existing residence	500 feet	< 500 feet	No
Maximum grade on reclamation plan for			
Unsubmerged area	1:4 feet	1:4 feet	Yes
Permanently submerged area to depth of five (5) feet below annual low water elevation	1:5 feet	1:5 feet	Yes

For the maximum grade of the unsubmerged areas adjacent to the active extraction area perimeter, the lesser or more restrictive grade of 1:3 feet in the Zoning Ordinance governs, per Section 2.17 of the Mineral Extraction Ordinance.

In the narrative, the applicant stated that structures associated with the processing plant will not be more than forty-five (45) feet in height. The applicant also provided a cross-section on Sheet 5D that shows how the processing plant will be screened from view on public roads. We recommend that a note restricting the height of structures associated with the processing plant to not more than forty-five (45) feet be added to the Mining Plan sheet as a condition if the Township chooses to grant the special land use permit.

To comply with Section 2.8 of the Sharon Township Mineral Extraction Ordinance, the buildings proposed to continue as a residential use must be located at least five hundred (500) feet from any fixed machinery, equipment, buildings, extraction, processing, loading, weighing, stockpiling or other operations or equipment storage or repair. The location of construction sand and gravel extraction areas on Cell 2 and Cell 3, and the mobile equipment parking need to be moved, at a minimum. This required setback will be evaluated with the annual mineral license approval and does not need to be revised for consideration of the Special Land Use.

However, we strongly recommend the following conditions of any special land use approval to protect the health, safety and welfare of the residents on the subject site:

1. Additional fencing and gates are required to prevent residents of and visitors to the residences on-site from encountering dangerous situations posed by the extraction activity and associate physical attributes on site.
2. The occupancy of the on-site residences could be limited by the applicant to the current residents.
3. If the occupancy is not limited to the current residents, conditions of approval for the Special Land Use could include maintenance of the on-site residences to be evaluated with the annual mineral license approval.
4. Testing of the water pressure and quality of the wells associated with those houses on site be part of the annual mineral license approval.

If the special land use is approved, the following items, either shown or lacking on the Mining Plan, must be provided at the time of site plan review:

1. Vehicle turnaround area for Cell 2.
2. Parking area for Cell 2, if proposed.
3. Notation of existing trees to be removed and trees that are to be preserved.
4. A detail of the proposed fence.

Items to be Addressed: *1.) The maximum grade of the unsubmerged areas adjacent to the active extraction area perimeter in the reclamation plan are 1:3 feet; 2.) Note added to Mining Plans limiting the height of the processing equipment to 45 feet; 3.) The mining plan is revised so that all occupied residences on site will be at least five hundred (500) feet from any fixed machinery, equipment, buildings, extraction, processing, loading, weighing, stockpiling or other operations or equipment storage or repair; and 4.) Planning Commission consideration of conditions of* *approval to protect the health and safety of residents on the subject site, if recommending approval.*

EXTRACTION, SOIL REMOVAL AND MINING OPERATIONS APPROVAL PROCESS

The approval process for extraction, soil removal and mining operations is as follows per Section 5.12 of the Sharon Township Zoning Ordinance and the Sharon Township Mineral Extraction Ordinance:

1. **Preliminary determination of the need and public interest in natural resources proposed to be extracted to inform decision on "no very serious consequences":** The process for this phase of approval is after any deficiencies in the application have been addressed, the Planning Commission holds a public hearing, and adopts findings and recommendations on the extent of need demonstrated by the applicant; and the Township Board makes its own findings and conclusions on the extent of the need demonstrated.

   Per the recommendation of the Planning Commission, the Township Board, at their June 22, 2022 Regular Meeting, passed a unanimous motion finding that ***the applicant has satisfied its demonstration of need only to the extent of a showing that there is a low-to-moderate need for the resources proposed to be mined on Sharon Township property.***

2. **Special Land Use approval:** If the applicant is found to have demonstrated need by the Township Board, the applicant may then file a special land use application. The Planning Commission holds a public hearing and makes a recommendation to the Township Board. The Township Board can approve, approve with conditions or deny the special land use.

   The applicant submitted a special land use application to the Sharon Township Clerk on September 29, 2022 and a revised submittal on December 16, 2022. The Planning Commission reviewed the special land use application, with reports from us and the Township Engineer, at their meeting on January 17, 2023, found the application complete and held a public hearing on February 15, 2023.

3. **License from Mineral License Board:** Chapter IV, Article 2 – Mineral Extraction in the Sharon Township Code of Ordinances requires a license from the Township Mineral Extraction License Board to commence or continue a business involving mineral extraction. A condition of filing a mineral license application is Special Land Use approval, per Section 5.12 of the Sharon Township Zoning Ordinance. The applicant may seek approval from the Township Board to apply for a mineral license during the special land use approval process, with the understanding that the applicant assumes the risk of expending the time and resources pursuing the mineral license approval prior to zoning approval. At this time, the applicant has not applied for a mineral license.

Prior to the initiation of any construction activities associated with the special land use, a preliminary and final site plan must be approved by the Township Board, upon recommendation by the Planning Commission, per Section 4.02 of the Sharon Township Zoning Ordinance. Preliminary and final site plan approval may be pursued under a single application. Site plans may be submitted for each cell in conjunction with the annual mineral license application.

Items to be Addressed: *None*

EXTRACTION, SOIL REMOVAL AND MINING OPERATIONS REVIEW STANDARDS

Section 5.12.D.3 provides the standards listed below based on Act 113, MCL 125.3205(5) (a)-(f) for the purpose of determining whether the applicant has proven that "no very serious consequences" would result from the applicant's proposed extractive operation and haul route. The standards are listed on the following pages in bold font, with CWA comments in regular font.

a. Existing Land Uses

(1) The relationship and impact of applicant's proposed use and associated activities with and upon existing land uses anticipated to be impacted, particularly those properties in the vicinity of the property and along the haul route(s).

<u>CWA Comments</u>: The existing land uses of the properties in the vicinity are agricultural and residential. The uses along the haul route are primarily agricultural, a few residential uses, with a place of worship and gas station at the intersection of M-52 and Pleasant Lake Road.

Except for the residences proposed to be occupied during the extraction operation, the site design meets all the dimensional setback, screening and buffering requirements in the Sharon Township Zoning Ordinance and in the Mineral Extraction Ordinance.

The applicant submitted in Appendix B of the application, dated September 2022, a Noise, Dust, and Fumes Evaluation by Natural Resources Management, LLC. The study used the currently operating mineral extraction operation at the Stoneco Zeeb Road Pit located 2670 S. Zeeb Road in Scio Township as a proxy for the proposed site. The applicant has stated that they intend to use the processing plant from the Stoneco Zeeb Road Pit at the proposed extraction operation.

The study found that the Stoneco Zeeb Road Pit operates without producing harmful impacts in terms of noise, dust, and fumes at locations equivalent to the entrance to the site and the required two hundred and fifty (250) feet setback in Sharon Township from the processing plant area. The study made the following conclusions:

- The sound levels measured did not exceed seventy (70) dBA for any one-minute increment during the testing. For context, seventy (70) dBA is equivalent to the sound level of a regular washing machine.
- Respirable dust and silica were not detected above the laboratory reporting limits, which the study concluded were at concentrations that would not affect the health of nearby residents.
- Diesel was not detected at the sample sites above the laboratory reporting limits, which the study stated were not likely to affect the public health, safety or welfare of residents.

While the site is similar in terms of surrounding land uses, the study did not provide a comparison of the volume of mining, processing, and traffic between the Zeeb Road Pit and the proposed activities at the subject site. Furthermore, in the applicant's April 2021 Special Land Use application for Demonstration of Need, the applicant stated that the proposed extraction operation at the subject site is proposed to replace the market share for both of Stoneco's Zeeb Road and Burmeister locations. The study is likely not an accurate representation of the potential impacts since the volume of mining, processing, and traffic may be less intensive on the Zeeb Road site than the proposed extraction activities at the subject site.

The proposed extraction operation and the volume of traffic along the haul route may impact land uses in the vicinity and along the haul route. Two examples are:

- In the public hearing on February 15, 2023, two nearby property owners shared that they have home-based counseling businesses that would potentially suffer if the proposed use was approved. Access to a quiet natural environment was a cornerstone of their practice. These home-based businesses as well as the nearby residences may be adversely impacted by noise and dust, if not adequately controlled, from the extraction operation.

- The properties abutting the subject site to the east, on either side of Pleasant Lake Road, are in agricultural use and owned by the same property owner. The increased truck traffic could affect this ability of this farm operation to move equipment across Pleasant Lake Road.

(2) The impact upon the public health, safety and welfare from the proposed use, including haul route(s), considering, among other things, the proposed design, location, layout and operation in relation to existing land uses.

CWA Comments: The proposed operation, particularly the volume of truck traffic, could have an impact on the public health, safety and welfare on existing land uses and those along the haul route. Increased truck traffic and idling of trucks on-site would concentrate fumes, potentially creating health issues for those living on the site, nearby the site or along the haul route.

The applicant has submitted a study based on the Stoneco Zeeb Road Pit operations. However, without a baseline for truck volume on the days when samples were taken (June 27, 2022 and August 9, 2022 for diesel fuel vapors and diesel particulate samples, respectively), the validity of that study is questionable, especially when the market share of the Zeeb Road Pit is one of two active pits that this proposed use is supposed replace.

During the public hearing, members of the public expressed concern about the health impacts of silica dust, fumes, odors, water contamination, and noise. An adjacent property owner and her disabled son testified as to how the potential noise from the proposed extraction operation and associated trucks could harm his health, as loud noises induce seizures due to his condition.

b. Property Values

(1) The impact of applicant's proposed use and associated activities on property values in the vicinity of the property and along the proposed haul route(s) serving the property.

CWA Comments: The proposed operation and associated truck traffic could have an impact on the property values in the vicinity and along the haul route. The applicant has submitted a market study on the potential impact of active gravel mining operations on residential market values by Brachter & Associates, dated September 6, 2022. The study compared the residential market values in four (4) areas in Washtenaw County near to active gravel mining operations. Comparisons were made based on the price per square foot for homes sold and the number of days on the market and then graphed in relationship to the number of miles from an active mine. The study concluded that:

- There was no detrimental impact to residential market values resulting from the proximity to an active gravel mining operation or along haul routes.
- The general demand for and value of residential real estate was not adversely affected by active gravel mining operation or along haul routes.

The study submitted does not address the following:

- The study does not address the market value or general demand for agricultural land, the predominant land use in the vicinity and along the proposed haul route.
- The study does not offer insight into the type of machinery, processes, truck volume, or any other aspect at the gravel mines in the four study areas. The existing gravel mine in Sharon Township, which was the focus of one of the study areas, does not generate as much truck traffic as is proposed for the subject site.
- The study does not offer insight into how residential property values would be affected by the development of a new gravel mine, since the study did not examine property values before and after the development of a gravel mine.

At the public hearing, the Sharon Preservation Society submitted a study that concluded that in Richland Township, Michigan a proposed extraction operation would have a negative effect on property values: “An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township” by George Erickcek of the W.E. Upjohn Institute for Employment, dated August 15, 2006. The author of the study had built a model based on the study of the effects of distance from a 250-acre gravel mine of the sale price of 2,552 residential properties in Delaware County, Ohio from 1996 to 1998 by Professor Diane Hite. The study concluded that the proposed Stoneco Gravel Mine Operation in Richland Township at that time would reduce residential property values in Richland and Richland Township by $31.5 million over 1,400 properties.

The Upjohn study examines analyses on the long-term relative difference in property values of properties and proximity from mines over decades, which did not see a widening in differentials over time based on distance. The study then criticizes the conclusions of these analyses that mines do not impact property values. Rather, the study states that a mine will have a impact on property values for a short period of time, following the announcement or establishment of a mine, and the long-term studies do not account for that market shock. The study further theorizes that if residential housing values climb at the same rate no matter the distance from a mine, that property owners will not be able to regain the initial, short-term loss of value.

While Upjohn study is based on home sales before and after the development of a mine, it does not address the same issues of the price of agricultural land and of the intensity of the proposed extraction operation in Sharon versus the gravel mine in the Hite study. In addition, the study looked at a different real estate market in terms of location and time period.

(2) The effect on the general demand for and value of properties in the Township anticipated to be caused by the proposed use, including use of the haul route(s).

<u>CWA Comments</u>: The proposed operation and associated truck traffic could have an impact on the general demand for and value of properties in the Township anticipated to be caused by the proposed use, including the use of the haul route. The studies discussed above looked at residential home sales within radii of three to five (3-5) miles from an extraction operation and address general demand for and value of properties in the Township. The studies have conflicting conclusions as to impact on the general demand and value of properties. As discussed above, neither study addresses land value nor demand for agricultural land, which is a different real estate market. In order to understand the impact on general demand and property values, in the vicinity or along the haul route or in the Township in general, a study with comparable properties in terms of use and a similar intensity to the extraction operation proposed would be needed.

(3) The impacts considered in this subsection b may taking into consideration: the number and type of vehicles proposed; machines and equipment to be used in the operation; location and height of buildings, equipment, stockpile or structures; location, nature and height of walls, berms, fences and landscaping; and all other aspects of the proposed use.

CWA Comments: The proposed extraction operation meets the Township's ordinances in terms of location and height of buildings, equipment, stockpile and structures; and the location, nature and height of walls, berms, fences and landscaping. Compliance with those regulations will minimize impacts on the value and demand for properties in the vicinity, along the haul route and in the Township overall.

The number and type of vehicles proposed, and machines and equipment to be used in the operation could have a negative impact on the value and demand for properties in the vicinity, along the haul route and in the Township overall. The real estate studies submitted, both by the applicant and the Sharon Preservation Society, did not specify the number and types of vehicles or the machines and equipment used the in mines in those studies.

c. Pedestrian and Traffic Safety

(1) The impact of the proposed use and associated activities on pedestrian and traffic safety in the vicinity of the property and along the proposed haul route(s) serving the property.

CWA Comments: Pleasant Lake Road is a two-lane County primary road, without sidewalks, safety paths or bicycle lanes. M-52 is a state trunkline with two to three (2-3) lanes in Sharon Township. M-52 does not have non-motorized facilities (sidewalks, safety paths or bicycle lanes). Pleasant Lake Road west of M-52 and M-52 in Sharon Township are planned for non-motorized improvements, as primary and locally identified routes in the Non-Motorized Chapter of the 2045 Long Range Plan for the Washtenaw Area Transportation Study in 2019. Both roads have a speed limit of fifty-five (55) miles per hour. The applicant is proposing to improve Pleasant Lake Road along the haul route to a designated all season route.

The applicant submitted a traffic study which examined the impact of the proposed use and associated activities on pedestrian and traffic safety in the vicinity of the property and along the proposed haul route. The study concluded:

- The employee and proposed truck traffic would not significantly impact delays, vehicles lining up, or the level of service at the intersection of Pleasant Lake Road and M-52.

- Since pedestrians and bicyclists were not present at the intersection of M-52 and Pleasant Lake Road during the 24-hour period that the study was conducted (Tuesday, June 8, 2022), any pedestrian and truck interactions would be non-existent.

The study did not document pedestrian or bicycle activity along the proposed haul route along Pleasant Lake Road or M-52. There is pedestrian activity at the intersection of M-52 and Pleasant Lake Road since Manchester Community Schools Route 5, Bus #23 stops at that intersection at 3:18 p.m. per the bus schedule for the 2022-2023 on the school district's website.[4] While a primarily rural area, pedestrians are active on both roads, if only to obtain their mail. Along the haul route, three residences, associated with farms, are on the north side of Pleasant Lake Road with their mailboxes on the south side of the road, including one of the residences on the subject site proposed to be occupied. Mailboxes are on a single side of M-52 as well. In terms of bicycle activity, recreational cyclists tend to be active on weekends. During the public hearing, a resident spoke about how he often bikes on M-52 on the weekends, but rarely on weekdays. The traffic study submitted did not take observations during a weekend period.

(2) Consistency with and authorization of the proposed use and haul route(s) under state, county, and/or local regulations that have been established for roadways, including regulations applicable to the use of roads for proposed haul route(s).

CWA Comments: The applicant is proposing to improve Pleasant Lake Road along the haul route to a designated all season route and stated that they will follow the requirements of the Washtenaw County Road Commission (WCRC). WCRC permits will be needed for the proposed driveways and road improvements.

(3) The impact of the proposed use, including haul route(s), on vehicular and pedestrian traffic, particularly in relation to hazards reasonably expected in the district(s) impacted, taking into consideration the number, size, weight, noise, and fumes of vehicles, vehicular control, braking, and vehicular movements in relation to routes of traffic flow, proximity and relationship to intersections, adequacy of sight distances, location and driveways and other means of access, off-street parking and provisions for pedestrian traffic. Consideration shall be

[4] https://sites.google.com/mcs.k12.mi.us/transportation/transportation-home, accessed on February 20, 2023.

given to the interaction of heavy vehicles used for the use with children, the elderly and the handicapped.

CWA Comments: The proposed use, including the haul route, could have an impact on vehicular and pedestrian traffic, particularly in relation to hazards reasonably expected in the district(s) impacted. The applicant proposes that this standard is met based on the conclusions of the traffic study that traffic at the intersection of M-52 and Pleasant Lake will not be significantly impacted, there is no significant pedestrian presence at the intersection of M-52 and Pleasant Lake, and the sight distances at the driveways meet AASHTO standards and provide sufficient visibility for drivers to make safe turning decisions.

The traffic study submitted by the applicant does not take into consideration the current afternoon bus stop for Manchester Community Schools at the intersection of M-52 and Pleasant Lake Road. In addition, it does not account for pedestrian or bicyclist activity along Pleasant Lake Road or M-52. Both roads have mail boxes on a single side of street, speed limits of fifty-five (55) miles per hour, have no sidewalks or safety paths, and are two-lane roads, with a few exceptions for small stretches on M-52. The trucks weights proposed range from a single-axle dump truck with a maximum gross weight of 27,000 pounds to quad axle semi-truck with a spread eight-wheeler with a maximum gross weight of 164,000 pounds.

(4) Whether the proposed use and associated activities would result in a hazard to children attending schools or other activities within the Township.

CWA Comments: As stated before, Manchester Community Schools has a bus stop at the intersection of M-52 and Pleasant Lake Road at 3:18 p.m., per the 2022-2023 Bus Route Schedule on the district's website. The bus stop time is during one of the waves of trucks proposed to visit the site. Five (5) other bus stops on that schedule occur on M-52 during the proposed waves of truck traffic. In addition, an estimated thirty-seven (37) trucks a day are anticipated to turn south on M-52, which would likely go by the Manchester Schools campus and the associated school bus traffic.

(5) Overall, the impact of the proposed use, including haul route(s), on children, older persons, and handicapped persons, with consideration to be given to the extent to which such persons shall be required to forego or alter their activities.

CWA Comments: The applicant has stated in their September 29, 2022 application that the proposed mine will not significantly impact children, older persons, and handicapped persons based on the lack of pedestrian activity at the intersection of M-52 and Pleasant Lake Road during the observation window of the traffic study submitted. As stated above, that study did not take into account the Manchester Community Schools bus stop for the current school year at M-52 and Pleasant Lake Road, nor did it observe pedestrian activity beyond the intersection itself.

At the public hearing, numerous residents, including senior citizens and a handicapped child, shared how the proposed use and increased truck traffic would cause them to alter their activities. During harvest season, nearby residents said how increased noise and dust from the farm operation on the site had caused them not to go outdoors.

d. Identifiable Health, Safety, and Welfare Interests

(1) If the property has been designated in the Master Plan as an appropriate site for heavy industrial use, this shall weigh in favor of the applicant under this provision, subject to consideration of the specific scope and impact of the operation and associated activities. Similarly, if the property has been designated in the Master Plan for non-industrial use, this shall weigh in favor of determining that the proposed Use would result in a very serious adverse consequence.

CWA Comments: The property is designated agricultural in the Master Plan and was not designated in the Master Plan as an appropriate site for heavy industrial use. In the Master Plan, industrial uses are limited to a node on the west side of M-52, immediately south of Bethel Church Road. Due to the limited public services and sensitive environmental resources, the Master Plan calls for future industrial uses to be of limited intensity.

As quoted in the future land use section of this review, the Master Plan has a specific section on mineral extraction. The Master Plan recognizes “one of its special resources is its mineral deposits, including sand and gravel” and “the extraction of these deposits can result in considerable environmental damage if not properly managed during operations, and properly reclaimed following the termination of extractive operations."[5]

(2) The impact of applicant's proposed use and associated activities on identifiable health, safety, and welfare interests in the Township.

CWA Comments: The applicant, in their application dated September 2022, states that the proposed operation will comply with all federal, state, and local regulations including the Sharon Township Mineral Extraction Ordinance, which requires an annual permit. The applicant further asserts that gravel mining operations in Sharon Township, as well as Washtenaw County and Michigan, have not resulted in very serious consequences to health, safety and welfare.

While other extraction operations are active in the Township, none are of the proposed scale in terms of truck traffic, acreage and volume of aggregate to be extracted on an annual basis. Also, the proposed operation is to replace two (2) active Stoneco mining sites in Washtenaw County and is assumed to be more intense than those two sites. Without a comparison to a comparable operation in terms of intensity, it is difficult to conclude that there will no health, safety and welfare impacts.

(3) The impact of the proposed use, including haul route(s), upon surrounding property in terms of noise, dust, fumes, smoke, air, water, odor, light, and/or vibration. In determining whether a proposed use amounts to a very serious consequence, the standards for the stated impacts contained within the Township's regulatory ordinance, as the same may be amended, will be considered, along with any one or a combination of components proposed for the use that have unique qualities relating to these impacts (such as crusher noise and vibration).

CWA Comments: The applicant has submitted a study in terms of dust, noise, and fumes. As discussed above, if the samples were taken in similar or more extreme operations or traffic situations at the Stoneco Zeeb Road plant than to what is proposed at the subject site, then the conclusions of no very serious consequences could be accepted.

In the Appendix G of the Special Land Use application dated September 2022, the applicant submitted a Vibration

[5] Sharon Township Master Plan, Adopted on October 1, 2020, page 37.

Discussion regarding the affect of a proposed expansion of Stoneco's Burnmeister Sand and Gravel on a nearby historic church, Bethel United Church of Christ. The report stated that the data indicated that the vibration from everyday traffic was equal to or greater than the expected vibration level from the Burnmeister Sand and Gravel mine to the Bethel United Church of Christ. As with the dust, noise and fumes study, the applicant did not provide a comparison of the level of traffic, equipment used, and intensity of the Burnmeister Sand and Gravel mine as compared to the proposed operations of the site. The Burnmeister site is one of the two operations that this proposed mine is slated to replace. The Vibration Discussion in and of itself does not provide enough information to evaluate possible consequences.

(4) The extent of impact of the proposed use, including haul route(s), on economic development and on the character and features that defines the community, or on development in other units of government that will be impacted by the use, including haul route(s).

CWA Comments: Sharon Township's economic base is agriculture. The extraction operation is proposed on prime agricultural soils and bordering other large farm operations. The proposed operation will replace a large farm operation and could threaten the viability of adjacent farms.

The properties abutting the subject site to the east, on either side of Pleasant Lake Road, are in agricultural use and owned by the same property owner. The increased truck traffic could affect this ability of this farm operation to move equipment across Pleasant Lake Road. Agricultural operations tend to locate on streets with little traffic, so equipment can easily be moved between fields. The increased truck traffic could detract from the economic viability of agricultural land along the proposed haul route.

In addition, the Township has a burgeoning cluster of businesses, many home-based, that rely on access to quiet natural spaces. A retreat center was established in the northern portion of the Township and has now changed ownership. During the public hearing, two (2) residents shared that their home-based businesses offering pain management or counseling services relied on the quiet, natural surroundings as part of their services.

The proposed use and haul route would impact the character and features of Sharon Township, due to the proposed volume of truck traffic. It is unlikely that the present or planned uses along the haul route would generate on average 150-175 trucks daily, or at peak hour a truck every two to three (2-3) minutes. While the intersection of M-52 and Pleasant Lake Road would operate at an acceptable capacity, the volume of truck traffic will impact the character of the area along the haul route, which is primarily agricultural area with open fields.

The anticipated truck traffic could affect the character and features of municipalities to the north and south of Sharon Township along M-52. A daily average of one hundred and twelve (112) trucks are estimated to turn north onto M-52, passing through Sylvan Township to access Interstate 96. That portion of Sylvan Township is similar in character to the rural atmosphere in Sharon Township, except for the Chrysler Chelsea Proving Grounds. If trucks proceeded north on M-52 to access gravel operations north of the City of Chelsea, the trucks would go through that municipality's downtown, affecting the character and walkability of that area.

An estimated thirty-seven (37) trucks a day are anticipated to turn south on M-52 and would then traverse through downtown Manchester. The increased truck traffic could affect the character and walkability of that downtown area, as well.

(5) The impacts of the proposed use on the planning, functioning and spirit of the community, factoring into such consideration whether the proposed use would be likely to render the applicable regulations in the zoning ordinance on other properties in the area unreasonable. This review shall analyze whether the heavy industrial nature of the proposed use would undermine reciprocity of advantage by creating impacts and character that would raise a reasonable question whether residential zoning restrictions on area property would represent arbitrary limitations on the use and enjoyment of such area property.

<u>CWA Comments</u>: In planning and zoning, the Township has strived to preserve agriculture through Zoning Ordinance changes to allow on-farm revenue producing activities, maintenance the large acreage lot minimums to qualify for state and federal preservation programs and specific goals, objectives and policies in the Master Plan regarding farmland preservation.

The Master Plan lays out four farmland preservation areas in an overlay, based on criteria cited in the Master Plan section of this review. None of the current mining operations in Sharon Township are in the farmland preservation area overlay. One property with an extraction operation borders the farmland preservation area in the northeast corner of the Township.

The proposed use and truck traffic on the haul route would negatively impact the viability of the preservation area in the southeastern part of the Township in the following ways:

- 168.99 acres of area in the Farmland Preservation Area would be converted to an extraction operation with mining in Cell 2. 19024 Pleasant Lake Road and 17020 Pleasant Lake Road are mostly prime agricultural soils. Once mined, the agricultural value of the land cannot be restored to its present state.
- The reclamation plan cites that agricultural and conversation uses could be facilitated by the design. However, we find it doubtful that the layout of the site proposed, and the previous extraction activity would be attractive to an agricultural use. A conversion of the property to a conservation use is more likely. While not as detrimental to agricultural preservation as housing, the proposed reclamation plan would prevent restoration of the agriculture on the subject site.

(6) The operation of the proposed use, including the haul route(s), shall be evaluated in light of the proposed location and height of buildings or structures and location, nature and height of stockpiles, walls, berms, fences and landscaping, and all other proposed aspects of the overall use, including whether such improvements would interfere with or discourage the appropriate development and use of adjacent land and buildings.

<u>CWA Comments</u>: Except for the residences proposed to be occupied during the extraction operation, the site design meets all the dimensional setback, screening and buffering requirements in the Sharon Township Zoning Ordinance and in the Mineral Extraction Ordinance. If in compliance with those standards, it is reasonable to assume that the operation of the proposed use would not interfere with or discourage the appropriate development and use of adjacent land and buildings.

(7) The extent to which the proposed use, including haul route(s), would be likely to cause limitations on the use and enjoyment of other property in the vicinity (zoning district or districts, as impacted) in which it is to be located and along the haul route(s), and the extent to which the proposed use would likely be detrimental to existing and/or other permitted land uses and future redevelopment in the manner specified in the Master Plan.

CWA Comments: The proposed use and volume of truck traffic along the haul route would likely cause limitations on the use and enjoyment of other property in the vicinity and along the haul route. Due to flaws in the studies provided, it is not possible to assess the impact of dust, noise, diesel fumes, and vibration on properties in the vicinity. At the public hearing, dozens of residents expressed that the noise, dust and traffic generated by the proposed use would affect their use and enjoyment of their property. Many shared how during harvest on the subject site created noise and dust, which caused them to stay indoors rather than be outside on their property.

In addition, the proposed use could be detrimental to the existing, permitted and planned agricultural uses in the vicinity. The 150-175 trucks anticipated on average daily would likely affect the ability of farm operations along Pleasant Lake Road to move equipment between fields. In addition, the conversion of a working farm in a cluster of large acreage farm operations could affect the viability of agricultural areas in the vicinity and along the haul route, since farm operations tend to cluster and prefer access to low volume traffic roads.

Finally, the likely resource conservation use on the reclamation plan, while an allowed use under zoning, is not the intended primary use for this portion of the Township per the Township Master Plan. The majority of the subject site is planned for Agriculture and either borders or is within an Agricultural Preservation area. While the planned use for the site could be updated in the next Master Plan update, the viability of a resource conservation use is questionable without funding and stewardship. Ideally, an organization, be it a government entity or a non-profit, would be slated to take over the site after reclamation with dedicated funds to restore and maintain the site. Without proper stewardship and maintenance, a resource conservation use could become a blighting influence as well as an attractive nuisance.

(8) The extent to which the proposed use, including haul route(s), would likely be detrimental to the development of new land uses in the zoning districts impacted.

CWA Comments: The proposed use would likely be detrimental to new housing or home-based businesses in the zoning district, General Agriculture (A-1), which is the zoning district for the subject site and the surrounding properties. The intent of the A-1 Zoning District is to, "to encourage and provide opportunities for agriculture and retention of land in Sharon Township which is well suited for production of food and fiber, while also providing opportunities for comparatively low density rural residential lifestyles and development patterns that encourage the preservation of open spaces, agricultural and other natural resources, and the Township's rural character."

(9) The burden from the proposed use, including haul route(s), on the capacity of public services, infrastructure or facilities.

CWA Comments: We defer to the Township Engineer in evaluation of this standard.

(10) The burden of the proposed use, including haul route(s), on retail uses, arts and culture, equestrian activities, non-motorized vehicle travel or recreation, school use, parks, playgrounds, residential uses, and the likely creation of physical vulnerability or degradation of any uses and resources, including the creation of the need for added public or private expenditures for maintenance of buildings, structures, and infrastructure.

CWA Comments: The proposed use, including the haul route, could burden non-motorized vehicle travel or recreation, school uses, residential uses and the cultural and historic resources of the place of worship at the intersection of Pleasant Lake Road and M-52. While no bicyclists were observed during the applicant's traffic study, a resident, at the public hearing, shared that he uses M-52 for recreational cycling. In the Non-Motorized Chapter of the 2045 Long Range Plan for the Washtenaw Area Transportation Study in 2019, both Pleasant Lake Road west of M-52 and M-52 in Sharon Township are planned for non-motorized improvements, as primary and locally identified routes. Without the installation of safety paths, the increased truck traffic proposed could create a hazardous situation for recreational bicyclists and pedestrians along M-52 and Pleasant Lake Road.

The increased truck traffic would likely coincide with bus stops and routes for both Manchester Community Schools and the Chelsea School District, based on information from those school districts and their 2022-23 transportation schedules. Twenty-five (25) percent of the proposed truck traffic will go south on M-52 and pass the campus for the Manchester High School and Junior High School, the associated athletic fields, an elementary school and a pre-school.

The Sharon United Methodist Church is located on the northwest corner of M-52 and Pleasant Lake Road. This site is marked by a historical marker from the State of Michigan. The original church building is located within thirty (30) feet of the back of the curb of the intersection. During construction on M-52, parishioners and church staff have shared with the Township that the church building shook when large trucks went through the intersection and that the curb was damaged due to trucks riding over it. They have expressed concern that the proposed increased truck traffic will further degrade the curb at the intersection and damage the structural integrity of their place of worship.

(11) The extent to which the proposed use, including haul route(s), would cause diesel fumes, dust, truck noise or physical/mental health issues, including along the haul route(s).

<u>CWA Comments</u>: We defer to the Township Engineer in evaluation of this standard, but note that due to flaws in the studies provided, it may not possible to assess the impact of dust, noise, and diesel fumes on properties in the vicinity, based on the information provided.

(12) The nature and extent of impact from the proposed use, including haul route(s), in relation to environmental resources in the Township, including air, ground water, surface water, soils, and wetlands. In determining impacts, the cumulative effect upon all environmental resources shall be evaluated.

CWA Comments: We defer to the Township Engineer in evaluation of this standard.

e. Overall Public Interest in the Proposed Extraction

(1) The overall public interest in the extraction of the specific natural resources on the property both in absolute terms and in relative terms in relation to the need for resources and the adverse consequences likely to occur.

CWA Comments: The Township Board, at their June 22, 2022 Regular Meeting, passed a unanimous motion finding that the applicant has satisfied its demonstration of need only to the extent of a showing that there is a low-to-moderate need for the resources proposed to be mined on the subject site. In their application, the applicant has disputed this finding, asserting that the need for the resources on the subject site is high.

Using the Township's Board's finding of a low-to-moderate need, the adverse consequences likely to occur seem to outweigh the need in relative terms. However, the amount of land used for extraction, the amount of aggregate proposed to be removed on an annual basis and the truck traffic could be scaled back to be more in line with a low-to-moderate need. Also, actions could be taken to mitigate the impacts, such as the installation of safety paths on Pleasant Lake Road and/or M-52, scheduling of peak truck waves when school buses are not active on the haul route, accommodations for passage of farm equipment along Pleasant Lake Road, and the relocation of the Sharon United Methodist Church to another location on their property.

(2) Public interest in the proposed use, as measured against any inconsistencies with the interests of the public as are proposed to be protected in Master Plan for the area to be impacted by the use and haul route(s).

CWA Comments: To prepare the Township Master Plan and subsequent updates, a citizen survey was conducted in 1996, 2008 and 2019. In all three surveys, respondents when asked why they continued to live in Sharon Township selected the option of the "rural atmosphere/open character." The proposed level of truck traffic will affect the rural atmosphere of the Township in the vicinity of the proposed operation and along the proposed haul route.

While small portions of the site are planned for Resource Conservation, the majority is designated for the Agriculture Future Land Use category. In addition, two of the parcels within the subject site are in an Agricultural Preservation area delineated in the Master Plan. The proposed extraction operation would strip the site of prime agricultural soils. Neither the proposed use nor the likely resource conservation reclamation use is agricultural in nature. If the extraction operation is approved, any portion of the subject site should be removed from the Agricultural Preservation Area and the future land use changed to Resource Conservation in the next update of the Township Master Plan.

The Master Plan does recognize the importance of sand and gravel as important construction materials and the presence of deposits that are commercially recoverable in the Township. At the same time the Master Plan notes that extraction has the potential to cause harm to the environment, water quality, agricultural soils, woodlands, wildlife habitats, and roadways.

The interests of the public protected on the subject site and along the haul route by the Master Plan are the rural character, natural resources and farmland preservation. The proposed extraction operation will impact those categories, in some manner. The Planning Commission and Township Board will need to determine how those impacts are measured against the public interest of a low-to-moderate need. The impact of the proposed extraction operation on the Township Master Plan could be lessened if the two parcels in an Agricultural Preservation area (19024 and 17020 Pleasant Lake Road) were excluded from the mining activity and remained in agricultural use.

(3) Public interest in the proposed extraction, as measured against any inconsistencies with regard to physical, historic, and economic interests in relation to the use and haul route(s).

CWA Comments: The proposed extraction in relation to the use and the haul route could be inconsistent with physical, historic, and economic interests.

The proposed volume of truck traffic could pose physical dangers to pedestrians, school children, and bicyclists. The impact of the truck traffic could be lessened with the installation of safety paths on both sides of Pleasant Lake Road, between the site and M-52, and on both sides of M-52 within the borders of Sharon Township as well as a stipulation that peak waves of truck traffic should not occur when school bus routes are operating on Pleasant Lake Road or M-52. Since school bus routes change from school year to school year, the peak wave coordination could occur during the annual mineral license evaluation.

In terms of historic interests, the applicant noted in their application, dated September 2022, that two (2) marked locations on the subject site and five (5) marked locations within 1,000 feet of the site were listed on the 'HistWeb' of the Washtenaw County Historical Society. The historic barn and shed but not the silos are proposed to be preserved at 19024 Pleasant Lake. No buildings are shown at 17020 Pleasant Lake Road on the survey submitted by the applicant, where two unspecified historic structures were noted. The use of any of the buildings to be preserved on the subject site, including the historical structures, as part of the likely resource conservation use in the reclamation plan is unclear. If buildings are proposed to remain past the extraction operation, they could be incorporated in a thoughtful way as part of the reclamation plan, perhaps as a museum or learning center. The preservation of the historic structures and any preserved buildings would be better assured if a future steward and funding for their use and upkeep were identified.

In addition, the Sharon United Methodist Church, which is marked by a historical marker from the State of Michigan, may be vulnerable to damage from the vibration of the increased truck traffic. The relocation of the Sharon United Methodist Church to another location on their property and/or a decrease in the proposed truck volume could decrease the impact.

The proposed use and haul route could have a negative economic impact on farm operations and businesses dependent on access to quiet, natural environments in the vicinity and along the haul route. The increased truck traffic could affect the ability of farm operations to move equipment across and along Pleasant Lake Road. The noise, vibration, and fumes from increased truck traffic could prove to be a detriment to businesses that have located in Sharon Township due to the quiet, natural character of the area. A decrease in the amount of aggregate to be removed on an annual basis and associated truck traffic could decrease the impact.

(4) Public interest in the proposed extraction, as measured against any likely creation of valid environmental concerns, including without limitation impairment, pollution and/or destruction of the air, water, natural resources and/or public trust therein.

CWA Comments: We defer to the Township Engineer in evaluation of this standard.

(5) Public interest in the proposed extraction, as measured against public costs likely to be caused by the proposed use, including haul route(s), considering alternative supplies of natural resources.

CWA Comments: We defer to the Township Engineer in evaluation of this standard.

Items to be Addressed: *Planning Commission determination of "very serious consequences" based the Act 113 Standards of Review as listed in Section 5.12.D.3 of the Sharon Township Zoning Ordinance.*

RECOMMENDATIONS

The Planning Commission makes a recommendation to the Township Board on Special Land Use for Extraction of Natural Resources based on Determination of No Very Serious Consequences.

If the Planning Commission were to recommend approval of the special land use, we recommend that the following conditions:

1. Finalization of setback distance from the existing natural gas pipelines and easements.
2. Approval by the Washtenaw County Road Commission.
3. Conveyance of materials between Cell 2 and Cell 3 are underground and the apparatus is below grade from the interior edges of the required berms.
4. Confirmation of the accuracy of the traffic study by the Township Engineer.
5. The information provided in the narrative that the location of the mobile plant will be provided during the annual Mineral Extraction License review be added to the notes of the Mining Plans.
6. A note restricting the height of structures associated with the processing plant to not more than forty-five (45) feet.
7. A note specifying that unstripped land not occupied by woodlands or wetlands will be maintained as agricultural use is added to the Mining Plan sheets.
8. Additional fencing and gates are required to prevent residents of and visitors to the residences on-site from encountering dangerous situations posed by the extraction activity and associate physical attributes on site.
9. The occupancy of the residences on-site is limited by the applicant to the current residents.
10. Maintenance of the residences on-site are to be evaluated with the annual mineral license approval.
11. Testing of the water pressure and quality of the wells associated with those houses on-site be part of the annual mineral license approval.

Further, we recommend the following conditions be considered in order to mitigate impacts of the proposed use on properties the vicinity and along the proposed haul route:

1. A decrease in the amount of aggregate to be removed on an annual basis and associated truck traffic. The Planning Commission and Township Board would need to determine a level measured against a low-to-moderate need.
2. Safety paths installed along both sides of Pleasant Lake Road, between the site and M-52, and along both sides of M-52 within the borders of Sharon Township.
3. Accommodations for passage of farm equipment on Pleasant Lake Road along the haul route.
4. The relocation of the Sharon United Methodist Church to another location on their property.
5. 19024 Pleasant Lake Road and 17020 Pleasant Lake Road, due to their location in an Agricultural Preservation area designated by the Sharon Township Master Plan, are excluded from the mining activity and remain in agricultural use.
6. Peak waves of truck traffic do not occur when school bus routes are operating on Pleasant Lake Road or M-52.
7. Designation of an organization to be responsible for and maintain the likely resource conservation use and any structures on-site after reclamation.
8. Establishment of a fund to finance the stewardship of the likely resource conversation use and preserved buildings on the subject site after reclamation.

If the Planning Commission were to recommend denial of the special land use, the Commission should table this matter while a resolution of denial is drafted showing the "very serious consequences" based the Act 113 Standards of Review as listed in Section 5.12.D.3 of the Sharon Township Zoning Ordinance.

Respectfully submitted,

CARLISLE WORTMAN ASSOCIATES, INC.
John L. Enos, AICP
Vice President

CARLISLE/WORTMAN ASSOC.,INC
Megan Masson-Minock, AICP
Principal

ENGINEERS ◆ SURVEYORS ◆ PLANNERS ◆ ARCHITECTS

March 6, 2023

Pat Kelly, Chair
Planning Commission
Sharon Township
18010 Pleasant Lake Road
Manchester, MI 48158

RE: Stoneco Pleasant Lake Road Site
Application for Special Land Use Approval

Dear Ms. Kelly:

Per your request, we have performed a more detailed review of the Stoneco submittal dated December 13, 2022. This information was reviewed against the Township zoning ordinance, the general mineral extraction ordinance, and the application form. Our comments and/or questions are as follows:

Noise, Dust and Fumes

The conclusions of the Noise, Dust & Fumes study may reflect conditions at the test sites, however since each site is unique the Pleasant Lake Road site should be tested prior to and after it becomes operational to ensure that the requirements and standards are met for this specific site. Baseline testing should show levels prior to the site being operational.

We would recommend repeating the tests outlined in this section once per year after the site is operational for the first five years just to verify requirements continue to be met. Once a favorable track record is established the frequency of testing can be reevaluated. If complaints arise between testing periods mitigating measures may be needed. The test for exhaust fumes should be done when there is a large number of trucks waiting to be loaded. Dust control should be an ongoing process during daily plant operations, especially at the plant entrances.

See the Traffic Impact Analysis section for more comments on noise and vibration due to the proposed truck trip generation.

Hydrogeological Study

While the sand and gravel mining will extend up to 50 feet below the water table, we understand that no dewatering is proposed. Process water will be pumped from the northern lake and returned to that pit. Mining is expected to be performed using a combination of excavator, dragline, and/or dredge.

Residences with domestic water wells are located in the general vicinity of the site. In addition, wetlands are located on and near the site. NRM describes some of these wetlands as groundwater-controlled and some as surface water- controlled. A county drain is located at the northwest corner of the site. These features have the potential to be impacted by the proposed mining operations.

Several monitoring wells and piezometers were installed at the site. NRM's groundwater level measurements determined a general flow from east to west and a season variation of over 2 feet. Groundwater monitoring will continue to be performed during mining operations, as required.

NRM determined the "water budget" for the operation. As dewatering is not proposed as a part of mining operations, the hydrogeological report and modeling consider precipitation and evaporation as the sole water inputs and outputs of the lakes.

In their 3D groundwater modeling, NRM uses the groundwater modeling software "MODFLOW" to approximate the groundwater potentiometric surface. Input parameters and boundary conditions are based on regional geologic map units and surface water bodies. The results were first compared and calibrated to the static water levels listed in logs for surrounding water wells, representing existing conditions. The model was then modified to reflect the creation of the proposed lakes and the results compared to the existing conditions. Differences between the proposed and existing conditions ranged between an increase in groundwater elevation of 0.14 feet to a decrease of 0.06 feet, due to the effect of precipitation recharge and evaporation.

In the hydrogeological report, NRM describes slug tests in on-site wells used to estimate the hydraulic conductivity of the surrounding subsurface strata, and then determines the effect on the nearby groundwater levels due to the net evaporative loss of water from the lakes using simulated well drawdown methods. The results of the analyses were shown as evaporative drawdown for each lake, varying from 0.06 to 0.20 feet at the property boundary. Calculated drawdown values were also given for wetlands (0.07 to 0.14 feet) and the nearest domestic wells (0.02 to 0.11 feet).

NRM concludes that the potential changes to the groundwater level due to mining operations will have no impact on wetlands, waterways, or domestic water supply wells since the estimated drawdown will be less than the seasonal fluctuation. To verify this, we would request the following clarifications and additional information from NRM and Stoneco:

1. Wetlands dependent on perched surface water are located near the proposed excavations. How will excavation adjacent to the surface water-controlled wetlands impact the hydrology of those wetlands?

2. How will the process/wash water be contained and collected after use before being returned to the north lake? Is there a potential for loss of wash water? How would this loss affect groundwater levels?

3. How much volume will be utilized in the process/wash water system at any one time? Would the potential storage within the system affect the drawdown estimates?

4. The act of mining will involve removal of saturated sand and gravel from the pits, which could be characterized as a temporary drawdown. How does this affect the groundwater response, considering the proposed rate of mining?

5. The distance-drawdown analysis appears to consider each lake separately. How do the effects of all three lakes superimpose upon each other?

6. We recommend the testing on the adjacent residential water wells, for both water elevation and water quality, be completed on a routine basis. The Township ordinance requires the water quality to be tested annually. We would recommend the water elevation in the residential wells be monitored on every 1-2 years for the first half of the mine life. If there are no changes during

the first half of the plant operation, the interval could be extended. It will be important to develop a good baseline for early potential problem detection.

Site Design Elements
The plans indicate the processing equipment will be located on the north side of Pleasant Lake Road. It is our understanding that material from Cell 2 on the south side of Pleasant Lake will be moved to the processing equipment by a series of conveyors. The conveyor system is proposed to be under Pleasant Lake road via a proposed culvert. This would require approval of the Washtenaw County Road Commission.

Additional details are needed for the berm grading around the perimeter of the site. The contours shown are not labeled for elevation and the proposed contours should be accurately tied off to the corresponding existing contour. This is needed to determine exactly where offsite drainage may be impeded by the berms and how water will flow around the berms. Blocking of upstream drainage is not permitted. This applies to both the operational plans and the reclamation plan. The additional grading detail can be provided at the time of site plan review.

The reclamation plan should indicate how the berm material will be redistributed on the site. Also, please clarify how the reduced slopes (between the mining slopes and the reclaimed slopes) within the lakes will be achieved. Will fill material need to be brought into the site?

Detailed road plans will be required with future site plan submittals. Cross sections will be needed. Turn lanes, driveways, sight distance, accel/decel tapers, etc. should all be included on the site plan drawings.

Traffic Impact Analysis
The traffic study demonstrates a significant increase in truck traffic for the areas surrounding the site. The applicant states that up to 175 trucks trips will be generated on a daily basis, with some peak days of approximately 330 truck trips per day. This is a large increase that will increase noise and potentially vibration along the truck haul routes. The study indicates that some movements at the M-52/Pleasant Lake intersection will be reduced from Level of Service B to LOS C. This is approximately a 10-15 second increase in delay. Normally this decrease is not problematic but in this instance the increased traffic poses impacts other than simply intersection delays.

The applicant should demonstrate that the church located at the corner of M-52 and Pleasant Lake Road will not be negatively affected by geometric changes that will be required at the intersection to accommodate increased truck turning movements. They should also show that vibration from the truck traffic will not negatively affect church or other properties along the haul route. Truck noise should also be analyzed along the haul route, particularly along Pleasant Lake Road, and prohibitions on engine braking should also be put in place to reduce operational sound levels.

Similar to the noise, dust and fumes study, studies of vibration done at other sites cannot be directly correlated with the Pleasant Lake site. Differences in soil conditions, truck loading, equipment types, etc. make comparisons difficult. This site should tested on it's own merits and conditions prior to the site becoming operational. Baseline conditions and continued monitoring should be performed to ensure that Township requirements are being met.

Approval of the traffic study will be required from both MDOT and the Washtenaw County Road Commission.

We are currently reviewing threatened and endangered species on the site and will be working with EGLE to complete that analysis.

If you have any questions or require anything further, please feel free to contact our office.

Sincerely,

Philip A. Westmoreland, P.E.
Principal
SPICER GROUP, INC.
125 Helle Drive, Suite 2
Dundee, MI 48131
Phone: (517) 375-9449
Mailto: philaw@spicergroup.com

CC: SGI File

MEMORANDUM REPORT

CONSIDERING FARMLAND PRESERVATION AS PART OF THE VERY SERIOUS CONSEQUENCES ANALYSIS

TO: **SHARON TOWNSHIP**

FROM: **GERALD FISHER, special Township counsel**

DATE: **FEBRUARY 25, 2023**

FOR USE IN THE REVIEW OF MINING APPLICATIONS FOR APPROVAL OF A SPECIAL LAND USE FOR MINING UNDER ZONING ORDINANCE SECTION 5.12

This Memo is to confirm for the Township that there is legal authorization to consider farmland preservation as part of the review of "very serious consequences."

This authorization arises under the following:

- Priority given to farmland preservation in Township zoning and planning
- Michigan's 1963 Constitution, Article 4, § 52
- Michigan Zoning Enabling Act, in MCL 125.3201, 125.3203, and 125.3504

MICHIGAN CONSTITUTION

Michigan Constitution, Art 4, **§ 52** directs the legislature to protect natural resources. There are two sides to this direction:

Article IV § 52. Natural resources; conservation, pollution, impairment, destruction.

> The **conservation** and **development** of the natural resources of the state are hereby declared to be of paramount public concern in the interest of the health, safety and general welfare of the people. The legislature shall provide for the **protection** of the air, water and other

> **natural resources** of the state from pollution, impairment and destruction.

An applicant will claim that this provision is favorable to it because it creates a special status for the *development* of natural resources.

However, because needed *farmland* is an important natural resource, this section of the Michigan Constitution also creates a special status for the *conservation of farmland*.

MICHIGAN ZONING ENABLING ACT

For farmland conservation, Michigan state law, in the following sections of the Michigan Zoning Enabling Act, MCL 125.3201, 125.3203, and MCL 125.3504 (governing special land uses), calls for zoning recognizing **natural resource preservation,** including for the production of **food and fiber**. USDA refers to important farmland being needed to provide for the nation's food and fiber. This law is especially important where farmland can be shown to be important.

FINAL ANALYSIS

In the final analysis of a mining application, where important farmland is at stake, there is a **dual natural resource consideration**, with two sections effectively conflicting with one another. Both types of natural resources are <u>recognized for special treatment, both protected by the Michigan constitution and the Michigan Zoning Enabling Act</u>.

Since the Michigan courts have never stated a basis for favoring one of these protections over the other, if the Township is considering the grant of *some* mining authorization, there is a reasonable basis for the Township to establish a *compromise,* allowing the preservation of important farmland on a portion of the property (at least for a minimum number of years), and allowing mining on another portion.

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Stoneco of Michigan Manchester Pit Special Land Use Approval for Extraction of Natural Resources

Response to Comments Received from the Planning Commission

March 27, 2023

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Sharon Township
18010 Pleasant Lake Rd.
Manchester, Michigan 48158

March 27, 2023

Attention: Township Clerk – Ms. Michelle Mrocko

Reference: Stoneco of Michigan Manchester Pit
Special Land Use Approval for Extraction of Natural Resources
Response to Comments Received from the Planning Commission

Dear Ms. Mrocko,

On behalf of Stoneco of Michigan (Stoneco), has prepared a response to the comments and concerns we received from the Sharon Township Planning Commission regarding Stoneco's Application for Special Land Use (SLU) Approval for Extraction of Natural Resources dated September 29, 2022. These correspondences were received after the public hearing was held on February 15, 2023.

The response addresses the correspondence Stoneco received in the following documents:

1. March 6, 2023, Review Letter from Spicer Group
2. March 6, 2023, Review Letter from Carlisle Wortman Associates, Inc.
3. Sharon Preservation Society documents presented at Public Hearing dated February 15, 2023
4. Public Comment contained in the DRAFT Sharon Township Planning Commission Regular Meeting Minutes dated February 15, 2023

This letter was prepared to address the comments that are contained in each of the four above-referenced documents under each of the corresponding headings below. Additionally, revisions were make to Site Plan Sheets 3, 3A and 3B. Each heading is listed in **black bold** text. The specific subject of the comments Stoneco Received in the corresponding documents is listed in ***black Italic text***. Stoneco's responses are listed in red text. We have also provided supporting documentation to our comments and have included as Attachments A through D.

A. Attachment A contains supporting documents relative to the residential market values dated September 6, 2022 by Bratcher & Associates.
B. Attachment B contains A 2022 study of the Gains Township property on Kalamazoo Avenue dated December 2020 prepared by NRM in support of concerns and questions regarding potential surface and groundwater impacts at the property owned by Doretta Anema.
C. Attachment C contains an aerial photograph and photographs taken at the ground level of the pond located at the Doretta Anema property in Gaines Township, Kalamazoo Avenue.
D. Attachment D contains correspondence dated June 14, 2019, from Ms. Paula Hitzler, manager of the Michigan State University Horse Teaching and Research Center.
E. Attachment E contains supporting information with respect to respirable crystalline silica sampling

March 6, 2023, Review Letter from Spicer Group

Stoneco has provided the responses set forth below in response to the Spicer Group, Inc (Spicer) review letter dated March 6, 2023. Spicer's review comments are provided in black and our responses to these comments and questions are provided in red.

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Noise, Dust, and Fumes

The conclusions of the Noise, Dust & Fumes study may reflect conditions at the test sites, however, since each site is unique the Pleasant Lake Road site should be tested prior to and after it becomes operational to ensure that the requirements and standards are met for this specific site. Baseline testing should show levels prior to the site is operational.

We would recommend repeating the tests outlined in this section once per year after the site is operational for the first five years just to verify requirements continue to be met. Once a favorable track record has been established the frequency of testing can be re-evaluated. If complaints arise between testing periods mitigating measures may be needed. The test for exhaust fumes should be done when there is a large number of trucks waiting to be loaded. Dust control should be an ongoing process during daily plant operations, especially at the plant entrances.

We agree that each site is unique; however, we have presented factual information and results from a location that will be operated in a similar manner, and therefore, no impacts from dust, noise, or fumes are expected. These studies have been presented in the application documents. Our current track record with respect to air permit compliance at all of our sand and gravel facilities is exemplary. Stoneco has had no violations with respect to fugitive dust compliance. Additionally, the Mine Safety & Health Administration (MSHA) will conduct sampling for respirable dust and silica on the site and we strive to exceed those standards. Baseline sampling will not be required. The EGLE air quality division permit and fugitive dust plan will be required as part of the operations that require the implementation of engineering and administrative controls to limit exposure of fugitive dust. There is no practical reason to conduct additional sampling. Stoneco will meet the Sharon Township standard for noise and therefore baseline testing is irrelevant. All equipment and vehicles will maintain the required emission equipment to ensure compliance with the applicable standards.

Hydrogeological Study

NRM concludes that the potential changes to the groundwater level due to mining operations will have no impact on wetlands, waterways, or domestic water supply wells since the estimated drawdown will be less than the seasonal fluctuation. To verify this, we would request the following clarifications and additional information from NRM and Stoneco:

1. Wetlands dependent on perched surface water are located near the proposed excavations. How will excavation adjacent to the surface water-controlled wetlands impact the hydrology of those wetlands?

There will be no impacts on the hydrology of the wetlands based on the following:

- The excavation is limited to no closer than 50 feet of the delineated wetland boundaries and the County Drain. Therefore, no excavation will impact the ground surface in or adjacent to the wetlands or streams.
- All surface water within the perimeter of the proposed excavation areas will continue to drain in those directions with the exception of locations where earthen berms will be constructed, which is limited to the southern portion of Wetland 4 and the northern portion of Wetland 5. Surface water flow near the earthen berms will be facilitated through the installation of underdrains at various locations perpendicular to the berms in order to avoid ponding of water at the toe of the berms or on adjoining property. If these installations are necessary, they will be installed in accordance with EGLE and County SESC requirements. More importantly, piezometers have been installed within the wetland boundaries and are currently being monitored to document hydrologic conditions within the wetlands, which are provided in the application documents.
- The perched wetlands are located above the groundwater table elevation. This is supported by the piezometer readings collected since August 2022. The perched wetlands do not always contain open water. Additionally, the types of dominant vegetation are indicative of species that are not typically supported by permanent inundation.

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The dominant vegetative species were facultative wet (FACW) reed canary grass that does not normally require permanent saturation or inundation to be present and has been documented to be a drought-resistant invasive species. This data is supporting evidence of seasonal variability in wetland hydrology and is documented in the wetland delineation report and piezometer monitoring information presented in the application documents.

- The hydrology in the wetlands is supported by direct precipitation which likely recharges the depressional areas and results in periods of inundation during seasonal and or annual above-normal precipitation events. Any surface water that would be collected in these depressions likely discharges slowly through seepage into the sandy muck soils during drought or dry seasons and into the dry sand and gravel beneath. This is demonstrated in historical aerial photography since at least 1937 as provided in the EIA, and within the soil types described in the wetland delineation report and soil types described in the USDA soil survey.
- The surrounding soils in each of the perched wetland areas are dominated by Oshtemo and Fox sandy loams and are characterized as high permeability soils and not likely to contribute to surface water run-off due to their low to medium run-off and non-hydric soil class as described in the soil survey referenced and provided in the EIA.
- The northwest corner of the property intersects with the Comstock County Drain and a secondary drain (Drain A) that flows into the Comstock Drain on the property (Figure 3 of the EIA). The Comstock Drain is under the Washtenaw County Drain Commission's jurisdiction. No disturbance or improvements to the Comstock Drain or the unnamed tributary to the Comstock Drain are proposed. Therefore, there will be no impacts to any streams on or within 1,000 feet of the subject property or haul routes as provided in our analyses presented in the application documents.

2. How will the process/wash water be contained and collected after use before being returned to the north lake? Is there a potential for loss of wash water? How would this loss affect groundwater levels?

The majority of the water used in processing will be collected in the equipment reservoirs and drained by discharge pipe to the sediment-holding ponds. Any water retained in the material stockpiles will drain into the soils beneath the piles and back into the groundwater zone through infiltration. A small percentage of wash water will be lost through normal evaporation during the growing season or an insignificant volume that is retained in the products loaded and shipped from the property. This potential loss is due to evaporation or inherent moisture in the processed material that does not drain back into the groundwater through infiltration. This loss is insignificant and will not result in any impacts or contribute to any predicted drawdown. The hydrogeologic model does not predict any effects on groundwater levels. In fact, the model predicts an increase in the total volume of flow, mainly due to precipitation reaching the groundwater system directly through the lake surface water levels, and will therefore, negate any perceived impacts from any "loss" of water from evaporation or inherent moisture in the material. This is supported by the hydrogeological analysis and groundwater model submitted with the application documents. Our practical experience confirms the model predicts.

3. How much volume will be utilized in the process/wash water system at any one time? Would the potential storage within the system affect the drawdown estimates?

The expected volume to be used in the processing of the material is 6,000-gpm. Storage within the aquifer will not be impacted. This is because the water used for processing will be discharged to a sedimentation pond where most of that water will then infiltrate into the subsurface and provide a groundwater recharge source for the shallow glacial sediments in addition to regional groundwater flow into the lake system. A small fraction of that water will evaporate. Evaporative loss is offset by annual precipitation. Thus, all the infiltrating water will recharge the shallow aquifer where the only loss to the aquifer is the fraction of water that evaporates. This loss has been included in the water budget considerations and

4. The act of mining will involve removal of saturated sand and gravel from the pits, which could be characterized as a temporary drawdown. How does this affect the groundwater response, considering the proposed rate of mining?

Removal of the sand and gravel will have no measurable impact on the normal fluctuations in the groundwater table and we

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disagree that this will result in a "temporary drawdown". This is because the volume of sand and gravel extracted is negligible compared with the volume of groundwater available for recharge. The slug testing completed at the monitoring wells showed that the sand and gravel aquifer has a high hydraulic conductivity and the rate of mining is conducted over several decades, the groundwater inflow is instantaneous and any drawdown from the removal of material would not be realized. Consequently, it is not expected to be detected during monthly monitoring that will be conducted on the site during operation as can be shown from similar sand and gravel operations where Stoneco conducts groundwater monitoring. This is demonstrated in the groundwater modeling and water budgets submitted with the application documents. Using the expected removal rates of the minerals at the proposed sand and gravel operation along with the groundwater aquifer characteristics in the groundwater model and hydrogeological analysis report, it can be shown that:

1) The excavation is recharged instantaneously through groundwater inflow as the material is being excavated. This is because the volume of groundwater entering the excavation from the normal horizontal flow of the groundwater (determined to average 160 ft/day from on-site testing) will instantaneously be 5 times greater than the projected volume of material removed. This is true for all stages of the project, from the creation of the 2 acres production pond to the final lake boundaries and can be calculated from the information provided in the application.

2) Additionally, over 80% of the water removed from the material immediately flows back into the excavation as the sand and gravel are removed. The remaining water contained in the saturated material infiltrates out of the stockpiles next to the excavation and back into the groundwater table through surface water flow and subsurface recharge.

5. The distance-drawdown analysis appears to consider each lake separately. How do the effects of all three lakes superimpose upon each other.

The distance-drawdown analysis was conducted in accordance with EGLE guidelines which require treating each lake separately. The Hydrogeological model incorporates all three lakes to their fullest extent. This information was presented in the application documents.

6. We recommend the testing on the adjacent residential water wells, for both water elevation and water quality, be completed on a routine basis. The Township ordinance requires the water quality to be tested annually. We would recommend the water elevation in the residential wells be monitored on every 1-2 years for the first half of the mine life. If there are no changes during the first half of the plant operation, the interval could be extended. It will be important to develop a good baseline for early potential problem detection.

The groundwater hydrogeological analysis and groundwater monitoring reports conclude that neither water quality or quantity will be impacted by the proposed operation. These have been presented in the application documents and include baseline groundwater quality information. Furthermore, Stoneco has and will continue to test the water quality from the monitoring wells that have been installed in the sand and gravel aquifer on the proposed site to provide additional baseline information. Water elevations will be collected monthly and be reported to EGLE and the Township in the annual reports. There has been no evidence that the proposed operation would support any negative impacts to domestic well quality or quantity. NRM does not recommend testing domestic wells for a number of reasons, mainly because each domestic well is uniquely different and Stoneco has no control over how they are installed, operated and maintained. For example, some domestic wells had purification or treatment systems connected to them that require regular maintenance and Stoneco has no control over whether this is conducted. Baseline water quality sampling from domestic wells will not clearly identify all performance standards or well deficiencies in each individual water treatment system.

Several Stoneco facilities have been the subject of sampling water quality from on-site monitoring wells (including the Zeeb Road facility) at similar sand and gravel locations to the proposed project. The sampling has been conducted for decades and has not identified any impacts on groundwater quality or quantity from any of these locations. The number of monitoring wells installed on the Stoneco property, as required by the Township Ordinances is sufficient to detect any

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changes in water quality or quantity at the property boundaries in all directions from the site and this information has and will continue to be collected.

Site Design Elements

Additional details are needed for the berm grading around the perimeter of the site. The contours shown are not labeled for elevation and the proposed contours should be accurately tied off to the corresponding existing contour. This is needed to determine exactly where offsite drainage may be impeded by the berms and how water will flow around the berms. Blocking of upstream drainage is not permitted. This applies to both the operational plans and the reclamation plan. The additional grading detail can be provided at the time of site plan review.

We can provide this at the time of site plan review. As stated above, any ponding water due to site grading will be addressed with the Soil Erosion and Sedimentation Control Plan.

The reclamation plan should indicate how the berm material will be redistributed on the site. Also, please clarify how the reduced slopes (between the mining slopes and the reclaimed slopes) within the lakes will be achieved. Will fill material need to be brought into the site?

The berms will be regraded back into the reclamation slopes and the final reclamation slopes will be achieved through the use of the berm material and the finer material that is recovered during processing.

Detailed road plans will be required with future site plan submittals. Cross-sections will be needed. Turn lanes, driveways, sight distance, accel/decel tapers, etc. should all be included on the site plan drawings.

We will submit this information if required by the Washtenaw County Road Commission.

Traffic Impact Analysis

The applicant should demonstrate that the church located at the corner of M-52 and Pleasant Lake Road will not be negatively affected by geometric changes that will be required at the intersection to accommodate increased truck turning movements. They should also show that vibration from the truck traffic will not negatively affect church or other properties along the haul route. Truck noise should also be analyzed along the haul route, particularly along Pleasant Lake Road, and prohibitions on engine braking should also be put in place to reduce operational sound levels.

Traffic Impact Study and Vibration Discussion documented three important items: 1) The level of service grade is currently a "B" at the intersection of M-52 and Pleasant Lake Road and the proposed truck traffic will not change that rating; 2) No improvements would be needed at the intersection of the Pleasant Lake Road and M-52 based on any expected increase in traffic related to the proposed operation; and 3) the Vibrations monitored at a mining site on gravel and paved roads did not detect vibrations on the order of magnitude where it would be expected that any structural damage would occur at distances of 10 to 64-feet from the roadways. These professional opinions provided by qualified professionals are presented in the application documents. Based on this information, Stoneco has provided evidence that no negative impacts to the church at the intersection of M-52 and Pleasant Lake Road or any structure along the haul route is expected and no one has presented any factual evidence in the public records for our review that would suggest otherwise. We are unaware of any complaints or documentation regarding potential impacts to the church from the current traffic.

In addition, we are unaware of any geometric changes that will be required at the intersection of M-52 and Pleasant Lake Road. As discussed in previous responses, it will be a decision by the Michigan Department of Transportation and the Washtenaw County Road Commission to require any geometric changes to M-52 intersection. If these agencies require any

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changes, we can evaluate any potential impacts at that time; however, this cannot be done until we receive the SLU and Mineral Extraction License from Sharon Township. Stoneco would fully support Sharon Township developing an engine brake ordinance or resolution. We trust this would be applicable to all areas of the Township.

We forwarded the traffic study comments to our Engineer. Based on their review of the comments, our response is as follows:

A vast majority of traffic impact studies rely on data from a single day, typically taken on a Tuesday, Wednesday, or Thursday during a typical week which is the case for this study. The daily traffic on our count fell in line with the other historical AADTs on M-52 and Pleasant Lake Road, therefore being representative of typical conditions. Given the existing conditions are at a level of service B, the intersection has plenty of available capacity, and the site will continue to have an insignificant impact on the average delays. Furthermore, forecasted delays where the level of service changed from "B" to "C" insignificantly changed by less than 1 second for the average delay.

Additionally, they did not analyze any other intersections besides the site driveway and Pleasant Lake/M-52, however from their experience, the delays at such intersections would not be significantly impacted given the traffic that the site is expected to generate, which our expert described as "limited." Trucks are allowed on M-52, and the insignificant impacts to peak delays at the intersection are included in the study, which remains at an acceptable level of service.

Similar to the noise, dust, and fumes study, studies of vibration done at other sites cannot be directly correlated with the Pleasant Lake site. Differences in soil conditions, truck loading, equipment types, etc. make comparisons difficult. This site should be tested on its own merits and conditions prior to the site becoming operational. Baseline conditions and continued monitoring should be performed to ensure that Township requirements are being met.

There has been no evidence submitted by anyone that would suggest vibrations from any truck traffic would affect any structures along the haul route.

March 6, 2023, Review Letter from Carlisle Wortman Associates, Inc

Stoneco has provided the responses set forth below in response to the Carlisle Wortman (CW) review letter dated March 6, 2023. The CW comments or items to be addressed are presented in black text and referenced by the corresponding page numbers where each comment/item/statement/recommendation can be found in the CW letter. Our responses are provided in red text.

Project and Site Description
Finalization of setback distance from the existing natural gas pipelines and easements. (Page 3)

This is being reviewed by the petroleum company engineers and as soon as we get their feedback, will incorporate any changes required in the site plans.

Traffic & Truck Waiting Areas
Confirmation of the accuracy of the traffic study by the Township Engineer (Page 12)

This review has been completed and Stoneco has provided a response to the Township Engineer's comments.

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Compliance with Zoning and Mineral Licensing Design Standards
We recommend that a note restricting the height of structures associated with the processing plant to not more than forty-five (45) feet be added to the Mining Plan sheet as a condition if the Township chooses to grant the special land use permit. (Page 14)

Stoneco will make that change to the Mining Plan.

The location of construction sand and gravel extraction areas on Cell 2 and Cell 3, and the mobile equipment parking need to be moved, at a minimum. This required setback will be evaluated with the annual mineral license approval and does not need to be revised for consideration of the Special Land Use. (Page 14)

This comment is specific to the residences that will remain on-site and be occupied by the previous owner. Stoneco will address these setbacks during the mineral extraction license approval process.

However, we strongly recommend the following conditions of any special land use approval to protect the health, safety, and welfare of the residents on the subject site: (Page 14)

1. Additional fencing and gates are required to prevent residents of and visitors to the residences on-site from encountering dangerous situations posed by the extraction activity and associate physical attributes on site.

   Stoneco will add a welded-wire fence to the site plan around the perimeter of the residences.

2. The occupancy of the on-site residences could be limited by the applicant to the current residents.

   There is no purpose for restricting who lives in the residences. This will not make a difference in the use of the site.

3. If the occupancy is not limited to the current residents, conditions of approval for the Special Land Use could include maintenance of the on-site residences to be evaluated with the annual mineral license approval.

   Stoneco will maintain the property in accordance with the current Zoning Ordinance requirements for agricultural residences in the Township.

4. Testing of the water pressure and quality of the wells associated with those houses on-site be part of the annual mineral license approval.

   Stoneco already conducts water quality testing and water elevation monitoring of these wells and will continue to do so.

If the special land use is approved, the following items, either shown or lacking on the Mining Plan, must be provided at the time of site plan review: (Page 14)

1. Vehicle turnaround area for Cell 2.
2. Parking area for Cell 2, if proposed.
3. Notation of existing trees to be removed and trees that are to be preserved.
4. A detail of the proposed fence.

Vehicle turnaround and parking areas for Cell 2 are not proposed at this time but can be revisited during annual Mineral Extraction license renewals. All trees will be subject to removal. Proposed fence details have been added to the site plans.

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The maximum grade of the unsubmerged areas adjacent to the active extraction area perimeter in the reclamation plan are 1:3 feet; (Page 14)

The slope that is presented is 1:4, which complies with the Mineral Extraction Ordinance and does not exceed a slope of 1:3 and therefore, meets Section 5.12 D 4 (b) (11 II. D).

Note added to Mining Plans limiting the height of the processing equipment to 45 feet; (Page 14)

This has been added to the site plans.

The mining plan is revised so that all occupied residences on site will be at least five hundred (500) feet from any fixed machinery, equipment, buildings, extraction, processing, loading, weighing, stockpiling or other operations or equipment storage or repair; and (Page 14)

We disagree that the residential setback applies to the buildings located within the property boundaries. This will be addressed during the site plan review.

Planning Commission consideration of conditions of approval to protect the health and safety of residents on the subject site, if recommending approval. (Page 14)

No response is necessary.

Extraction, Soil Removal and Mining Operations Review Standards

a. Existing Land Uses

While the site is similar in terms of surrounding land uses, the study [referring to Noise, Dust and Fume Study by NRM] did not provide a comparison of the volume of mining, processing, and traffic between the Zeeb Road Pit and the proposed activities at the subject site. Furthermore, in the applicant's April 2021 Special Land Use application for Demonstration of Need, the applicant stated that the proposed extraction operation at the subject site is proposed to replace the market share for both of Stoneco's Zeeb Road and Burmeister locations. The study is likely not an accurate representation of the potential impacts since the volume of mining, processing, and traffic may be less intensive on the Zeeb Road site than the proposed extraction activities at the subject site. (Page 17)

There is no reason to believe, and no evidence or data has been presented by the Township Engineer, that would suggest any material difference in the volume of mining, processing, or traffic that would affect the relevance of the noise, dust and fumes study conducted by NRM. The studies presented in the application documents related to noise, dust, and fume conditions are associated with the same equipment that will be moved from the Zeeb Road operation to the proposed site. The study NRM conducted, demonstrates that when the processing of the material is taking place and trucks are actively transporting material to and from the site while all appropriate control measures and screening are in place, the impacts from noise comply with the Sharon Township performance standards, and no respirable dust, respirable silica, diesel particulate matter or vapors were detected. Similar results would be expected regardless of the volume of material being processed or the volume of truck traffic because the engineering and administrative controls required by applicable environmental permits and by the Mine Safety and Health Administration which are created to limit impacts to human health and the environment, regardless of the scope of any operation under permitted conditions. The study is, therefore, an accurate representation of the operation that Stoneco proposes in Sharon Township and the findings are consistent with peer-reviewed and published studies such as the one presented in Appendix E.

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The applicant has submitted a study based on the Stoneco Zeeb Road Pit operations. However, without a baseline for truck volume on the days when samples were taken (June 27, 2022 and August 9, 2022 for diesel fuel vapors and diesel particulate samples, respectively), the validity of that study is questionable, especially when the market share of the Zeeb Road Pit is one of two active pits that this proposed use is supposed replace. (Page 18)

We disagree for the reasons stated above. The data demonstrates that when the processing of the material is taking place and trucks are actively transporting material to and from the site while all appropriate control measures and screening are in place, the impacts from noise comply with the Sharon Township performance standards, and no respirable dust, respirable silica, diesel particulate matter or vapors were detected. Similar results would be expected regardless of the volume of material being processed or the volume of truck traffic because the engineering and administrative controls required by applicable environmental permits and by the Mine Safety and Health Administration which are created to limit impacts to human health and the environment, regardless of the scope of any operation under permitted conditions. The study is, therefore, an accurate representation of the operation that Stoneco proposes in Sharon Township.

b. Property Values

The study submitted does not address the following: (Page 19)

- The study does not address the market value or general demand for agricultural land, the predominant land use in the vicinity and along the proposed haul route.

The Bratcher study examined the potential for disamenities to residential property values from sand and gravel operations. There is no logical reason to suspect, nor does the Township Planner provide any reason to suggest that undeveloped agricultural land would be affected any more or less than residential property. On the contrary, residential property values typically exhibit more elasticity to adjoining uses than undeveloped agricultural properties. Moreover, the result of the Bratcher study are consistent with numerous similar property value studies and evaluations as discussed in detail in the Ford (2022), Ford and Seals (2018), Grant (2017), and Krumenacher & Orr (2016) reports (see Attachment A) among others. Our references are listed below.

- Ford, George S., PhD. "What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities". Phoenix Center Policy Paper No. 57 (May 2022). Phoenix Center for Advanced Legal and Economic Policy Studies.
- Ford, George S., PhD and R. Alan Seals, PhD. "Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence" Phoenix Center Policy Paper No. 53 (March 2018). Phoenix Center for Advanced Legal and Economic Policy Studies.
- Grant, A., "Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach, Master's Thesis." University of Guelph (2017).
- Krumenacher, Mark, and Isaac Orr. "Social Impacts of Industrial Silica Sand (Frac Sand) Mining: land Use and Value. Policy Study No. 140 (February 2016) published by the Heartland Institute.
- Dorrian, Anne M., and Clifford G. Cook. "DO ROCK QUARRY OPERATIONS AFFECT APPRECIATION RATES OF RESIDENTIAL REAL ESTATE?" (1996).
- Rabianski, J., and N. Carn. "Impact of Rock Quarry Operations on Value of Nearby Housing." *Atlanta: Department of Real Estate at Georgia State University, Georgia* (1987).
- Radnor, M., Hofler, D., et al. "Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries." U.S. Bureau of Mines (1981).

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• The study does not offer insight into the type of machinery, processes, truck volume, or any other aspect at the gravel mines in the four study areas. The existing gravel mine in Sharon Township, which was the focus of one of the study areas, does not generate as much truck traffic as is proposed for the subject site.

The requirements of the ordinance as it relates to the comment are as follows, "*The impacts considered in this subsection b* ***may*** *taking [sic] into consideration: the number and type of vehicles proposed; machines and equipment to be used in the operation; location and height of buildings, equipment, stockpile, or structures; location, nature and height of walls, berms, fences, and landscaping; and all other aspects of the proposed use."* The Bratcher study chose to account for the general design standards (location, nature, and height of walls, berms, fences, and landscaping) of the referenced mines in order to determine whether the sites were substantially similar in nature. Each of the study areas was selected because the operations are substantially similar to the Stoneco operation proposed in Sharon Township.

The results of the Bratcher study are also consistent with previously published research by *Grant, A., "Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach, Master's Thesis." University of Guelph (2017).* In his statistical analysis, Grant notes, "My second hypothesis states that the effect of proximity to an aggregate site may depend on its level of activity. If a site had higher extraction activity, I would expect the slope of the willingness to pay curve in Figure 3.1 to be steeper, and the effect to diminish with greater distance away from a site (the larger the extraction activity, the greater the effect on property values). These hypotheses were tested and were effectively rejected, as small positive effects (instead of negative) were seen in the full sample, and no statistically significant effects were found in the subsample of high activity clusters."

• The study does not offer insight into how residential property values would be affected by the development of a new gravel mine, since the study did not examine property values before and after the development of a gravel mine.

As stated above, the Bratcher study and numerous other studies all conclude that there is no correlation between property values and aggregate mining. If others have evidence to the contrary, we are happy to review it.

As discussed above, neither study addresses land value nor demand for agricultural land, which is a different real estate market. In order to understand the impact on general demand and property values, in the vicinity or along the haul route or in the Township in general, a study with comparable properties in terms of use and a similar intensity to the extraction operation proposed would be needed. (Page 20)

See response above.

c. Pedestrian and Traffic Safety

The traffic study submitted by the applicant does not take into consideration the current afternoon bus stop for Manchester Community Schools at the intersection of M-52 and Pleasant Lake Road. In addition, it does not account for pedestrian or bicyclist activity along Pleasant Lake Road or M-52. (Page 23)

There was no pedestrian or bicycle traffic observed during the traffic study. Bus stops are not unique to this intersection or the proposed Stoneco project site. By definition, ordinary (as opposed to extraordinary) traffic interaction cannot rise to the level of "very serious consequences".

d. Identifiable Health, Safety, and Welfare Interests

The property is designated agricultural in the Master Plan and was not designated in the Master Plan as an appropriate site

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for heavy industrial use. (Page 24)

Master Plan and zoning map designations are irrelevant to the Planning Commission's decision, which is the entire point of the very serious consequences test.

While other extraction operations are active in the Township, none are of the proposed scale in terms of truck traffic, acreage and volume of aggregate to be extracted on an annual basis. Also, the proposed operation is to replace two (2) active Stoneco mining sites in Washtenaw County and is assumed to be more intense than those two sites. Without a comparison to a comparable operation in terms of intensity, it is difficult to conclude that there will no health, safety and welfare impacts. (Page 25)

While the average daily production at the proposed Sharon Township location will likely be greater than the individual production at either Zeeb Road or the Burmeister pit, the equipment that is proposed for Sharon Township is the exact same equipment as is currently being used at the other two sites, and will, in fact, be moved from those locations to this site. There is no evidence that the same equipment operating at Sharon Township will result in more intensive impacts than at the locations it is replacing. More importantly, however, Carlisle-Wortman's suggestion that Stoneco must prove "no health, safety and welfare impacts," is incorrect. The statute merely requires that there will be "no very serious consequences."

The applicant has submitted a study in terms of dust, noise, and fumes. As discussed above, if the samples were taken in similar or more extreme operations or traffic situations at the Stoneco Zeeb Road plant than to what is proposed at the subject site, then the conclusions of no very serious consequences could be accepted. (Page 25)

As discussed above, the Stoneco Zeeb Road plant and operations are nearly identical to the plant and operations proposed for Sharon Township. The mining equipment (front end loaders, draglines & dredges), processing equipment (crushers, screens, conveyors, etc.), and haul trucks used at Zeeb Road and Burmeister are going to be moved to the Sharon Township location. There is no evidence to prove that the Sharon Township operations will create any more intensive impacts than what has been documented at the current Zeeb Road or Burmeister operations. Therefore, we agree that the conclusion of "no very serious consequences" should be accepted.

[Regarding the Vibration Study] as with the dust, noise and fumes study, the applicant did not provide a comparison of the level of traffic, equipment used, and intensity of the Burmeister Sand and Gravel mine as compared to the proposed operations of the site. The Burmeister site is one of the two operations that this proposed mine is slated to replace. The Vibration Discussion in and of itself does not provide enough information to evaluate possible consequences. (Page 26).

As discussed above, the Stoneco Burmeister plant and operations are nearly identical to the plant and operations proposed for Sharon Township. There is no evidence that vibrations at the proposed Sharon Township operation will be materially different than at the Burmeister location.

The proposed operation will replace a large farm operation and could threaten the viability of adjacent farms. Agricultural operations tend to locate on streets with little traffic, so equipment can easily be moved between fields. The increased truck traffic could detract from the economic viability of agricultural land along the proposed haul route. (Page 26)

There is no evidence that the proposed operation will threaten the viability of adjacent farms. Carlisle-Wortman's proposition is purely speculative. To the contrary, there are agricultural operations in the immediate vicinity of the majority of sand and gravel operations throughout Michigan. There is no evidence that mining activity has detracted from the economic viability of any of these agricultural operations.

The anticipated truck traffic could affect the character and features of municipalities to the north and south of Sharon

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Township along M-52. An estimated thirty-seven (37) trucks a day are anticipated to turn south on M-52 and would then traverse through downtown Manchester. The increased truck traffic could affect the character and walkability of that downtown area, as well. (Page 27).

We disagree, and again, this statement is purely speculative. M-52 is a State Route and therefore, not subject to any traffic restrictions from any location and it is neither practical nor feasible to speculate with any accuracy what the future traffic movement on M-52 or in fact if motorists using the State Route will follow traffic laws when traveling through the Village of Manchester and how it "could" impact the character of the downtown area or "walkability". In 2022, the annual average daily vehicle trips in the village of Manchester was 5,298 trips per day (MDOT TCDS, 2022) or nearly 2 million trips annually. It is hard to imagine that an additional 37 trips per day would rise to the level of "very serious consequences".

The traffic study provided in the application documents clearly indicates that based on the expected volume of truck traffic to and from the proposed quarry will not change the grade of Level of Service of M-52.

The proposed use and truck traffic on the haul route would negatively impact the viability of the preservation area in the southeastern part of the Township in the following ways: (Page 28)

• 168.99 acres of area in the Farmland Preservation Area would be converted to an extraction operation with mining in Cell 2. 19024 Pleasant Lake Road and 17020 Pleasant Lake Road are mostly prime agricultural soils. Once mined, the agricultural value of the land cannot be restored to its present state.

• The reclamation plan cites that agricultural and conversation uses could be facilitated by the design. However, we find it doubtful that the layout of the site proposed, and the previous extraction activity would be attractive to an agricultural use. A conversion of the property to a conservation use is more likely. While not as detrimental to agricultural preservation as housing, the proposed reclamation plan would prevent the restoration of the agriculture on the subject site.

- The Traffic Study submitted with the application documents concludes that the Stoneco property located on Pleasant lake Road, one mile west of M-52, is not expected to significantly impact traffic conditions in the study area, which includes the haul route. Furthermore, there is no evidence, studies, or reports presented to Stoneco by any traffic engineers or experts that would suggest that truck traffic will have any negative impacts on the viability of any preservation area in the southeastern part of the Township.
- Agricultural use will be maintained on the site concurrently with the mining and reclamation. The final reclamation plan is to restore approximately 45% of the total site area to an alternative natural resource; specifically, a water of the State. This includes wetlands and deep-water inland lake habitats. The remaining 55% of the property that is currently in agricultural use will be restored for that purpose or any other legally permitted use in the zoning district as the owner desires. Therefore, the reclamation of the property has been designed to not only facilitate current and future agricultural use but can be offered to be included in the WCPRCs NAPP program if the owner chooses to re-visit that opportunity.
- The WCPRC has already attempted to conserve the subject property formerly identified as the Schnerle Farm through the NAPP for the purpose of preserving the agricultural land after funding was approved (see attached meeting minutes of December 2020). This project failed in negotiations with the property owner. Subsequently, the owner exercised his right to explore the mineral value of the property for which Stoneco has purchased.

Based on the above facts, we disagree that any change in truck traffic will have any impact on the viability of any "preservation area" along the haul route or in the southeast part of the Township as presented in the current Master Plan adopted in October of 2020. Moreover, inconsistency with a master plan and even contradiction of existing ordinance cannot be a "very serious consequence."

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The proposed use and volume of truck traffic along the haul route would likely cause limitations on the use and enjoyment of other property in the vicinity and along the haul route. Due to flaws in the studies provided, it is not possible to assess the impact of dust, noise, diesel fumes, and vibration on properties in the vicinity. (Page 29)

We disagree that the traffic studies provided by Stoneco are flawed. There is no indication that the traffic associated with the proposed Stoneco operation will be any more impactful than is typical with any sand and gravel mining operation. Consequently, any such impact cannot be "very serious consequences."

The 150-175 trucks anticipated on average daily would likely affect the ability of farm operations along Pleasant Lake Road to move equipment between fields. In addition, the conversion of a working farm in a cluster of large acreage farm operations could affect the viability of agricultural areas in the vicinity and along the haul route, since farm operations tend to cluster and prefer access to low volume traffic roads. (Page 29)

There is no evidence that the proposed operation will threaten the viability of adjacent farms. This assertion is purely speculative, with absolutely no evidence to support it. As stated above the vast majority of sand and gravel operations throughout Michigan are located within primarily agricultural areas. There is no evidence that any increase in truck traffic would detract from the economic viability of agricultural land along the proposed haul road.

While the planned use for the site could be updated in the next Master Plan update, the viability of a resource conservation use is questionable without funding and stewardship. Ideally, an organization, be it a government entity or a non-profit, would be slated to take over the site after reclamation with dedicated funds to restore and maintain the site. Without proper stewardship and maintenance, a resource conservation use could become a blighting influence as well as an attractive nuisance. (Page 29)

See the above response regarding inconsistency with the Master Plan.

The proposed use would likely be detrimental to new housing or home-based businesses in the zoning district, General Agriculture (A-1), which is the zoning district for the subject site and the surrounding properties. (Page 30)

There is no evidence presented to us that would support this. To the contrary, our studies submitted with the application documents conclude that there will be no impacts on property values or the health, safety, and welfare of the Township.

The proposed use, including the haul route, could burden non-motorized vehicle travel or recreation, school uses, residential uses and the cultural and historic resources of the place of worship at the intersection of Pleasant Lake Road and M-52. (Page 30)

There is no evidence presented to us that would support this. To the contrary, our studies submitted with the application documents conclude that there will be no impacts on property condition, property values, or the health, safety, and welfare of the Township. This includes the church located at the intersection of Pleasant Lake Road and M-52 or any other building in the vicinity of the project site or haul route.

Without the installation of safety paths, the increased truck traffic proposed could create a hazardous situation for recreational bicyclists and pedestrians along M-52 and Pleasant Lake Road. (Page 30)

There is no evidence that any increased truck traffic associated with the proposed Stoneco operation will have any consequences that are not typical to any sand and gravel operation, and therefore, are not "very serious consequences."

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e. Overall Public Interest in the Proposed Extraction

Recommendation
If the Planning Commission were to recommend approval of the special land use, we recommend that the following conditions: (Page 35)

1. Finalization of setback distance from the existing natural gas pipelines and easements.

   This is being reviewed by the petroleum company engineers and as soon as we get their feedback, will incorporate any changes required in the site plans.

2. Approval by the Washtenaw County Road Commission.

   Agreed.

3. Conveyance of materials between Cell 2 and Cell 3 are underground and the apparatus is below grade from the interior edges of the required berms.

   Agreed.

4. Confirmation of the accuracy of the traffic study by the Township Engineer.

   No response necessary.

5. The information provided in the narrative that the location of the mobile plant will be provided during the annual Mineral Extraction License review be added to the notes of the Mining Plans.

   Agreed.

6. A note restricting the height of structures associated with the processing plant to not more than forty-five (45) feet.

   Agreed.

7. A note specifying that unstripped land not occupied by woodlands or wetlands will be maintained as agricultural use is added to the Mining Plan sheets.

   We will add a note to the Mining Plan sheets that unstripped land that is currently in agricultural production will be maintained in agricultural production.

8. Additional fencing and gates are required to prevent residents of and visitors to the residences on-site from encountering dangerous situations posed by the extraction activity and associate physical attributes on site.

   Agreed.

9. The occupancy of the residences on-site is limited by the applicant to the current residents.

   We disagree that the on-site residential use should be limited in any way by this permit.

10. Maintenance of the residences on-site are to be evaluated with the annual mineral license approval.

    Agreed.

11. Testing of the water pressure and quality of the wells associated with those houses on-site be part of the annual mineral license approval.

    Agreed.

Further, we recommend the following conditions be considered in order to mitigate impacts of the proposed use on moderate need.

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1. A decrease in the amount of aggregate to be removed on an annual basis and associated truck traffic. The Planning Commission and Township Board would need to determine a level measured against a low-to-moderate need.

This suggestion is directly contradictory to the Michigan Zoning Enabling Act and is not acceptable.

2. Safety paths installed along both sides of Pleasant Lake Road, between the site and M-52, and along both sides of M-52 within the borders of Sharon Township.

As suggested, such mitigation efforts would be excessive and unnecessary. Stoneco would be willing to discuss appropriate safety paths at the intersection of Pleasant Lake Road and M-52.

3. Accommodations for passage of farm equipment on Pleasant Lake Road along the haul route.

Not acceptable.

4. The relocation of the Sharon United Methodist Church to another location on their property.

Not acceptable

5. 19024 Pleasant Lake Road and 17020 Pleasant Lake Road, due to their location in an Agricultural Preservation area designated by the Sharon Township Master Plan, are excluded from the mining activity and remain in agricultural use.

Not acceptable.

6. Peak waves of truck traffic do not occur when school bus routes are operating on Pleasant Lake Road or M-52.

Not acceptable and contrary to the Michigan Zoning Enabling Act. Any such regulation must be reasonable in accommodating customary mining operations.

7. Designation of an organization to be responsible for and maintain the likely resource conservation use and any structures on-site after reclamation.

We are willing to discuss this.

8. Establishment of a fund to finance the stewardship of the likely resource conversation use and preserved buildings on the subject site after reclamation.

The final use of the property after reclamation has not been determined and is not required to be determined at this time. This recommendation is not acceptable.

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Sharon Preservation Society documents presented at Public Hearing dated February 15, 2023

Stoneco received comments from the Planning Commission Chair sent by the Sharon Preservation Society (SPS) in February 2023 regarding Stoneco's Special Land Use Application. Stoneco has reviewed these comments. The *black italic* text summarizes the SPS comments/concerns/statements. Soneco's responses to the SPS comments is provided in red text.

Lack of Impact to Regulated Wetlands and Inland Streams:

There will be no impacts on the hydrology of the wetlands based on the following:

- The excavation is limited to no closer than 50 feet of the delineated wetland boundaries and the County Drain. Therefore, no excavation will impact the ground surface in or adjacent to the wetlands or streams.
- All surface water within the perimeter of the proposed excavation areas will continue to drain in those directions with the exception of locations where earthen berms will be constructed, which is limited to the southern portion of Wetland 4 and the northern portion of Wetland 5. Surface water flow near the earthen berms will be facilitated through the installation of underdrains at various locations perpendicular to the berms in order to avoid ponding of water at the toe of the berms or on adjoining property. If these installations are necessary, they will be installed in accordance with EGLE and County SESC requirements. More importantly, piezometers have been installed within the wetland boundaries and are currently being monitored to document hydrologic conditions within the wetlands, which are provided in the application documents.
- The perched wetlands are located above the groundwater table elevation. This is supported by the piezometer readings collected since August 2022. The perched wetlands do not always contain open water. Additionally, the types of dominant vegetation are indicative of species that are not typically supported by permanent inundation. The dominant vegetative species were facultative wet (FACW) reed canary grass that does not normally require permanent saturation or inundation to be present and has been documented to be a drought-resistant invasive species. This data is supporting evidence of seasonal variability in wetland hydrology and is documented in the wetland delineation report and piezometer monitoring information presented in the application documents. These conditions are being evaluated in the Part 301 and 303 EGLE permit application.
- The hydrology in the wetlands is supported by direct precipitation which likely recharges the depressional areas and results in periods of inundation during seasonal and or annual above-normal precipitation events. Any surface water that would be collected in these depressions likely discharges slowly through seepage into the sandy muck soils during drought or dry seasons and into the dry sand and gravel beneath. This is demonstrated in historical aerial photography since at least 1937 as provided in the EIA, and within the soil types described in the wetland delineation report and soil types described in the USDA soil survey.
- The surrounding soils in each of the perched wetland areas are dominated by Oshtemo and Fox sandy loams and are characterized as high permeability soils and not likely to contribute to surface water run-off due to their low to medium run-off and non-hydric soil class as described in the soil survey referenced and provided in the EIA.
- The northwest corner of the property intersects with the Comstock County Drain and a secondary drain (Drain A) that flows into the Comstock Drain on the property (Figure 3 of the EIA). The Comstock Drain is under the Washtenaw County Drain Commission and EGLE jurisdiction. No disturbance or improvements to the Comstock Drain or the unnamed tributary to the Comstock Drain are proposed. Therefore, there will be no impacts to any streams on or within 1,000 feet of the subject property or haul routes as provided in our analyses presented in the application

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documents. These conditions are being evaluated in the Part 301 and 303 EGLE permit application.

- With respect to the Pangea Environmental, LLC report referenced above dated February 14, 2023 ("the Pangea Report"), no additional data, groundwater modeling, hydrogeologic calculations, or other scientific evidence has been provided that would allow us to evaluate the validity of the statements made with the exception of some photographs from a location not in the vicinity of the proposed Pleasant Lake Road site. We appreciate the fact that our analyses have been reviewed by others and comments were offered for us to review; however, all of our hydrogeological, groundwater modeling, and wetland delineation reports have been submitted to EGLE along with the Part 301 and 303 joint permit application. We will work with EGLE Hydrologic Data & Analyses Unit regarding their review comments and continue to monitor the site-specific conditions. As new information is gathered, our reports will be revised if necessary. Regarding any specific expected lake elevations, these are predicted elevations based on the current information and as stated in the NRM Hydrogeological Report and acknowledged in the Pangea Report, the expected lake elevations will fluctuate seasonally (as do all nearby naturally-occurring lakes) and as indicated on the site plans, the final lake elevations are estimates of the proposed lake elevations based on the modeling. The purpose of the groundwater model and hydrogeological analysis is to predict these conditions and any impacts due to evaporation and changes in groundwater flow direction or gradient and impacts on wetlands. Both reports show that the final predicted lake elevations are 949 to 950-feet, mean sea level. Because there are no surface water elevation controls required for the lakes, their final elevations will be dependent upon the equilibrium of the groundwater table once the lakes are completed, seasonal precipitation, and atmospheric conditions. All of these have been taken into account in the hydrogeological evaluations and were determined to have no impacts on the surrounding drinking water wells or wetlands as both the groundwater model and hydrogeological report submitted with the application supports.

Regarding additional permits that will be required by EGLE, we agree that water withdrawal and groundwater discharge permits will be necessary, similar to the soil erosion and sediment control permit, industrial stormwater permit, and air quality division permits. Stoneco is in the process of working on the water withdrawal and groundwater discharge applications and once completed, will submit them to EGLE for review. These permits are a requirement of the Mineral Extraction Ordinance and therefore, once the SLU is processed is completed, they will be submitted for EGLE review concurrent with the Mineral Extraction License application. We are confident that these applications will be processed and permits will be granted based on our pre-application discussions with EGLE.

Regarding the two photographs of the pond submitted by Pangea Environmental, LLC , we disagree it was drained as the Pangea Report suggests. Stoneco had retained NRM to provide a very detailed evaluation of the pond and surrounding site through a review of various maps, aerial photographs, topographic and geological evaluations, and several site visits. This is provided in Attachments C and D. It was determined that the "pond" is an emergent wetland containing characteristics that include fluctuating surface water levels historically documented since at least 1938 and there was no evidence that the adjoining sand and gravel mining operations would have any impact to the wetland. Current evaluations show the pond continues to have standing water in it subsequent to the December 2020 report being issued (see attached NRM report dated December 16, 2020 and corresponding photographs dated March 2022 through December 2022). EGLE visited the site and determined that the mining operation had no impact on the emergent wetland.

Property Value Study Methodology with Respect to Methodology

With regards to using real sales data as opposed to tax values, no one with an understanding of property valuation or property tax administration would agree that property tax values are a more accurate reflection of property value. The two are done using completely different techniques, in accordance with different laws, and the values sought even have different terms (market value versus true cash value). There is nothing in a study of a real estate market that would be useful in

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property taxation, including an analysis of a real estate market "over time." Any study of market change would require an analysis of **actual sales** over time, not true cash values.

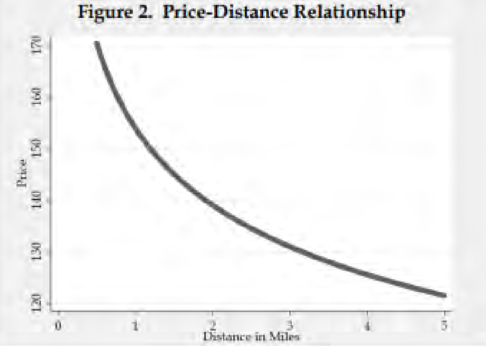
The report cited by Mr. Brouwer as the basis of his opinion and referred to above as a report by the W.E. Upjohn Institute has been reviewed and evaluated in several subsequent studies (see references below) and is often referred to as the "Erickcek" report. Note that the Upjohn report relies on a methodology that was originally published in what's known as the "Hite Report" but is not the same as the Hite Report (as is sometimes incorrectly suggested). The information presented in the Erickcek report is in fact not a study but a theoretical model based on an unpublished, non-peer-reviewed working paper by Diane Hite (the so-called "Hite Report")(Krumenacher and Orr, 2016). The Hite Report, since publishing, has been assessed by George S. Ford, Ph.D. and R. Alan Seals, Ph.D. in a report entitled, "Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence" (hereafter referred to as the 2018 Ford and Seals Report and subsequently followed up by Ford in a 2022 report titled "What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities") in which the authors review the methodology as well as attempt to replicate its findings to determine accuracy and appropriateness.

The 2018 Ford and Seals Report notes the following four findings with respect to the Hite methodology which are summarized below quoted directly from the 2018 Ford report.

1. "First, there are almost no details regarding model specification and few details on the data used. Not even descriptive statistics are provided.
2. Second, the choice of model specification is entirely ad hoc, treating nearly identical variables (distance) differently with respect to functional form and using a non-standard and unnecessary estimation procedure. Such inconsistent, unconventional, and inconvenient choices are symptomatic of ends-driven analysis.
3. Third, no explanation is provided as to how the chosen model and analysis of transactions occurring decades after the quarry operations began might identify the effect of *that particular quarry* (or any new quarry) on housing pricings. Selection bias is clearly a concern but is neither mentioned nor addressed.
4. Fourth, no analysis is provided to suggest that the homes near the quarry are sufficiently similar to those distant from the quarry to provide reliable estimates of the effect of distance (i.e., covariate overlap)."

Aside from the methodology concerns listed above, Ford and Seals, as previously stated, attempted to replicate the study's findings. They conclude, "Despite using exactly the same regression model and data on sales around the same quarry, we find that the transaction prices of homes *decrease* (not increase) as the distance from the quarry increases." They also concluded "Consequently, we find no evidence that supports the findings of the Hite report, despite using the same model, and in one instance, the same quarry from that earlier study. We conclude that the Hite Report's experimental design is incapable of quantifying the effect of quarries on house prices." The price-distanced relationship found in their replication of the study is displayed to the right. The full report is attached for review.

Figure 2. Price-Distance Relationship



With respect to the variables chosen in the Bratcher study, i.e., price per square foot and days on market, these variables were determined to be representative measures of property values and the corresponding market, which may or may not respond to the corresponding distance of an active sand and gravel mine.

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To expand, the sale price per square foot deals with market value, while days on market deals with the question of how long it takes to get a comparable sale price. The days-on-market analysis is intended to determine whether a value near the active sand and gravel operation might be similar but take longer to get the sale price.

Sales data is universally understood to be the beginning point for any analysis of the real estate market. Analysis of the real estate market begins with available sales data, verified to the extent possible, to make sure the data is as accurate as possible. Once the sales data has been gathered and verified, systematic analysis begins. Like units must be compared, so the sale price should be stated in terms of appropriate units of comparison. In the single-family residential market (as well as most other real estate markets), price per square foot is the typical unit of comparison.

The Bratcher study used these variables to test two specific hypotheses. First, if the active sand and gravel mine did, in fact, have an impact on property home values, one would expect that price per square foot would decrease (i.e., lower monetary value) as proximity to the mine increased (i.e., home is closer to mine). It could then also be hypothesized that as a measure of the market, if proximity to a mine did, in fact, have an impact on the ability of the homeowner to sell, then days on market would increase along with closer proximity to the mine. In this study, the answer to both indicates there is no significant relationship in terms of proximity to an active sand and gravel operation.

As such, these variables were determined to be relevant and appropriate indicators for the study. Further, the Sharon Township Zoning Ordinance Section 5.12.D.3 Act 113 Standards of Review Subsection b. Property Values does not dictate which methodologies are to be utilized in the study, nor the number of variables or specific variables utilized. Only that the property values and general demand be addressed, in which case price per square foot and days on market are suitable.

Bratcher Study Areas Studied and Level of Activity

First, it is important to note that mining generally occurs in phases, i.e., a project site is divided into sub-areas that will be mined and subsequently reclaimed over time. This process is dependent upon the total reserve volume and the depletion rate of the reserves and generally, takes several years to complete. Second, the boundaries indicated in the study area figures presented in the Bratcher study represent each project site as a whole, which can be inclusive of both active mining and active reclamation areas and, in some instances, currently yet to be developed areas. In each case, the size of the sand and gravel operations constitute several hundred acres. The Sharon Township project site is proposed to occur in this same manner with three separate mining areas and subsequent reclaimed lakes. The figures presented in the report are only a screenshot of a specific time but in all four cases, each site is being operated as a sand and gravel mine similar to the one proposed by Stoneco in Sharon Township.

As stated in the Bratcher Report, the four study areas were chosen because they were closest in proximity to the proposed site, were surrounded by similar land uses as the proposed site, and all being within similar market areas in rural Washtenaw County Michigan, in the vicinity of Class A transportation networks. The two Stoneco facilities specifically referenced above, are approximately 300 acres each (if inclusive of a fully reclaimed area). Not only are they similar in this manner, but also in the type of homes to those located near the mines, which was important to the validity of the study, and in the design and operating standards implemented at the mining site, all of which address the requirement of the Sharon Township Zoning Ordinance Section 5.12.D.3 Act 113 Standards of Review Subsection b.

Moreover, it can be shown that the "output or level of activity," is not statistically significant when evaluations of property values in proximity to aggregate mining site are conducted. In the study conducted by Grant "Estimating the Marginal Effect

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of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach, Master's Thesis." University of Guelph (2017), Grant notes with respect to testing these effects, "My second hypothesis states that the effect of proximity to an aggregate site may depend on its level of activity. If a site had higher extraction activity, I would expect the slope of the willingness to pay curve in Figure 3.1 to be steeper, and the effect to diminish with greater distance away from a site (the larger the extraction activity, the greater the effect on property values). These hypotheses were tested and were effectively rejected, as small positive effects (instead of negative) were seen in the full sample, and no statistically significant effects were found in the subsample of high activity clusters."

Number of Variables Used in the Bratcher Methodology

As previously stated, these variables were determined to be relevant and appropriate indicators for the study. The Sharon Township Zoning Ordinance Section 5.12.D.3 Act 113 Standards of Review Subsection b. Property Values do not dictate which methodologies are to be utilized in the study nor the number of variables or specific variables utilized. Only the property values which were represented by price per square foot, and general demand which was represented by days on market can be addressed, in which case, are the variables most suitable to determine a correlation between property values and proximity to similar projects as the one proposed and therefore, relevant to forming our conclusions.

ANOVA (Analysis of Variance) methodology vs MANOVA (Multi-level Analysis of Variance)

MANOVA is used only when the study contains multiple independent or dependent variables. In the Bratcher study, this was not the case. ANOVA was chosen appropriately for that reason. With respect to "cause-and-effect conclusions," it would be naïve to think that any currently known AND peer-reviewed methodology could determine true causality. To date, there is no universally accepted methodology that incorporates all of the known and numerous variables which may or may not impact property values. This is due to the fact that even if all the variables could be controlled (such as bathrooms, bedrooms, upgrades, square footage, school district, etc.), one would still have to account for the willingness to pay of the buyer, which in any given case of a home sale may be vastly different. In addition to the variables used as examples above, the events in the overall timeline would have to be controlled for, i.e., when or if the buyer ever became aware of the mine, if overall economic conditions played a part, i.e., the recession of 2008 or COVID-19 home buying boom, etc. Further, the results of any statistical test are limited by the data available. It is a known limitation that there is a "thinness of market" issue in proximity to mines. Generally speaking, a significant number of homes have to have been bought and or sold in proximity to the mine. Data acquisition is also limited in that mines may operate on adjacent or nearby parcels over the span of decades, which makes acquiring singular sale data or repeat sale data (appreciation) from homes prior to and after the operations of mines difficult, if possible, at all. In short, if the data does not exist, analysis cannot be conducted.

In an efficient market, goods and services are essentially homogeneous items that are readily substituted for one another and are frequently available equally and at the same time to a large number of market participants. In comparison, the real estate market is heterogeneous in that no two properties of real estate are physically identical, they are infrequently traded, and there are usually only a few market participants for a particular property at one time. Real estate markets can differ significantly from the markets for other goods or services, and real estate markets have historically been considered less efficient than other types of markets.

Because the real estate market is inefficient, statistical analysis is extremely difficult to use. Understanding that the 15th Edition of "The Appraisal of Real Estate" warns the appraiser that any statistical analysis must be supported by market data. Without understanding the basic issues, any use of statistical calculations is dangerous or ill-advised. It is due to these

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presented facts that the Bratcher study relied on a correlation study to determine simply whether there was a relationship between the representative variables as discussed. Variation was controlled for in the statistical analysis presented by NRM in that comparable homes (to the extent possible) were selected for, by Bratcher, in the study data.

As a follow-up to the 2018 Ford and Seals Report, Ford conducted further research regarding such shortcomings and published in 2022 entitled, "What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities," (hereafter referred to as the 2022 Ford Report). In this study, he applies multiple empirical methods to again attempt to determine if quarries reduce home values. He concludes, "Like most prior studies, I do not estimate plausibly causal effects… An impediment to causal analysis is the difficulty in obtaining sufficient samples of home sales around new quarry sites, given their mostly rural locations. **Correlation studies are most frequently cited before regulators**, so these results are useful in that respect." And in furtherance, "Evidence supporting the effect of a quarry on home values is scant, which is something I attempt to rectify here with the most extensive study to date. Evidence from three cities for thousands of home sales reveals no robust effect of quarries on home values."

It is important to note that both the 2018 Ford and Seals Report and the 2022 Ford Report are supported by multiple other studies, all of which are in contrast to the Hite Report, which appears to be the sole source of contradicting data. These studies, including the Ford and Seals (2018) and Ford (2022) report are referenced below. The 2022 Ford report, 2018 Ford and Seals report, 2017 Grant thesis and 2016 Krumenacher & Orr report are presented in Attachment A.

- Ford, George S., PhD. "What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities". Phoenix Center Policy Paper No. 57 (May 2022). Phoenix Center for Advanced Legal and Economic Policy Studies.
- Ford, George S., PhD and R. Alan Seals, PhD. "Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence" Phoenix Center Policy Paper No. 53 (March 2018). Phoenix Center for Advanced Legal and Economic Policy Studies.
- Grant, A., "Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach, Master's Thesis." University of Guelph (2017).
- Krumenacher, Mark, and Isaac Orr. "Social Impacts of Industrial Silica Sand (Frac Sand) Mining: land Use and Value. Policy Study No. 140 (February 2016) published by the Heartland Institute.
- Dorrian, Anne M., and Clifford G. Cook. "DO ROCK QUARRY OPERATIONS AFFECT APPRECIATION RATES OF RESIDENTIAL REAL ESTATE." (1996).
- Rabianski, J., and N. Carn. "Impact of Rock Quarry Operations on Value of Nearby Housing." *Atlanta: Department of Real Estate at Georgia State University, Georgia* (1987).
- Radnor, M., Hofler, D., et al. "Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries." U.S. Bureau of Mines (1981).

The findings of the Bratcher report are supported by the aforementioned reports and are particularly consistent with the findings of the 2018 Ford and Seals Report which concluded that "We find no compelling statistical evidence that either the anticipation of or on the ongoing operation of, rock quarries negatively impact home prices."

Impact on Traffic/Traffic Study

We forwarded the traffic study comments to our Engineer. Based on their review of the comments, our response is as follows:

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A vast majority of traffic impact studies rely on data from a single day, typically taken on a Tuesday, Wednesday, or Thursday during a typical week which is the case for this study. The daily traffic on our count fell in line with the other historical AADTs on M-52 and Pleasant Lake Road, therefore being representative of typical conditions. Given the existing conditions are at a level of service B, the intersection has plenty of available capacity, and the site will continue to have an insignificant impact on the average delays. Furthermore, forecasted delays where the level of service changed from "B" to "C" insignificantly changed by less than 1 second for the average delay.

Additionally, they did not analyze any other intersections besides the site driveway and Pleasant Lake/M-52, however from their experience, the delays at such intersections would not be significantly impacted given the traffic that the site is expected to generate, which our expert described as "limited." Trucks are allowed on M-52, and the insignificant impacts to peak delays at the intersection are included in the study, which remains at an acceptable level of service.

Noise, Dust, Fumes, and Vibration Studies

We have presented factual information and results from a location that will be operated in a similar manner, and therefore, no impacts from dust, noise, or fumes are expected. These studies have been presented in the application documents. The study provided by the Sharon Township Preservation Society was from a general evaluation of different types of operations, some of which included blasting or contained types of mining that are not comparable to the sand and gravel processing proposed by Stoneco in Sharon Township. Additionally, the study focused on worker exposure and not zoning compliance

A more relevant study than the one provided by SPS, was published in a more recent article in the scientific journal *Atmosphere (Richards and Brozell, 2021),* a study was conducted that compiled and evaluated ambient air conditions at sand and gravel quarries and processing facilities located in California as it relates to respirable crystalline silica. This study is provided in Attachment E. The study included 21 facilities that processed a variety of sand products including frac sand, milled sand and construction sand. Sampling focused on air quality near the property boundaries or "fenceline" location and also in the processing areas of some of the quarries. Samples were collected at various schedules during varying time-periods, some as long as a year. A summary of the results provided that…

> *"The authors conclude that (1) the ambient concentrations in the diverse set of mineral processing facilities were consistently lower than the 3.0 microgram per cubic meter chronic reference exposure level (REL) adopted by OEHHA, (2) upwind-to-downwind fenceline concentration differences were small, and (3) the fenceline concentrations were often at background concentration levels. The authors recommend additional sampling studies to better characterize background concentrations of ambient respirable crystalline silica."*

The NRM Noise, Dust and Fumes report referenced several pieces of equipment in operation at the Zeeb Road facility during testing was conducted and stated, "This is completed by using heavy construction equipment including, **but not limited to**, a dredge, loaders, generators, excavators, bulldozers and haul trucks". The equipment being operated during sampling included a rock screening and crushing operation which Stoneco intends to move to the Sharon Township location. Therefore, the testing is reflective of conditions when the mining, sorting, processing, loading and transfer of sand and gravel is being conducted. Stoneco's track record with respect to air permit compliance at all of our sand and gravel facilities is exemplary. The Additionally, the Mine Safety & Health Administration (MSHA) will conduct sampling for respirable dust and silica on the site and we strive to exceed those standards. The EGLE air quality division permit and fugitive dust plan will be required as part of the operations that require the implementation of engineering and administrative controls to limit exposure of fugitive dust. There is no practical reason to conduct additional sampling. Stoneco will meet the Sharon Township standard for noise which is determined at the property boundary, not at the point of worker exposure. All equipment and vehicles will maintain the required emission equipment to ensure compliance with the applicable standards.

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Individual Public comment

Most of the public comments raised issues that were also raised in the Spicer and or Carlisle-Wortman review comments, such as wetlands, property values, traffic, noise, dust, fumes, water quality, and vibration. See responses to those comments as provided above.

One item noted in the public comment that was not specifically addressed above is a concern regarding possible impacts to horses in the vicinity of the proposed operation. We have included with this response, Attachment D, which is a letter from Paula Hitzler who has been the manager of the Michigan State University Horse Teaching and Research Center for over 40 years. This letter was written in 2019 to the Gaines Township Planning Commission, specifically with respect to Friesian horses located in the vicinity of a sand and gravel pit expansion proposed by Stoneco in Kent County, Michigan. Ms. Hitzler's opinion is that horses that live in relatively close proximity to mining activities are not likely to exhibit negative reactions. In addition, a horse's sensitivity to dust tends to be similar to that of a human, such that dust levels that would not cause discomfort to humans would not be expected to cause discomfort in horses.

Regarding predicted disruptions to existing businesses that claim some special sensitivity, we trust that the various regulatory limitations contained in Sharon Township's Zoning Ordinances as well as State and Federal regulations, are protective of such sensitivities. As demonstrated in our application and all supporting documents, Stoneco's proposed operation will comply with all such regulations.

Closing

In closing, we trust these responses are adequate to process our application in a timely manner. In order to facility an efficient review of our responses, we have included the following:

- 5 hard copies of this response and supporting documents.
- Site Plan Sheet 3: Mining Plan, Sheet 3A: North Mining Plan Detail, Sheet 3B: South
- 2 USB flash drives containing digital copies of the application

Please feel free to contact me with any questions with my contact below.

Respectfully,

Austin Fisher

Austin.Fisher@mipmc.com
15203 S. Telegraph Road, Monroe MI

Cc: Mr. Ken Vermeulen – Honigman, LLP; Mr. Chip Tokar- Natural Resources Management, LLC

ATTACHMENT A

PROPERTY VALUE STUDIES

2022 FORD REPORT
2018 FORD AND SEALS REPORT
2017 GRANT THESIS
2016 KRUMENACHER AND ORR REPORT

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Phoenix Center Policy Paper Number 57:

What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities

George S. Ford, PhD

(May 2022)

Phoenix Center Policy Paper No. 57
What is the Effect of Rock Quarries on Home Prices? An Empirical Analysis of Three Cities

George S. Ford, PhD†

Abstract: For many Americans, a home is their most valuable asset. Naturally, the threat of a reduction in home values causes concern, which leads to opposition to several sorts of economic development projects and essential infrastructure. Opposition to rock quarries is one example. Evidence on the effects of quarries on home values is scant; the studies are often limited to a single city, leading to questions about generalizability, and use home sales occurring long after the quarry begins operations, introducing selection bias. In this POLICY PAPER, I apply multiple empirical methods to data on homes sales from three cities in Ohio. I find no evidence to suggest quarries reduce home values. I also offer evidence to suggest that the typical approach to quantify such effects—a home's distance from the quarry—may be unreliable given the idiosyncrasies of real estate markets.

TABLE OF CONTENTS:

† Chief Economist, Phoenix Center for Advanced Legal & Economic Public Policy Studies. The views expressed in this paper are the authors' alone and do not represent the views of the Phoenix Center or its staff.

I. Introduction

Hedonic models of home prices seek to explain sales prices by accounting for housing characteristics (e.g., square footage, acres, and so forth) and other factors that affect home values. Typically included in the set of covariates is the distance from a city's center or its central business district ("CBD"), or several such districts, with the expectation that home prices fall as distance from these employment centers rises.[1]

Along the same lines, researchers sometimes include the distance to an amenity or disamenity—a beach, an airport, a landfill—to quantify the effect of proximity to such establishments on home values.[2] For instance, rock quarries are sometimes subject to "not in my backyard" ("NIMBY") resistance due to their alleged effect on home values. Yet, research on the effect of rock quarries on home values is scarce. Opposition to quarries based on home valuations relies almost universally on Hite (2006), a brief report analyzing data from a few thousand homes sales around a single quarry in Delaware, Ohio.[3] Using an unconventional regression model and data on transactions within five miles of the quarry occurring decades after the quarry opened, the report finds a positive relationship between home prices and distance from the quarry. In contrast to Hite (2006), Rabianski and Carn (1987), Dorrian and Cook (1996), Bureau of Mines (1981), Grant (2017) and various other reports find no consistent relationship between

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[1] The "monocentric" assumption originated in the works of W. Alonso, LOCATION AND LAND USE: TOWARD A GENERAL THEORY OF LAND RENT (1964); E.S. Mills, STUDIES IN THE STRUCTURE OF THE URBAN ECONOMY (1972); R.F. Muth, CITIES AND HOUSING: THE SPATIAL PATTERN OF URBAN RESIDENTIAL LAND USE (1969).

[2] *See, e.g.*, J.P. Cohen and C.C. Coughlin, *Spatial Hedonic Models of Airport Noise, Proximity, and Housing Prices*, FEDERAL RESERVE BANK OF ST. LOUIS WORKING PAPER No. 2006-026 (2006) (available at: https://research.stlouisfed.org/wp/more/2006-026); M. Rahmatian and L. Cockerill, *Airport Noise and Residential Housing Valuation in Southern California: A Hedonic Pricing Approach*, 1 INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCE AND TECHNOLOGY 17–25 (2004) (available at: https://doi.org/10.1007/BF03325812); M. Thayer, H. Albers, and M. Rahmatian, *The Benefits of Reducing Exposure to Waste Disposal Sites: A Hedonic Valuation Approach*, 7 JOURNAL OF REAL ESTATE RESEARCH 265-282 (1992); R.B. Palmquist, *Estimating the Demand for the Characteristics of Housing*, 66 REVIEW OF ECONOMICS AND STATISTICS 394-404 (1984); P. Graves, J.C. Murdoch, M.A. Thayer and D. Waldman, *The Robustness of Hedonic Price Estimation: Urban Air Quality*, 64 LAND ECONOMICS 220-233 (1988).

[3] For a discussion of the Hite (2006) model, *see* G.S. Ford and R.A. Seals, *Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence*, PHOENIX CENTER POLICY PAPER NO. 53 (March 2018) (available at: https://www.phoenix-center.org/pcpp/PCPP53Final.pdf).

property values and proximity to a quarry.[4] Two recent studies offer conflicting evidence. Malikov, Sun and Hite (2018) look again at home prices around the quarry in Delaware, Ohio, and report price attenuation for homes nearer the quarry. Ford and Seals (2018) estimate plausibly causal effects for two quarries using Difference-in-Differences ("DiD") and find no effect of the quarry on home prices. Also, Ford and Seals (2018) study the Delaware quarry and find no effect of the quarry on home values, though the available data precluded a DiD analysis for this quarry.[5]

In this POLICY PAPER, I return to the question of the effect of rock quarries on home prices, although many of our findings are also relevant for any other sorts of spatially-centered disamenities. Given the idiosyncrasies of real estate markets across cities, there is little reason to suspect the results on a single quarry can be generalized to other cities. Here, I use data on three cities in Ohio, including, once more, the city of Delaware. Estimates of the effects are based on Ordinary Least Squares regression ("OLS"), Robust Regression ("RREG"), Quantile Regression ("QREG"), Spatial Regression ("SREG"), and Semiparametric Regression ("SPR"). As in most studies of disamentities and rock quarries, all home sales occur after the quarry began operations, so selection bias may be an issue. Like Hite (2006) and Malikov, Sun and Hite (2018), I am unable to make causal claims. Nonetheless, this sort of evidence is routinely used to address the effect of quarries on home values, so it is worth undertaking such analysis.

To establish expectations, I begin with an analysis of the geographic scope of quarry blasting, since blasting is a root cause of the disamenity nature of a quarry. This analysis, based on standard methods, reveals a narrow geographic impact of blasting (less than one-half mile across a wide range of charge strengths). For the three quarries, I find no attenuation of prices based on proximity to the quarry. I likewise evaluate the statistical validity of distance-from-site variables in econometric models. As in Ford and Seals (2018), Randomized Inference reveals that these sorts of models can produce very high rejection rates for the distance-

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4 A.M. Dorrian and C.G. Cook, *Do Rock Quarry Operations Affect Appreciation Rates of Residential Real Estate*, Working Paper (1996); J. Rabianski and N. Carn, *Impact of Rock Quarry Operations on Value of Nearby Housing, Prepared for the Davidson Mineral Properties* (August 25, 1987); M. Radnor, D. Hofler, et al., *Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries*, U.S. Bureau of Mines (May 1981); A. Grant, *Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach*, Master's Thesis, University of Guelph (June 2017).

5 Ford and Seals (2018) also demonstrate that the positive results in Hite (2006) may be due to the unconventional estimation method.

from-site variable, suggesting distance-from-site models tend to over-reject the null hypothesis (of no effect). These empirical distributions of distance-from-site coefficients are typically quite wide, encompassing even very large distance-from-site coefficients. Some analysis of the data used in Malikov, Sun and Hite (2018), which is, in part, publicly available, is also provided, revealing sign changes on the distance-from-quarry coefficient under plausible circumstances.

II. Background

There exists a large literature on the effect of disamenities, like airports and landfills, on home values. Rock quarries have received less attention, though "not in my backyard" ("NIMBY") resistance to quarries or quarry expansions is commonplace. Opponents of the quarries, normally residents in the city or county of operation, must rely on scant evidence to support their positions on home valuations. Two analyses are typically offered to support resistance: (1) a six-page description of results from a consulting report by Hite (2006); and (2) a more thorough study of the same quarry (using later data) by Malikov, Sun, and Hite (2018).[6] Only the latter study provides a detailed accounting of the data and analyses, though much of the NIMBY resistance relies on Hite (2006). These reports, like most studies of (dis)amenities, rely on the "distance-from-site" methodology in a hedonic framework. To counter the NIMBY claim, quarry advocates sometimes rely on Ford and Seals (2018), among other studies, which finds no effect (either mere correlation or causal) of quarries on home prices.

Data on sales prices used by Hite (2006) and Malikov, Sun, and Hite (2018) are for sales occurring long after the quarry began operations; the quarry in Delaware, Ohio, opened in 1904. Malikov, Sun and Hite (2018) use data on home sales across the entire county, so much of the sample is for sales many miles from the quarry; the data also span multiple cities. Since quarries are not randomly sited and are often located in rural areas where land prices, home prices, and housing density are low, there is the obvious problem of selection bias.[7] While Malikov, Sun, and Hite (2018) use a sophisticated econometric approach, nothing in the model

6 A summary presentation of results for a student project by Sun (2018) on the effects of a surface mine (for gold and silver), for which there is no accompanying paper and no detailed description of the data or methods, is sometimes cited, though mineral mines use very different techniques than do rock quarries. B. Sun, *An Econometric Analysis of the Effect of Mining on Local Real Estate Values*, Unpublished Presentation (Undated).

7 With the founding literature on home prices suggests prices fall as distance from the city center increases, it is little surprise that home prices may be lower around rock quarries located on the edge of town.

addresses selection bias so there can be no claim of a causal impact, and the authors never formally make a causal claim (though infer it).[8] In large part, the study appears to be more a presentation of a novel econometric methodology (semiparametric quantile spatial regression) than an attempt to quantify the causal effect of a quarry on home values. That is, the study is of academic interest more than of policy interest. Also, Ford and Seals (2018) find no effect of the Delaware quarry on homes prices, and I confirm that result here.

When looking at a single quarry, the generalizability of the result to other quarries is questionable. As demonstrated by Ford and Seals (2018), and again here, the coefficient on a distance-from-site covariate, which tend to statistically significance, may simply reflect the idiosyncrasies of individual real estate markets. Here, I look at three quarries to shed light on the generalizability of the findings.

A. *The Challenge and Advantages of Causal Analysis*

Though common in the literature, distance-from-site models have several serious shortcomings. First, there is selection bias. Available data for home sales often covers periods long after the amenity or disamenity is in place, precluding reliable causal estimation by methods such as Difference-in-Differences ("DiD").[9] Since the location of an amenity or disamenity is presumably not random, the risk of spurious correlation in distance-from-site relationships is high. Does the quarry reduce home prices, or are quarries located in areas where home prices are low? Studies like Hite (2006) and Malikov, Sun, and Hite (2018) cannot say, and my analysis here suffers from the same problem.

Disamenities are often placed away from population centers and where land prices (and thus home prices) are lower. Rock quarries often occupy hundreds of acres, so they are often places where land prices are lower, subject to the desirability of the geography. Public policy also influences site selection and (dis)amenities are sometimes clustered, thus making identification of a single (dis)amenity difficult. For instance, the quarry in Delaware, Ohio, sits on the edge of the city, adjacent to the municipal airport and an outdoor shooting range. Second, the available data on home characteristics varies among county assessors, so omitted variables may be a problem. Third, real estate markets are complex;

8 The same holds for the Hite (2006) study.

9 *See*, *e.g.*, J.D. Angrist and J. Pischke, MOSTLY HARMLESS ECONOMETRICS: AN EMPIRICIST'S COMPANION (2009); J.D. Angrist and J. Pischke, MASTERING METRICS: THE PATH FROM CAUSE TO EFFECT (2014); S. Cunningham, CAUSAL INFERENCE: THE MIXTAPE (2021); G.S. Ford and R.A. Seals, *supra* n. 3.

home values rise or fall from nearly any location, irrespective of the presence of an amenity or disamenity. Ford and Seals (2018) show that the null hypothesis (no effect) for a distance-from-site coefficient from nearly any location in a city is rejected at rates far exceeding the alpha level of the test. This finding forces the question about how unusual the estimated distance-from-site coefficient really is, irrespective of its statistical significance.

While I do not conduct a DiD analysis of home values here, a concise review of DiD analysis sheds light on why the distance-from-site approach is prone to bias. It also reveals the condition that must be satisfied for the results of such analysis to render a plausibly causal effect. Let us consider a hypothetical scenario. Say a quarry receives approval to begin operations on the outskirts of town. For several reasons, quarries are typically and intentionally located away from housing density where land prices are low. Before even the planning phase of the quarry, assume the average (quality-adjusted) price for a home near the quarry site is $95,000, and the average price is $100,000 for homes far from the future quarry site. This 5% price difference cannot be due to the quarry because the lower average price is present prior to the quarry even being proposed (by assumption).

After the quarry initiates operations, homes are bought and sold, and the prices are observed. Assume, for now, that the quarry has *no effect* on property values (and average prices do not change). If a researcher looked only at post-operations prices, then a 5% price difference is observed, though, by assumption, this price difference is not due to the quarry as the difference preceded the quarry. Nonetheless, this difference may be attributed falsely to the quarry. (The same would be true if home prices near the quarry were initially 5% higher than those far away).

The *true* effect of the quarry on home prices is revealed by the Difference-in-differences estimator,

$$\delta = (P_1^N - P_0^N) - (P_1^F - P_0^F)\,, \qquad (1)$$

where δ is the DiD estimator, P is price before (0) and after (1) the quarry begins operations for houses near (N) and far (F) from the quarry. In this "no effect" case, the DiD estimator is zero [(95,000 – 95,000) – (100,000 – 100,000) = 0], correctly identifying the causal effect of the quarry. Using only post-operation prices, the calculated statistic from empirical analysis is,

$$\Delta = P_1^N - P_1^F\,, \qquad (2)$$

where Δ equals δ only when $P_0^N - P_0^F = 0$, which seems unlikely given the economics and policies related to siting a quarry. In this hypothetical, the Δ coefficient equals -$5,000, which is not the effect of the quarry. Thus, when a quarry's effect on home prices draws conclusions from an estimate of Δ and not δ, no plausible claim of a causal effect is possible.

As an alternative scenario assume that the quarry reduces prices for nearby homes to $90,000 (a reduction of $5,000), with more distance home prices remaining constant. Looking only at post-quarry transactions materially overstates the effect size [90,000 - 100,000 = -10,000], with selection bias accounting for a $5,000 overstatement. The DiD estimator, contrariwise, accurately quantifies the effect of the quarry [(90,000 – 95,000) – (100,000 – 100,000) = -5,000]. Absent special circumstances, an analysis restricted to home sales after the quarry becomes operational cannot quantify reliably the effect of the quarry on home prices.

Conducting a DiD study on home values and quarry operations, while desirable if not necessary, is complicated by the fact many quarries near housing density are decades old and new quarries are almost always located in more rural areas where housing density is low. Even in instances where a new quarry site is selected, obtaining adequate price data on home sales near a quarry site is challenging given low housing density. I do not conduct a DiD analysis here; instead, I use the traditional hedonic models. As such, I can make no causal claims. Still, my analysis speaks to the issue using the methods commonly relied upon and addresses the reliability of existing estimates of a quarry's effects and to the use of distance-from-site covariates generally.

B. *Forming Expectations*

Central to the distance-from-site analysis is that the effects of the (dis)amenity are larger the closer is the home to the (dis)amenity, with presumably stronger effects near the quarry that dissipate over distance. It makes sense, therefore, to consider the practical distances over which a rock quarry's operations may be felt. Local resistance to rock quarries often focuses on the use of explosives that create ground vibrations and sound waves ("overpressure"), both of which can cause annoyance if not damage to property if sufficiently intense. (Other concerns include truck traffic and the water table.) Advances in blasting technology and operator care over the last thirty years has greatly diminished these effects, even if such advances have not reduced NIMBY resistance. An analysis on the geographic scope of blasting may shed light on the distances over which a quarry's operations may influence home values.

The geographic scope of the blasting on a quarry's neighbors is measured by ground vibrations and overpressure. Ground vibration is measured in terms of Peak Particle Velocity ("PPV"), which measures the movement of particles at the surface. Such vibrations may be felt at nearby homes and may cause cosmetic damage (e.g., drywall). A typical (empirical) equation for PPV is,

$$PPV = 160\left(\frac{D}{\sqrt{W}}\right)^{-1.6}, \tag{3}$$

where D is the distance from the charge in meters and W is the charge mass (maximum pounds per 8 millisecond delay).[10] While the parameters of the equation may vary by circumstances (e.g., vibration frequency, rock characteristics, the water table), the listed parameters are recommended absent field blast data at a particular site. The Bureau of Mines' standard for drywall damage is 0.75 inches per second.[11] Home damage is a serious concern, but there is also the potential for human annoyance. Studies suggest that the human perception for blast vibration ground motion is about 0.03 inch/s (0.80 mm/s) and that complaints are unusual below 0.08 inches/s (2.03 mm/s).[12] In a study of

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[10] The parameter selection is based on the INTERNATIONAL SOCIETY OF EXPLOSIVES ENGINEERS BLASTER'S HANDBOOK (18th Edition) (2011) at p. 567; *see also,* R. Kumar, D. Choudhury, and K. Bhargava, *Determination of Blast-Induced Ground Vibration Equations for Rocks Using Mechanical and Geological Properties*, 8 JOURNAL OF ROCK MECHANICS AND GEOTECHNICAL ENGINEERING 341-349 (2016) (available at: https://www.sciencedirect.com/science/article/pii/S167477551600024X).

[11] D.E. Suskind, M.S. Stagg, J.W. Kopp, and C.H. Dowding, *Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting*, United States Bureau of Mines RI-8507 (1980), Appendix B.

[12] *See*, *e.g*., Suskind *et al.*, *id.*; T. Ongen, G. Konak, and D. Karakus, *Vibration Discomfort Levels Caused by Blasting According to Gender*, 7 ENVIRONMENTAL AND EARTH SCIENCES RESEARCH JOURNAL 109-115 (2020) (available at: https://www.iieta.org/journals/eesrj/paper/10.18280/eesrj.070303); B.T. Lusk, *An Analysis and Policy Implications of Comfort Levels of Diverse Constituents with Reported Units for Blast Vibrations and Limits: Closing the Communication Gap*, Ph.D. Thesis the Faculty of the Graduate School of the University of Missouri-Rolla in Mining Engineering (2006); Q. Yao, X. Yang, and H. Li, *Comparative Analysis on the Comfort Assessment Methods and Standards of Blasting Vibration*, 17 JOURNAL OF VIBROENGINEERING 1017-1036 (2015); A.K. Raina, M. Baheti, A. Haldar, M. Ramulu, A.K. Chakraborty, P.B. Sahu, C. Bandopadhayay, *Impact of Blast Induced Transitory Vibration and Air-Overpressure/Noise on Human Brain—An Experimental Study*, 14 INTERNATIONAL JOURNAL OF ENVIRONMENTAL HEALTH RESEARCH 143-14 (2004); A.K. Raina, A. Haldar, A.K. Chakraborty, P.B. Choudhury, M. Ramulu, and C. Bandyopadhyay, *Human Response to Blast-Induced Vibration and Air-Overpressure and Indian Sceranio*, 63 BULLETIN OF ENGINEERING GEOLOGY AND THE ENVIRONMENT 209-214 (2004); K. Medearis, *The Development of Rational Damage Criteria for Low-Rise Structures Subjected to Blasting Vibrations*, Final Report for the National Crushed Stone Association (1976).

human perception of blasting at a rock quarry, Ongen, Konak, and Karakus (2020) report perception occurring only at a PPV of 0.03 inches/s (0.80 mm/s), no annoyance at a PPV of 0.033 inches/s (0.84 mm/s), and slight annoyance at a PPV of 0.09 inches/s (2.27 mm/s).[13]

In addition to ground vibration, a blast produces a shock wave. This overpressure—the pressure (above normal atmospheric pressure) caused by a shock wave— may be felt and heard. Overpressure is measured in linear decibels ("dBL").[14] To limit structural damage to property, the U.S. Bureau of Mines sets a threshold of 133 dBL.[15] Again, the threshold for human annoyance may be different than that for structural damage. The U.S. Bureau of Mines sets the annoyance threshold at 120 dBL. In Australia and New Zealand, the Environmental Council sets the annoyance threshold at 115 dBL.[16] In studying sonic booms, NASA found that none of participants viewed as annoying a sonic boom producing a dBL of 121 and only 10% of respondents were annoyed by a boom of 128 dBL.[17] To avoid annoyance, NASA recommended a sonic boom should not exceed 125 dBL. Overpressure may be estimated using the formula,[18]

$$P = 164.8\left(\frac{D}{\sqrt[3]{W}}\right)^{-0.0696}. \quad (4)$$

Using these two formulae, it is possible to establish the distance from a quarry at which nearby residences and businesses may experience either structural damage or annoyance.

13 Ongen, *et al.*, *id*.

14 dBL is a linear scale and thus different from the logarithmic scale typically used for sound.

15 D. E. Suskind, V.J. Stachura, M.S. Stagg, and J.W. Kopp, *Structure Response and Damage Produced by Airblast from Surface Mining*, United States Bureau of Mines RI-8485 (1979).

16 *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*, Australian and New Zealand Environment Council (1990).

17 *Environmental Impact State for the Kennedy Space Center*, National Aeronautics and Space Administration (1979) at pp. 5-40.

18 Parameters are based on conversations with J. Straw, Vice President and Area Manager, GeoSonics, Inc. (https://www.geosonicsvibratech.com), which are based on testing at quarry locations. A typical charge weight for quarry operation is 78.75 kg/ft^3.

Table 1. Miles from Blast for Threshold PPVs and Overpressures

	PPV inch/s			Overpressure dBL		
W	**0.75**	**0.08**	**0.03**	**133**	**125**	**115**
50 kg	0.038	0.155	0.286	…	0.036	0.122
75 kg	0.047	0.190	0.350	…	0.042	0.140
100 kg	0.054	0.219	0.404	…	0.046	0.154
125 kg	0.060	0.245	0.452	0.020	0.050	0.166
150 kg	0.066	0.268	0.495	0.021	0.053	0.177
175 kg	0.071	0.290	0.535	0.023	0.056	0.186
200 kg	0.076	0.310	0.572	0.024	0.059	0.194

Table 1 summarizes the two measures for varying blast charges at different levels of PPV and Overpressure. For PPV, the values are 0.75 for drywall damage and 0.08 for annoyance and 0.03 for human detection. For overpressure, the values are 133 dBL for structural damage, 125 dBL based on NASA's threshold for annoyance, and 115 based on the Environmental Council's threshold for annoyance. The potential for damage is quickly exhausted (less than one-tenth of a mile), mild human annoyance is exhausted at less than one-third mile from the quarry, and human perception at about one-half mile. Overpressure does not appear to be problem for damage or annoyance at distances greater than two-tenths of a mile. The claim that a rock quarry affects homes prices up to ten miles, as reported by Malikov, Sun and Hite (2018) seems incredible, at least with respect to the influence of blasting.

C. *Randomized Inference*

Hedonic regression analysis with distance-from-site variables quantifies the relationship between home prices and distance from some location of interest. Usually, only a few distance-from-site variables are included in hedonic models. Yet, real estate markets are complex and may include a wide array of (dis)amenities. It is possible, if not likely, that in many cities a statistically-significant coefficient on a distance-from-site covariate will be observed from many locations, not simply the location(s) of a researcher's interest. Thus, rejecting the null hypothesis at a particular location using the traditional asymptotic approach (e.g., a t-test) may overstate how unusual is the price-to-distance relationship. Moreover, failing to account for all amenities, disamenities, or market idiosyncrasies (the latter being very difficult), the distance-from-site coefficient at one location may simply reflect the influence of another location.

Randomized Inference can shed some light on this problem. Randomized inference is a statistical technique that randomly assigns a treatment, in this case distance from a randomly-selected location, for the purpose of creating a reference distribution under the null hypothesis of "no effect."[19] How unusual a particular measured distance-from-site effect may be quantified by comparing the estimated coefficient (or its t-statistic) for a particular distance-from-site coefficient to this reference distribution. For instance, say the regression analysis indicates that a 10% increase in distance from a quarry reduces home prices by 5%, and this relationship has a one-tailed p-value of 0.05, allowing for the rejection of the null hypothesis of no effect. If, however, the effect of distance is also 5% for 30% of randomly-selected locations in a city, then the "true" one-tailed p-value would be 0.30 (or 60% in a two-tailed test), which does not permit a rejection of the null hypothesis (*i.e.*, the 5% effect is not very rare).

Property values rise and fall across the area of a city for a host of reasons, so testing for a price difference from a given location is prone to find prices rising or falling. Ford and Seals (2018), using data from Delaware, Ohio, find that a statistically significant coefficient on a distance-from-site variable is almost certain to appear. Selecting one thousand locations at random within a city, Ford and Seals (2018) find the null hypothesis of "no effect of distance" was rejected in 93% of cases at the 10% level. A statistically-significant positive or negative distance-from-site coefficient is almost guaranteed. Of course, the observed rejection rate may vary by city, model specification, variables included, and the estimation method.

I apply Randomized Inference for the cities in our sample. One thousand locations are randomly chosen, and a hedonic regression is used to estimate the distance-from-site coefficient. The distance-to-quarry coefficient can then be compared to this null-reference distribution to determine whether the coefficient indicates an "unusual" relationship by computing the one-tail p-values. Or, the estimated distance-to-quarry coefficient can be evaluated against the 90% or 95% confidence interval of the reference distribution, thus mimicking the traditional approach of using 10% or 5% significance levels.

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19 R.A. Fisher, THE DESIGN OF EXPERIMENTS (1951).

III. Data

Data on home sales are obtained for three cities in Ohio of similar size: the cities of Delaware, Findlay, and Lima.[20] These data are obtained from the relevant county assessor's webpage. Prices from arms-length transactions of single-family homes within five miles of the quarry (as in Hite 2006) and on ten acres or less are included in the samples.[21] Data are obtained for years 2010 through 2021. Some summary statistics are provided in Table 2.[22] Prices and home sizes in Delaware are much higher than in the other cities, and home prices are correlated with median income.

Table 2. Cities in Sample

City	Sample Size	Average Price	Average Sqft	Average Price/Sqft	Population (2019)	Median Income (2019)
Findlay	2,843	154,227	1,600	95.4	41,335	51,002
Delaware	2,439	234,378	1,901	124.9	40,568	69,087
Lima	1,169	86,049	1,351	64.6	37,117	35,779

Delaware and Findlay are an interesting pair. The Delaware quarry is the only one analyzed in Hite (2006) and Malikov, Sun, and Hite (2018), and is also studied in Ford and Seals (2018). Like Delaware, the quarry in Findlay is in the Southwest corner of the city and sits adjacent to the municipal airport (a disamenity frequently studied in the literature). We might expect, therefore, similar results for the distance-from-site covariate in both cities. Note, however, that given these quarries' proximity to these other disamentities (an airport in both and an outdoor

[20] The locations of the quarries are: Findlay (41.013530, -83.690632); Delaware (40.281032, -83.136392); and Lima (40.751028, -84.083442). Delaware is in Delaware County; Findlay is in Hancock County; and Lima is in Allen County.

[21] A valid sale is an "arm's length, open market transaction as of a specific date whereby there is a willing buyer and seller, each acting in what he/she considers his/her best interest; a reasonable time is allowed for exposure in an open market; payment is made in terms of cash or comparable financial arrangements; and the price represents the normal consideration for the property sold unaffected by special or creative financing or sales concessions granted by anyone associated with the sale (https://wedge1.hcauditor.org/page/Glossary)." Valid sales are typically by Warranty Deed and these samples are restricted to Warranty Deeds or comparable deeds. Deeds such as Quit Claim and Survivorship Deeds are excluded since these deeds, while valid transfers, are not arms-length transactions. A minimum price of $10,000 is imposed and mobile homes are excluded.

[22] Population and income data available at: https://datausa.io. Also see home value statistics from Zillow: Findlay (https://www.zillow.com/findlay-oh/home-values); Delaware (https://www.zillow.com/delaware-oh/home-values); Lima (https://www.zillow.com/lima-oh/home-values).

shooting range in Delaware), it is impossible to say which "disamenity" might be correlated with lower home prices. Normally, we expect airports and shooting ranges to be sited away from higher-value housing, so low prices may simply reflect the choice of site rather than any causal effect on home prices. By most standards, the proximity to another disamenity (or two) would disqualify the city for analysis, but these prior studies on the Delaware quarry have ignored this possibility.

As is standard in hedonic models of home prices, data is collected on a variety of home characteristics. Some county assessors provide more detail than others and the lack of some characteristics may lead to omitted variables bias and fail to address selection bias. Home and area characteristics included, when possible, are square footage, acreage, indicators for the number of bedrooms and (full and half) bathrooms, basement square footage, an indicator for single-story homes, indicators for the number of fireplaces (one, two, or three or more), the age of the home at the sale date, an indicator for homes remodeled in the ten years prior to the sale, the distance (in miles) to the city center and the rock quarry, indicators for the assessor's grade of the quality of construction materials and the condition of the home, indicators for the type of garage (attached, detached, finished, unfinished), and sale-year fixed effects. Demographic data on median income, the share of the White population, and the share of vacant homes is also used.[23]

IV. Regression Model

Home prices are affected by many factors, so I proceed with multivariate regression analysis. As is standard, the regression model takes the general form,

$$P_{it} = \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \varepsilon_{it} \ , \qquad (5)$$

where P_i is the sale price of home i at time t, M_i is the home's distance in miles from the rock quarry, X_{it} is a vector of home- and transaction-specific characteristics such as square footage, acres, and distance from the city center, Z_{it} is a vector of area characteristics such as median income, τ_t is a year fixed effect, and ε_{it} is the econometric disturbance term. As home prices vary considerably, the dependent variable is the natural log of price. Standard errors are clustered at the census tract level when feasible. The same model is used for OLS, RREG, and QREG.

Housing markets are an archetype case of spatial correlation—the price of a home depends, in part, on the prices of nearby homes (which also affect the

23 Data available at: https://docs.safegraph.com/docs/open-census-data.

valuation for mortgage approval). In OLS, the assumption is that the disturbances (ε) are independent, so the presence of spatial relationships requires an alternative estimation approach. Failing to account for these spatial relationships represents a form of omitted variables bias (though there are other justifications for spatial regression), which may or may not bias the coefficients.[24] For all cities in this analysis, Moran's test indicates the presence of spatial correlation. So, in addition to the traditional regression analysis, I perform spatial regression including a spatially-lagged dependent variable and spatial errors (a Spatial Durbin Model, or "SDM"). Spatial analysis is based on a row -normalized spatial weight matrix (W) where distance is truncated at three miles. The spatial regression model is,

$$\begin{aligned} P_{it} &= \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \theta WP + \mu_{it} \\ \mu_{it} &= \lambda_t W \mu_{it} + \varepsilon_{it} \end{aligned} , \quad (6)$$

where WP is the spatial lag of price and μ_{it} is the spatial error term. With a spatial regression model, the effect of a variable has a direct, indirect, and total effect, though here the sign on the Δ coefficients are of primary interest. For comparison purposes, I also estimate the Spatial Lag Model ("SAR"),

$$P_{it} = \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \theta WP + \mu_{it} , \quad (7)$$

and the Spatial Error Model ("SEM"),

$$P_{it} = \Delta M_i + \beta X_{it} + \alpha Z_{it} + \tau_t + \lambda W \varepsilon_i + \mu_{it} . \quad (8)$$

I also estimate a semiparametric relationship between home prices and quarry-distance,

$$P_{it} = g(M_i) + \beta X_{it} + \alpha Z_{it} + \tau_t + \theta WP + \nu_{it} , \quad (9)$$

where $g(M_i)$ permits a non-parametric and flexible relationship between prices and quarry distance. Since g(Mi) is not a parameter, the semi-parametric results are graphed (though confidence intervals may be computed). The other covariates enter parametrically and include the WP regressor (the spatial lag).

[24] *See, e.g.*, J. LeSage and R.K. Pace, INTRODUCTION TO SPATIAL ECONOMETRICS (2008); M.D. Ward and K.S. Gleditsch, SPATIAL REGRESSION MODELS (2018).

Outliers are a potential problem in home sales data due to the idiosyncrasies of transactions and perhaps coding problems. I have tried to limit such problems by looking only at arms-lengths transactions, but it may be worth evaluating the effect of potential outliers. I mark outliers as those transactions with a Cook's D exceeding $4/N$.[25] RREG and QREG are also employed to limit the effect of outliers.

A. *Findlay, Ohio*

I begin my analysis with Findlay, Ohio, in Hancock County. The county assessor provides extensive data on home characteristics. Like Delaware, the quarry in Findlay is in the Southwest corner of the city and adjacent to the municipal airport. Presumably, if the distance-to-quarry coefficient truly measures the effect of the quarry, then the Δ coefficients should be similar across the two cities. For Findlay, there are 2,843 homes sales meeting the sample restrictions over the 2010-2021 period. There are two distance-from-site covariates (measured in miles) including distance from the city center and distance from the rock quarry. About 5.6% of sales are identified as outliers based on Cook's D; these outliers are marked with a dichotomous indicator.

Four models are estimated including two by OLS (with one including the outlier indicator), one by RREG and another by QREG. Given the large number of covariates, a detailed summary of the estimates is placed in Appendix A (for all models and cities). The estimated coefficients are mostly as expected. Home prices rise in square footage and acreage, fall in age, and rise over time. Prices are higher as the condition of the home is better.

Table 3. Summary of Regression Results, Findlay

Variable	Model A OLS	Model B OLS	Model C RREG	Model D QREG
ln(Quarry Dist.)	-0.030	-0.033	-0.031***	-0.042***
ln(City Center Dist.)	0.011	0.001	0.032***	0.034***
ln(sqft)	0.386***	0.409***	0.484***	0.482***
ln(acres)	0.041	0.086**	0.067***	0.059***
Outlier Indicator	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	…	Robust
Observations	2,843	2,843	2,843	2,843
R^2	0.645	0.723	0.838	…

Stat. Sig. * 10% ** 5% *** 1%

[25] R.D. Cook, *Detection of Influential Observations in Linear Regression*, 19 TECHNOMETRICS 15-18 (1977).

Table 3 provides a summary of the results for a few key parameters. As expected, the coefficient on square footage is positive, large, and statistically significant at better than the 1% level; prices rise with larger lots. A positive coefficient is estimated for the distance-from-city center covariate, but the coefficient is statistically different from zero only in RREG and QREG. Turning to the quarry, the quarry-distance variable has negative coefficients across the board suggesting home prices fall as distance-from-the-quarry increases. The quarry-distance coefficients are statistically different from zero only in Models C and D. Home prices, conditioned on many variables, tend to be lower as distance from the quarry increases.

Table 4. Summary of Spatial Regression Results, Findlay

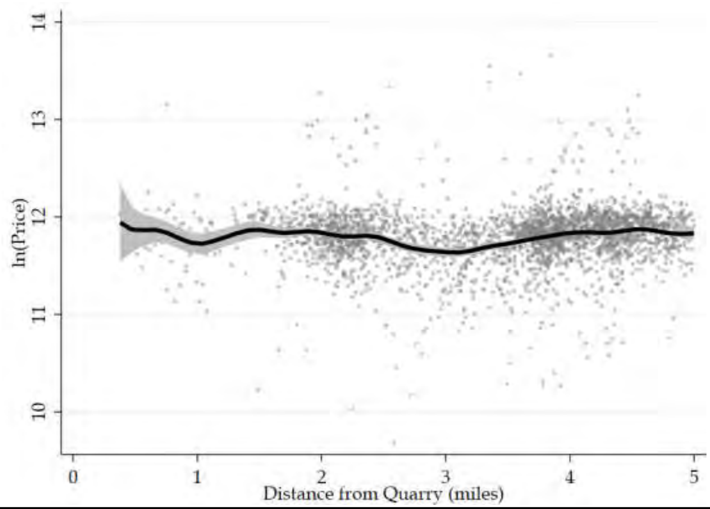
Variable	Model E SDR	Model F SDR	Model G SAR	Model H SEM
ln(Quarry Dist.)	-0.030	-0.036	-0.009	-0.056**
ln(City Center Dist.)	-0.027	-0.042**	-0.001	0.011
ln(sqft)	0.345***	0.366***	0.341***	0.361***
ln(acres)	0.038**	0.085***	0.015	0.107***
Spatial Lag	0.912***	0.907***	0.880***	…
Spatial Error	0.941***	0.953***	…	3.012***
Outlier Indicator	No	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust	Robust	Robust	Robust
Observations	2,843	2,843	2,843	2,843

Stat. Sig. * 10% ** 5% *** 1%

Turning the spatial regression model, Moran's test statistic is 144.3, which is statistically significant at the 1% level. As expected, the data are spatially related. A summary of Spatial Regression results is provided in Table 4; standard errors are robust to heteroskedasticity. Again, the coefficients on the quarry-distance covariate are negative and of similar size to the non-spatial models, but now most of the coefficients are statistically insignificant. Only in the SEM variant is the quarry-distance coefficient statistically different from zero (at the 5% level). In the spatial models, home prices are mostly uncorrelated with distance from the quarry.

I turn now to semiparametric regression where the relationship between prices and quarry distance is non-parametric. For ease of interpretation, the distance from the quarry covariate is measured in miles (not its natural log). Results are illustrated in Figure 1, which includes the confidence interval. Consistent with the regression analysis, prices tend to fall as distance from the quarry increases, though the effect is small. The low housing density near the quarry is apparent in the scatter plot and the large confidence interval around the estimated relationship when near the quarry. While some statistically significant coefficients are found, across all the models there is very little evidence to suggest the quarry is affecting home prices.

Figure 1. Semiparametric Regression, Findlay



Following Ford and Seals (2018), an empirical distribution of a distance-from-site coefficient is crafted using Randomized Inference. One thousand locations are chosen randomly, and then the distance-from-site coefficient is estimated.[26] The quarry-distance covariate is excluded (but replaced by the distance from the random site) but all other variables are included in the regression, so the model most closely resembles Model A from Table 3 with a coefficient on the quarry-distance variable of -0.030 with a p-value of 0.285. The 95% confidence interval on the simulated coefficient distribution is -0.095 to 0.074, a wide range that easily encompasses the coefficient value of -0.030. The -0.03 coefficient cuts off 26.1% of the empirical distribution (a one-tail cutoff, a two-tail p-value of 52.2%). Across all simulations, the null hypothesis for the coefficient on simulated locations is rejected 11.8% of the time at the 10% level for tract-clustered errors, which is close to the alpha level. For robust standard errors, the rejection rate is 33.6%, more than three-times the alpha level. The choice of standard errors is important. These rejection rates are well below that reported in Ford and Seals (2018), suggesting randomized inference may produce different rejections rates in different cities (confirmed *infra*) and for models with different covariates (our model has many more covariates than in Ford and Seals 2018). For instance, removing the census-

[26] The maximum distance from the city center in the sample is six miles, so the random locations are chosen within five miles of the city center.

level variables from the model increases the rejection rates to 16.9% for clustered and 58.2% for robust standard errors.

B. *Delaware, Ohio*

Like Hite (2006), Malikov, Sun, and Hite (2018), and Ford and Seals (2018), data on home prices from the city of Delaware, Ohio, are analyzed. The sample include 2,439 home sales subject to the established criteria. Like Findlay, the quarry is in the Southwest corner of the city and adjacent to the municipal airport, which perhaps should disqualify this city from analysis (there are two treatments). The outdoor shooting range just North of the quarry may represent a third treatment. Nonetheless, the city of Delaware has been studied before, so it worth looking at again.

Table 5. Summary of Regression Results, Delaware

Variable	**Model I OLS**	**Model J OLS**	**Model K RREG**	**Model L QREG**
ln(Quarry Dist.)	-0.019	-0.022	0.011	0.009
ln(City Center Dist.)	0.066**	0.049	0.063***	0.070***
ln(sqft)	0.557***	0.596***	0.530***	0.535***
ln(acres)	0076***	0.081***	0.090***	0.075***
Outlier Indicator	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	…	Robust
Observations	2,439	2,439	2,439	2,439
R^2	0.705	0.736	0.881	…

Stat. Sig. * 10% ** 5% *** 1%

Table 5 summarizes both the OLS, RREG and QREG results. About 6.4% of observations are marked as outliers. Prices rise in distance from the city center, square footage, and acreage. The Δ coefficients on the quarry-distance covariate are of mixed sign across model types but none are statistically different from zero and all are quite small. Homes prices are uncorrelated with distance from the quarry.

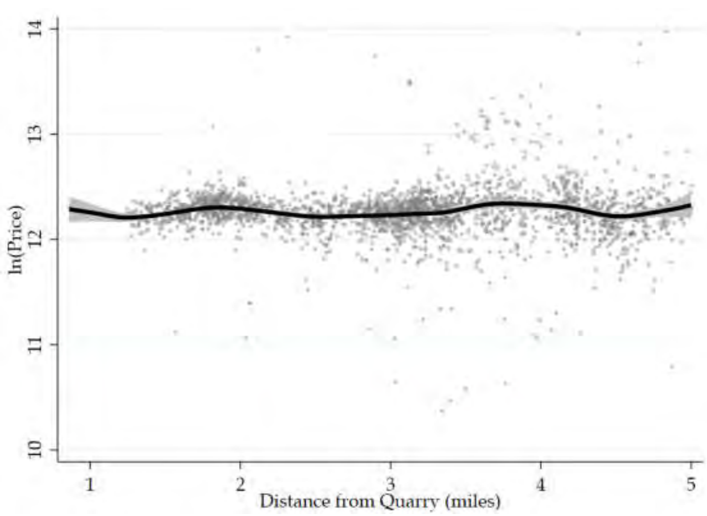
Table 6. Summary of Spatial Regression Results, Delaware

Variable	Model M SDR	Model N SDR	Model O SAR	Model P SEM
ln(Quarry Dist.)	-0.078*	-0.081**	-0.025	-0.034
ln(City Center Dist.)	0.088***	0.038*	0.014	0.072***
ln(sqft)	0.555***	0.582***	0.522***	0.551***
ln(acres)	0.067***	0.073***	0.070***	0.068***
Spatial Lag	-0.271***	-0.133	0.293***	…
Spatial Error	0.903***	0.915***	…	0.582***
Outlier Indicator	No	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust	Robust	Robust	Robust
Observations	2,439	2,439	2,439	2,439

Stat. Sig. * 10% ** 5% *** 1%

Turning to the Spatial Regressions summarized in Table 6, Moran's test statistic is 120.7, which is statistically significant at the 1% level. For the spatial models, the coefficients on the quarry-distance covariate are always negative and statistically different from zero in the two OLS models. If anything, there is a decay in home prices as distance from the quarry increases.

Figure 2. Semiparametric Regression, Delaware



Semiparametric regression, illustrated in Figure 2, offers little more insight than does the regression analysis. Consistent with much of the regression analysis, there is no apparent relationship on prices as distance from the quarry increases, and the thin market near the quarry produces a wide confidence interval.

Randomized Inference is conducted using Model I to determine whether the coefficient is truly unusual. One thousand random locations are selected within seven miles of the city center including locations more than five miles from the quarry. The 95% confidence interval on the empirical coefficient distribution is -0.064 to 0.184, a very wide range that easily encompasses the coefficient value of -0.019 from Model I. The coefficient is not unusual at all, but the t-test indicates the same. Across all simulations, the null hypothesis for the coefficient on simulated locations is rejected 16.1% of the time at the 10% level for tract-clustered errors. For robust standard errors, the rejection rate is 38.5%. As in Ford and Seals (2018), rejection rates for distance coefficients are above the alpha level, though not as high as the earlier study reports.

C. *Lima, Ohio*

If the three quarries analyzed here, the quarry in Lima is closest to the city's center. Of the three cities, Lima has the smallest population and lowest median income, the lowest home prices, and the smallest homes. A sample of 1,169 home sales meeting the sample criteria are included in the analysis. Results are summarized in Table 7 for OLS, RREG, and QREG models. About 4.4% of sales are identified as outliers.

Table 7. Summary of Regression Results, Lima

Variable	Model Q OLS	Model R OLS	Model S RREG	Model T QREG
ln(Quarry Dist.)	0.019	-0.025	-0.110**	-0.018
ln(City Center Dist.)	0.085	0.081	0.074**	0.082*
ln(sqft)	0.490***	0.439***	0.537***	0.469***
ln(acres)	0.136**	0.124**	0.054	0.093**
Outlier Indicator	No	Yes	No	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Clustered	Clustered	…	Robust
Observations	1,169	1,169	1,169	1,169
R^2	0.342	0.421	0.606	…

Stat. Sig. * 10% ** 5% *** 1%

For Lima, three of the four quarry-distance coefficients are negative but only one is statistically significant (RREG). The one positive coefficient is not statistically different from zero. In Lima, there is little-to-no evidence of the quarry being correlated with lower home prices. Prices rise as distance from the city center increases (with two of four coefficients statistically significant) and as home and lot sizes increase.

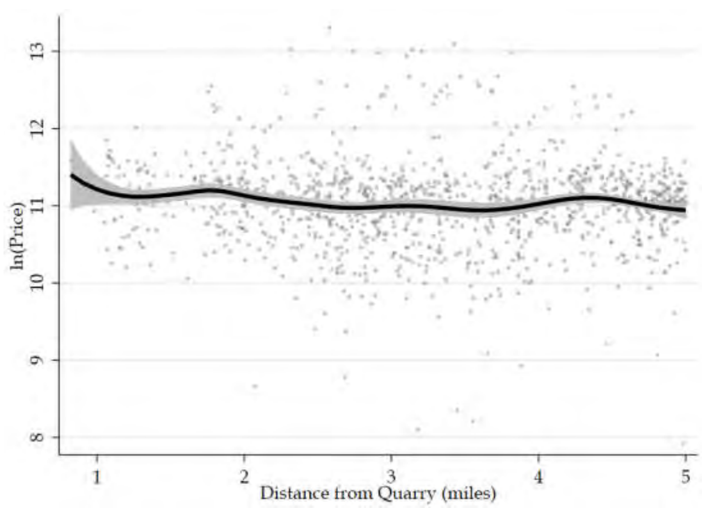
Table 8. Summary of Spatial Regression Results, Lima

Variable	Model U SDR	Model V SDR	Model W SAR	Model X SEM
ln(Quarry Dist.)	-0.065	-0.116	-0.073	-0.011
ln(City Center Dist.)	0.147*	0.158**	0.101**	0.182**
ln(sqft)	0.477***	0.424***	0.475***	0.484***
ln(acres)	0.141***	0.128**	0.138***	0.142***
Spatial Lag	0.520***	0.607***	0.589***	…
Spatial Error	0.234	0.132	…	0.621***
Outlier Indicator	No	Yes	No	No
Year Fixed Effects	Yes	Yes	Yes	Yes
Standard Errors	Robust	Robust	Robust	Robust
Observations	1,169	1,169	1,169	1,169

Stat. Sig. * 10% ** 5% *** 1%

Results from the spatial regression (summarized in Table 8) are comparable. Moran test is 35.5 with probability less than 0.01. For the Spatial Regressions, the quarry-distance covariates are negative but never statistically different from zero at standard levels. Spatial models have very similar coefficients to the non-spatial models with the exception of the two distance variables (as might be expected).

Figure 3. Semiparametric Regression, Lima



Semiparametric regression, illustrated in Figure 3, shows declining prices as distance from the quarry increases, a result consistent with the regression analysis. Confidence intervals are again wide nearer the quarry. There is nothing in the figure, or in the regression results, to suggest that the quarry reduces home prices.

Nor do we expect that the quarry increases home prices but view the negative coefficients as largely an artifact of distance-from-site covariates. Indeed, Randomized Inference on Model Q produces an empirical distribution with a wide range. The 95% confidence interval of the distance coefficients is -1.45 to 1.38, whereas the coefficient on quarry-distance from Model Q is 0.02. The overall rejection for clustered errors is only 74.6% and 81.5% for robust standard errors. Plainly, the generalizability of distance-from-site models is suspect.

V. Analysis of Prior Evidence

A sketch of the data from the Malikov, Sun and Hite (2018) are available online.[27] The data do not permit a reproduction of the paper's results, so only a limited analysis of the data is permitted. For instance, parcels and their locations are not identified, precluding spatial analysis (though OLS and spatial regression produce similar results above). The data covers the entire county (not just Delaware city) and spans years 2009 through the third-quarter of 2011. The data does not include a distance-from-city-center variable or the year of sale indicators, which are omitted variables. There are 5,500 observations in the sample.

Using county level data includes homes quite distant from the quarry (as high 15 miles). In Hite (2006) and here, distance from the quarry was limited to five miles. Presumably, the effects, if any, of the quarry would be limited to a few miles, as suggested by the analysis above. So, I estimate the model when limiting the distance to the quarry to five miles (Model Z). Standard errors are clustered at the block-group level, since a variable in the dataset is block-group level. Results are summarized in Table 9.

Table 9. Summary of Regression Results

Variable	Model Y	Model Z
ln(Quarry Dist.)	0.068***	-0.124***
ln(sqft)	0.693***	0.662***
ln(acres)	0.089***	0.122***
Outlier Indicator	No	No
Year Fixed Effects	No	No
Standard Errors	Clustered	Clustered
Observations	5,500	1,173
R^2	0.658	0.514
Stat. Sig. * 10% ** 5% *** 1%		

27 Data available at: http://qed.econ.queensu.ca/jae/2019-v34.1/malikov-sun-hite.

For the full sample (Model Y) of the Malikov, Sun, and Hite (2018) study, the coefficient on the quarry-distance variable is positive and statistically different from zero. When limiting the date to home sales within five-miles of the quarry (Model Z), the coefficient is negative and statistically different from zero. A review of the data indicates that the average home size rises sharply at about six miles, so it appears there is an anomaly in the real estate market far from the quarry that may be driving the positive coefficient.[28] The results from a distance-from-site hedonic model appear very sensitive to model specification and the data used.

VI. Conclusion

For many Americans, a home is their most valuable asset. Naturally, the threat of a reduction in home values causes concern. Opposition to rock quarries, which are typically located in rural areas with low housing density, is motivated, in large part, by a fear of a loss in home values. Yet, the geographic scope of a quarry's activities is narrow and usually less than one-half mile. Modern quarrying methods have greatly reduced the influence of quarry operations on surrounding areas. Evidence supporting the effect of a quarry on home values is scant, which is something I attempt to rectify here with the most extensive study to date. Evidence from three cities for thousands of home sales reveals no robust effect of quarries on home values.

Like most prior studies, I do not estimate plausibly causal effects. Ideally, Difference-in-Differences methods, or some other causal model, would be used, as in Ford and Seals (2018). An impediment to causal analysis is the difficulty in obtaining sufficient samples of home sales around new quarry sites given their mostly rural locations. Correlation studies are most frequently cited before regulators, so these results are useful in that respect. However, I stress that this study, as well as the commonly cited Hite (2006) study, as well as Malikov, Sun and Hite (2018), need not offer plausibly causal estimates of the effect of quarries on home sales.

I note that efforts to establish the effect of a (dis)amenity on home prices is not merely an academic exercise. Such studies may be relied upon for public policy decisions restricting property rights of landowners and potentially affecting millions of dollars in economic activity. Distance-from-site regressions, as I demonstrate here, are unreliable and often plagued by selection bias. Results are often sensitive to the richness of the model, the estimation method, and the

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[28] The average square footage within five miles of the quarry is 1,901. Between five and ten miles from the quarry, the average home size is 2,887.

geographic scope of the data. A serious effort to assess the robustness of any estimate, using different methods, models, data, and inference procedures (including Randomized Inference), seems prudent if not essential.

APPENDIX:

Variable Definitions

Variable	Description
ld_quarry	Natural log of distance from quarry in miles.
ld_center	Natural log of distance from the city center in miles
lsqft	Natural log of home's square footage.
lacres	Natural log of home's lot size in acres.
basementshare	Percentage of square footage in basement.
onestory	House has one story.
lage	Natural log of age of home.
remodel10	Home remodeled in the 10 years prior to sale.
airc	Home has central air conditioning.
bedroomsN	Home as N bedrooms. "m" indicates "or more."
fullbathN	Home has N full bathrooms. "m" indicates "or more."
halfbathN	Home has N half bathroom. "m" indicates "or more."
fireplaceN	Home has N fireplaces. "m" indicates "or more."
gradeN	Grade of N for housing construction.
condN	Condition N of household.
garage_	AF (attached finished); AU (attached unfinished); DF (detached unfinished); DU (detached unfinished); BA (basement attached); CP (carport); N indicates count of garages.
lmedinc	Natural log of median income in census block group.
white	Share of white population in census block group.
vacant	Share of vacant homes in census block group.
outlier	Outlier indicator.

Table A-3. Findlay, Ohio

	Model A	Model B	Model C	Model D
ld_quarry	-0.0299	-0.0325	-0.0313***	-0.0417***
ld_center	0.0107	0.00132	0.0318***	0.0335**
lsqft	0.386***	0.409***	0.484***	0.482***
lacres	0.0414	0.0864***	0.0666***	0.0586***
basementsh~e	0.215***	0.220***	0.188***	0.183***
onestory	0.0193	0.00819	-0.0019	0.00453
lage	-0.0477**	-0.0555***	-0.105***	-0.103***
remodel10	0.123**	0.0918	0.0647**	0.0868**
airc	0.174***	0.132***	0.109***	0.126***
bedrooms2	0.0109	-0.0757	0.00393	-0.0112
bedrooms3	0.0503	-0.0464	0.0372	0.0186
bedrooms4	0.0825	-0.0259	0.0308	0.0147
bedrooms5m	-0.0455	-0.0956	-0.0124	-0.0486
fullbath2	0.159***	0.149***	0.115***	0.114***
fullbath3	0.280***	0.298***	0.159***	0.157***
fullbath4m	0.246	0.421**	0.336***	0.395***
halfbath1	0.0553***	0.0535***	0.0478***	0.0388***
halfbath2m	0.246***	0.293***	0.120***	0.111***
fireplace1	0.0812***	0.0655**	0.0409***	0.0540***
fireplace2m	0.108**	0.130*	0.0617***	0.0397
gradeB	-0.416***	-0.328**	-0.252***	-0.243***
gradeC	-0.554***	-0.489***	-0.386***	-0.375***
gradeD	-0.655***	-0.557***	-0.482***	-0.484***
condG	0.584**	-0.0595	-0.0667	0.116
condA	0.578**	-0.1	-0.0905*	0.114
condF	0.352	-0.19	-0.129**	0.0185
garage_AF	0.123***	0.0976***	0.0496***	0.0674***
garage_AU	0.0892**	0.0673***	0.0309***	0.0470***
garage_DF	0.0852	0.105	0.0196	0.0256
garage_DU	0.0646	0.0952*	0.0166	0.00765
garage_BA	0.0882	0.314**	-0.0222	-0.00473
garage_CP	-0.119	0.135	-0.0807	-0.109
lmedinc	0.0984*	0.0971**	0.0837***	0.0675***
white	0.302**	0.323**	0.144***	0.208***
vacant	-0.151	-0.141	-0.0632	-0.0834
outlier		-0.776***		
_cons	7.136***	7.908***	7.737***	7.631***
Year Fixed Effects	Yes	Yes	Yes	Yes
N	2,843	2,843	2,843	2,843
R2	0.645	0.723	0.838	
Sig. Level: * 10% ** 5% *** 1%				

Table A-3. Findlay, Ohio

	Model A	Model B	Model C	Model D
ld_quarry	-0.0298	-0.036	-0.00921	-0.0562**
ld_center	-0.0268	-0.0416*	-0.00144	0.011
lsqft	0.345***	0.368***	0.341***	0.361***
lacres	0.0384**	0.0854***	0.0145	0.107***
basementsh~e	0.190***	0.195***	0.200***	0.193***
onestory	0.0216	0.0119	0.0191	0.0111
lage	-0.0189*	-0.0294***	-0.0187*	-0.0265**
remodel10	0.138***	0.108**	0.133***	0.116***
airc	0.156***	0.116***	0.171***	0.101***
bedrooms2	0.00348	-0.0825**	0.0127	-0.0899**
bedrooms3	0.0428	-0.053	0.0526	-0.0602
bedrooms4	0.0679	-0.0399	0.0840*	-0.0506
bedrooms5m	-0.0506	-0.100*	-0.0376	-0.107*
fullbath2	0.134***	0.125***	0.140***	0.118***
fullbath3	0.252***	0.269***	0.254***	0.270***
fullbath4m	0.225***	0.393***	0.246***	0.362***
halfbath1	0.0439***	0.0428***	0.0480***	0.0423***
halfbath2m	0.241***	0.289***	0.239***	0.284***
fireplace1	0.0630***	0.0489***	0.0627***	0.0453***
fireplace2m	0.103***	0.122***	0.107***	0.103***
gradeB	-0.391***	-0.300***	-0.407***	-0.285***
gradeC	-0.505***	-0.437***	-0.527***	-0.422***
gradeD	-0.602***	-0.501***	-0.629***	-0.479***
condG	0.510***	-0.107	0.508***	-0.0987
condA	0.504***	-0.146*	0.491***	-0.123
condF	0.274***	-0.241***	0.260***	-0.209**
garage_AF	0.100***	0.0770***	0.0962***	0.0869***
garage_AU	0.0800***	0.0595***	0.0812***	0.0618***
garage_DF	0.0735	0.0974	0.0796	0.0864
garage_DU	0.0691	0.0976**	0.0716	0.0982***
garage_BA	0.0977	0.317***	0.0871	0.336***
garage_CP	-0.12	0.134*	-0.132	0.137*
lmedinc	0.0343	0.0364	-0.00608	0.111***
white	0.160*	0.176**	0.189**	0.183
vacant	-0.164	-0.153	-0.16	-0.147
outlier		-0.760***		-0.742***
_cons	-2.541**	-1.769*	-1.706***	8.189***
Year Fixed Effects	Yes	Yes	Yes	Yes
lprice	0.912***	0.907***	0.880***	
e.lprice	0.941***	0.953***		3.012***
var(e.lprice)	0.105***	0.0818***	0.107***	0.0814***
N	2,843	2,843	2,843	2,843

Sig. Level: * 10% ** 5% *** 1%

Table A-5. Delaware, Ohio

	Model I	Model J	Model K	Model L
ld_quarry	-0.0194	-0.0222	0.0106	0.00898
ld_center	0.0661**	0.0489	0.0629***	0.0702***
lsqft	0.557***	0.596***	0.529***	0.535***
lacres	0.0758***	0.0805***	0.0895***	0.0754***
onestory	0.0775**	0.0860**	0.0765***	0.0853***
lage	-0.0358**	-0.0314*	-0.0481***	-0.0422***
remodel10	0.0439***	0.0508***	0.0602***	0.0405***
airc	0.0437	0.0191	-0.0221**	0.016
fullbase	0.149***	0.150***	0.145***	0.151***
partbase	0.118***	0.113***	0.129***	0.136***
bedrooms2	0.0283	-0.260***	0.156**	0.251***
bedrooms3	0.140**	-0.183**	0.192***	0.315***
bedrooms4	0.117**	-0.215**	0.174**	0.300***
bedrooms5m	0.0981*	-0.186**	0.0941	0.234***
fullbath2	0.0361	0.0406	0.0715***	0.0665***
fullbath3	0.144**	0.144**	0.157***	0.153***
fullbath4m	0.190**	0.212**	0.186***	0.165***
halfbath1	0.0297	0.0297	0.00161	0.00818
halfbath2m	0.217***	0.261***	0.133***	0.157***
fireplace1	0.0346*	0.0330*	0.0348***	0.0324***
fireplace2	0.157**	0.166**	0.0703***	0.0731*
fireplace3m	0.396***	0.513***	0.301***	0.341***
lmedinc	0.101*	0.112*	0.0703***	0.0780***
white	0.0902	-0.0233	0.0952*	0.0558
vacant	0.0482	0.0143	-0.185**	-0.309***
garage1	0.0983**	0.0728**	0.0287**	0.0569***
garage2	0.109**	0.0869**	0.0445***	0.0687***
garage3	0.108**	0.123***	0.131***	0.152***
garage4m	0.195***	0.233***	0.146***	0.148***
outlier		-0.378***		
_cons	6.272***	6.356***	6.978***	6.652***
Year Fixed Effects	Yes	Yes	Yes	Yes
N	2,439	2,439	2,439	2,439
R2	0.705	0.736	0.881	

Sig. Level: * 10% ** 5% *** 1%

Table A-6. Delaware, Ohio

	Model I	Model J	Model K	Model L
ld_quarry	-0.0778*	-0.0810**	-0.0246	-0.0337
ld_center	0.0879***	0.0383*	0.0139	0.0716***
lsqft	0.555***	0.582***	0.522***	0.551***
lacres	0.0669***	0.0730***	0.0696***	0.0677***
onestory	0.0633***	0.0745***	0.0705***	0.0653***
lage	-0.0294***	-0.0246***	-0.0278***	-0.0287***
remodel10	0.0408**	0.0478***	0.0398**	0.0417**
airc	0.0415**	0.0163	0.0493**	0.0423**
fullbase	0.139***	0.133***	0.133***	0.137***
partbase	0.109***	0.0992***	0.106***	0.108***
bedrooms2	0.0514	-0.248**	0.0651	0.0492
bedrooms3	0.176	-0.162	0.185	0.175
bedrooms4	0.156	-0.192	0.161	0.151
bedrooms5m	0.148	-0.15	0.141	0.141
fullbath2	0.0312	0.0416**	0.0387**	0.0340*
fullbath3	0.134***	0.134***	0.133***	0.141***
fullbath4m	0.198***	0.225***	0.190***	0.199***
halfbath1	0.0265	0.0311**	0.0291*	0.0267
halfbath2m	0.202***	0.252***	0.208***	0.203***
fireplace1	0.0291**	0.0286**	0.0328***	0.0308**
fireplace2	0.152***	0.161***	0.160***	0.154***
fireplace3m	0.390***	0.515***	0.398***	0.389***
lmedinc	0.125***	0.120***	0.0589**	0.103***
white	0.0953	0.0323	0.222**	0.105
vacant	0.0685	0.077	0.122	0.0323
garage1	0.0920***	0.0743***	0.104***	0.0928***
garage2	0.0958***	0.0804***	0.112***	0.0974***
garage3	0.126***	0.143***	0.124***	0.128***
garage4m	0.217***	0.247***	0.215***	0.221***
outlier		-0.405***		
_cons	9.345***	7.987***	3.256***	6.264***
Year Fixed Effects	Yes	Yes	Yes	Yes
lprice	-0.271***	-0.133	0.293***	
e.lprice	0.903***	0.915***		0.582***
var(e.lprice)	0.0652***	0.0573***	0.0660***	0.0660***
N	2,439	2,439	2,439	2,439

Sig. Level: * 10% ** 5% *** 1%

Table A-7. Lima, Ohio

	ModeQ	Model R	Model S	Model T
ld_quarry	0.0185	-0.0254	-0.110**	-0.0178
ld_center	0.0854	0.081	0.0738	0.0822
lsqft	0.490***	0.439***	0.537***	0.469***
lacres	0.136**	0.124**	0.0539	0.0931**
basementshare	0.262**	0.317**	0.292**	0.294
onestory	0.00474	0.0125	0.123***	0.0622
lage	-0.290***	-0.269***	-0.294***	-0.267***
remodel10	0.0369	0.0134	0.126**	0.0521
airc	0.0383	0.0843**	0.185***	0.124***
fullbase	0.00846	-0.0221	-0.0231	-0.0262
bedrooms2	0.0905	0.256	-0.000842	0.0675
bedrooms3	0.128	0.282	-0.0157	0.0549
bedrooms4	-0.0346	0.0509	-0.0484	-0.00189
bedrooms5m	0.388	0.169	0.15	0.268*
fullbath2	0.022	0.0201	0.0736*	0.0611
fullbath3	-0.148	0.268	-0.0671	-0.136
fullbath4m	0.362	0.503	-0.0121	0.44
halfbath1	0.0109	0.0289	0.0863**	0.0623*
halfbath2m	-0.303**	-0.741**	-0.126	-0.286
fireplace1	0.0494	0.0535	0.0937**	0.0438
fireplace2m	0.0548	0.0399	0.104	0.0627
gradeB	-0.0611	0.656	-0.733**	-0.29
gradeC	-0.378	0.438	-1.033***	-0.58
gradeD	-0.655	0.141	-1.343***	-0.898**
garage1	0.0153	0.0115	0.0552	0.0584*
garage2	0.0512	-0.00986	0.0112	0.0174
garage3	0.258*	0.0308	0.106	0.116
lmedinc	0.185*	0.247**	0.365***	0.240***
white	-0.097	-0.0152	0.0495	0.0301
vacant	-0.347	-0.446*	-0.389**	-0.375*
outlier		1.203***		
_cons	7.132***	5.773***	5.339***	6.657***
Year Fixed Effects	Yes	Yes	Yes	Yes
N	1,169	1,169	1,169	1,169
R2	0.333	0.432	0.591	

Sig. Level: * 10% ** 5% *** 1%

Table A-8. Lima, Ohio

	Model U	Model V	Model W	Model X
ld_quarry	-0.0654	-0.116	-0.0728	-0.0109
ld_center	0.147*	0.158**	0.101	0.182**
lsqft	0.477***	0.424***	0.475***	0.484***
lacres	0.141***	0.128***	0.138***	0.142***
basementsharee	0.253	0.315*	0.26	0.245
onestory	-0.00787	-0.00536	0.00659	-0.0185
lage	-0.278***	-0.253***	-0.284***	-0.275***
remodel10	0.0176	-0.00967	0.0164	0.0221
airc	0.0174	0.0587	0.0253	0.017
fullbase	0.0219	-0.00563	0.0194	0.0195
bedrooms2	0.101	0.27	0.0998	0.101
bedrooms3	0.154	0.311*	0.153	0.149
bedrooms4	0.00679	0.0949	0.000812	0.00597
bedrooms5m	0.407	0.194	0.402	0.401
fullbath2	0.00796	0.00387	0.0166	0.00293
fullbath3	-0.159	0.261	-0.145	-0.173
fullbath4m	0.454	0.599	0.463	0.415
halfbath1	0.000382	0.0165	0.00212	0.00102
halfbath2m	-0.309	-0.752***	-0.315	-0.303
fireplace1	0.0408	0.0411	0.0396	0.0488
fireplace2m	0.0432	0.0249	0.0482	0.0452
gradeB	-0.0228	0.693*	-0.0338	-0.027
gradeC	-0.318	0.5	-0.333	-0.33
gradeD	-0.551	0.252	-0.57	-0.569
garage1	0.0114	0.00475	0.0193	0.00653
garage2	0.0508	-0.00981	0.0521	0.0486
garage3	0.241	0.0132	0.251	0.229
lmedinc	0.123*	0.183***	0.119*	0.148**
white	-0.103	-0.00632	-0.129	-0.0813
vacant	-0.242	-0.343	-0.228	-0.287
outlier		1.211***		
_cons	3.384	1.947	2.293*	7.409***
Year Fixed Effects	Yes	Yes	Yes	Yes
lprice	0.401**	0.407**	0.512***	
e.lprice	0.326	0.396*		0.585***
var(e.lpri~)	0.371***	0.324***	0.372***	0.373***
N	1,169	1,169	1,169	1,169

Sig. Level: * 10% ** 5% *** 1%

2018 FORD AND SEALS REPORT

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Phoenix Center Policy Paper Number 53:

Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence

George S. Ford, PhD
R. Alan Seals, PhD

(March 2018)

Electronic copy available at: https://ssrn.com/abstract=3138712

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Quarry Operations and Property Values: Revisiting Old and Investigating New Empirical Evidence

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Abstract: A large literature exists on the impact of disamenities, such as landfills and airports, on home prices. Less frequently analyzed is the effect of rock quarries on property values, and what little evidence is available is dated and conflicting. This question of price effects is a policy relevant one, with one study in particular used frequently to support "not in my backyard" campaigns against new quarry sites. In this POLICY PAPER, we revisit the literature and conduct a new analysis of the price effects of quarries, estimating the effect of quarries on home prices with data from four locations across the United States and a wide range of econometric specifications and robustness checks along with a variety of temporal circumstances from the lead-up to quarry installation to subsequent operational periods. We find no compelling statistical evidence that either the anticipation of, or the ongoing operation of, rock quarries negatively impact home prices. Our study likewise highlights a number of shortcomings in the empirical methodologies generally used to estimate the effect of disamenities on real estate prices. First and foremost, many existing studies are naïve as to the empirical conditions necessary to identify a causal relationship and do not establish credible strategies to estimate the counter-factual outcome. Second, the inclusion of "distance to the site" regressors in hedonic models is shown to be an unreliable statistical method. Using the method of randomized inference, the null hypothesis of "no effect" of placebo quarries is rejected in as much as 93% of simulations.

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I. Background

Odds are that underneath your feet is a construction material made of sand, crushed stone, and gravel. These construction materials are an essential ingredient into nearly every construction project, from residential housing, office buildings, retail outlets, entertainment structures, to the roads that connect them.[1] Sand, rock and gravel are literally the foundation of economic development, but their extraction process can generate dust, noise, vibration, and truck traffic. While modern technologies and methods have greatly reduced quarries' impact, the environmental and economic consequences of quarry operations receive considerable attention, often in the form of "not in my backyard" (or "NIMBY") campaigns opposing quarry expansions or new sites. Choosing a quarry site is a delicate task. While a quarry may be best located far from residential density on NIMBY concerns, it also needs to be near the final point of demand due to its high transportation cost. Quarries must balance the need to be both "near" and "far," so they are typically found on the outskirts of cities and towns.

A key NIMBY complaint in the siting and expansion of quarries is the effect of the operations on nearby home values. According to Census data, housing amounts to about 70% of the average American's net wealth, so naturally homeowners are sensitive to any adverse effect, real or imagined, on property values.[2] Despite NIMBY opposition, nearly all the evidence on quarry operations finds no price effect. Frequently mentioned studies include Rabianski and Carn (1987) and Dorrian and Cook (1996), both of which find no relationship between appreciation rates of property values near to and far from quarries.[3] An

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1 *2014 Minerals Yearbook, Construction Sand and Gravel*, U.S. Geological Survey (2014) at p. 1 (available at: https://minerals.usgs.gov/minerals/pubs/commodity/sand_&_gravel_construction/myb1-2014-sandc.pdf) ("Construction sand and gravel is a traditional basic building material and is one of the earliest materials used by humans for dwellings and later for outdoor areas such as paths, roadways, and other constructs. Despite the relatively low, but increasing, unit value of its basic products, the construction sand and gravel industry is a major contributor to and an indicator of the economic well-being of the Nation").

2 *Wealth, Asset Ownership, & Debt of Households Detailed Tables: 2013*, U.S. Census Bureau (2017) (available at: https://www.census.gov/data/tables/2013/demo/wealth/wealth-asset-ownership.html).

3 A.M. Dorrian and C.G. Cook, *Do Rock Quarry Operations Affect Appreciation Rates of Residential Real Estate*, Working Paper (1996); J. Rabianski and N. Carn, *Impact of Rock Quarry*

even earlier study conducted for the U.S. Bureau of Mines in 1981 also found no consistent relationship between quarry operations and the prices of nearby homes.[4] There are a number of consulting reports on the question, and none report price attenuation attributable to a quarry.[5]

Opposition to quarries based on home valuations relies universally on a report by Professor Patricia Hite (2006).[6] This brief, 250-word study (hereinafter the "*Hite Report*") analyzes data from a few thousand homes sales (apparently in the mid-to-late 1990s) around a single quarry in Delaware, Ohio. Using an unconventional regression model and data on transactions occurring decades after the quarry opened, the *Hite Report* finds a positive relationship between home prices and distance from the quarry. Based on that evidence, the *Hite Report* concludes that quarries reduce home values. Yet, the *Hite Report*'s methods and data do not support a causal interpretation.

As economic development marches on, new quarries will be required to satisfy the demand for basic building materials. In light of the mostly dated and conflicting evidence on the effect of quarries on housing prices, this POLICY PAPER offers new evidence, and a review of old evidence, on the relationship between housing prices and rock quarries. First, given its frequent use by NIMBY opposition to quarries, we revisit the *Hite Report*, analyzing home sales data

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Operations on Value of Nearby Housing, Prepared for the Davidson Mineral Properties (August 25, 1987).

4 M. Radnor, D. Hofler, *et al.*, *Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries*, U.S. Bureau of Mines (May 1981) (available at: http://www.cdc.gov/niosh/nioshtic-2/10006499.html).

5 *See*, *e.g.*, *Study of Impact of Proposed Quarry on The Real Estate Values of Surrounding Residential Property in Raymond, New Hampshire*, Crafts Appraisal Associates Ltd. (April, 2009) ("The evidence does however suggest that the overall marketplace does not react to an influence such as a quarry with a measurable negative reaction as it relates to sale price."); *Martin Marietta New Design Quarry: Analysis of Effect on Real Estate Values*, Stagg Resources Consultants, Inc. (November 17, 2008); *A Property Valuation Report: Affect [sic] of Sand and Gravel Mines on Property Values*, Banks and Gesso, LLC (October 2002); *Impacts of Rock Quarries on Residential Property Values in Jefferson County, Colorado*, Banks and Gesso, LLC (May 1998); R.J. McKown, *Analysis of Proposed Sand & Gravel Quarry: Granite Falls, WA*, Schueler, McKown & Keenan, Inc. (September 25, 1995).

6 D. Hite, *Summary of Analysis: Impact of an Operational Gravel Pit on House Values: Delaware County, Ohio*, Working Paper (2006). We assign the date "2006" as is conventional, but that year is merely the recording stamp date on the document when it was filed in some type of proceeding. We do not know whether a more detailed analysis was provided at some point. We have never seen such a document cited and were unable to locate it.

around the same Delaware-Ohio quarry. Despite replicating both the location and methods of the *Hite Report*, our regression analysis finds that prices *fall*—not rise—as distance from the quarry increases. This result conflicts with that appearing in the *Hite Report*, so we look for more evidence by analyzing data on homes sales near a quarry outside of Murfreesboro, Tennessee, over the same time interval. Again, we find prices *fall* as distance from the quarry increases.

We are reluctant, however, to claim this evidence implies quarries raise home prices. Rather, we conclude, based on the method of randomized inference and other tests, that the *Hite Report*'s method is unreliable. Using a simulation of pseudo-treatments, we find that the null hypothesis that home prices rise or fall in distance from a *randomly selected location* is rejected in no less than 67% of cases at the 10% nominal significance level. Estimating price-distance relationships, especially without explicitly considering selection bias, is a highly-unreliable statistical procedure. The nature of real estate markets do not permit the effect of quarries to be identified with such naïve empirical tests.

Second, using data on home sales near a relatively new quarry in Gurley, Alabama, we augment the Hite-style analysis with a difference-in-differences estimator, which quantifies the price-distance relationship both before-and-after operations begin. By exploiting the timing of the quarry buildout and the location of home sales with respect to the quarry, we can credibly identify a causal relationship, at least in theory. Unlike the analysis for Delaware and Murfreesboro, home prices rises in distance from the Gurley quarry site, but do so *before* the quarry becomes operational. After operations begin in 2013, the positive effect of distance is attenuated, again suggesting a positive effect of quarries on housing values.

One critique of our Gurley analysis is that market participants shift price forecasts downward in response to the prospect of a quarry so that the deleterious effects of the quarry could be realized before the quarry opens. Quarry site approvals normally take a decade or so, providing ample time for anticipatory responses to valuation fears. To address this concern, we analyze transactions near a recently approved quarry in Madera County, California. Using a difference-in-differences estimator in conjunction with Coarsened Exact Matching, we test for the anticipatory effect of the proposed quarry on nearby housing prices located along the major roadways serving the site. We find no evidence the quarry reduced housing prices. If anything, relative home prices rose near the quarry site.

While our evidence suggests that quarries do not reduce, but may increase, home prices, our analysis suggests more than anything that the identification of the effect of quarries on prices is a very difficult problem, facing many conceptual and practical obstacles. We do not resolve all these difficulties. That said, we can conclude the evidence strongly implies the *Hite Report* and its methods are unreliable. Further analysis is, as usual, encouraged.

This paper is outlined as follows. First, we discuss the empirical requirements of quantifying a plausibly causal relationship between property values and quarry operations. Second, we revisit the *Hite Report*, estimating the price-distance relationship for the same quarry in Delaware, Ohio, and replicating the analysis for a quarry near Murfreesboro, Tennessee. Using a simulation method, we demonstrate the futility of estimating the price effects of quarries using the method proposed in the *Hite Report*. Third, we turn to the estimation of causal effects using the difference-in-differences estimator for quarry sites in Gurley, Alabama, and Madera County, California. Across multiple methods, we find, if anything, that home prices near quarries rise, not fall. In all, however, we believe our analysis best supports the hypothesis of "no effect" of quarries, or the announcement of quarries, on home prices. Conclusions are provided in the final section.

II. Empirical Framework

Disamenities such as landfills, airports, windfarms and prisons may plausibly reduce the prices of nearby homes. Such effects have been widely studied.[7] Modern empirical methods for observational data based on the Rubin Causal Model, however, suggest that much of the work may offer biased estimates of such disamenities because much it looks only at prices after the "treatment," making it difficult to address selection bias.[8] To conclude that a disamenity reduces home values, the researcher's interest must be in the *causal effect* of an amenity or disamenity on property values. Using only post-treatment prices is problematic since the locations of amenities and disamenities are not randomly selected, and

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[7] Other disamenities that may affect property values, airports and waste disposal, are frequently opposed by homeowners. *See, e.g.*, J.P. Nelson, *Airport and Property Values: A Survey of Recent Evidence*, 14 JOURNAL OF TRANSPORT ECONOMICS AND POLICY 37-52 (1980) (available at: http://www.bath.ac.uk/e-journals/jtep/pdf/Volume_X1V_No_1_37-52.pdf); J.B. Braden, X. Feng, and D. Won, *Waste Sites and Property Values: A Meta-Analysis*, 50 ENVIRONMENTAL AND RESOURCE ECONOMICS 175-201 (2011).

[8] Excellent resources on the modern methods of causal inference for economic analysis include G.W. Imbens and J.M. Wooldridge, *Recent Developments in the Econometrics of Program Evaluation*, 47 JOURNAL OF ECONOMIC LITERATURE 5-86 (2009); J.D. Angrist and J. Pischke, MOSTLY HARMLESS ECONOMETRICS: AN EMPIRICIST'S COMPANION (2008); and J.D. Angrist and J. Pischke, MASTERING 'METRICS: THE PATH FROM CAUSE TO EFFECT (2015).

disamenities are typically located away from residential density to minimize impact and to placate NIMBY resistance.

The non-random selection of a quarry site greatly complicates the quantification of a quarry on housing prices due to selection bias. Finding that housing prices rise at increased distance from a quarry may merely reflect the economics of site choice (i.e., real estate is cheaper per unit in less densely populated areas on the outskirts of town) rather than any causal effect on property values. Also and consequently, empirical work may be frustrated by the lack of housing density near the site, rendering small sample sizes, which may, in turn, lead to the undue influence of outliers. Many quarries, especially new ones, have almost no housing within a mile or two of the site (the typical distance within which negative effects are claimed), as shown in the maps provided in the Appendices. And, given the lengthy approval process, if a quarry does affect housing prices, then such effects may occur prior to operations by an "announcement effect." In conducting empirical work on quarries and housing prices, the researcher must address, and deal with the theoretical and empirical consequences of, the non-random nature of site location.

A. *Quantifying the Effect of a Quarry on Housing Prices*

Resistance to new quarry sites (or the expansions of old ones) based on property values rests exclusively on the *Hite Report*. In that report, the effect on prices is quantified by comparing the mean, quality-adjusted transactions prices around the quarry outside of Delaware, Ohio, as the home's distance from the quarry increases. This "experiment," however, has little hope of accurately measuring the effect of quarries on home prices.

To better grasp the nature of the problem, let there be two types of residential locations: (1) locations proximate to and potentially affected by quarry operations (labeled *N*, for "near"); and (2) locations distant from and entirely unaffected by quarry operations (labeled *F*, for "far"). Also, let there be two periods: the period prior to (t = 0) and after (t = 1) the initiation of quarry operations. For now, assume the approval process is instantaneous and that the quality and type of homes in the two locations are very similar (or, that such differences can be accounted for by statistical methods).

Prior to quarry operations homes sell for the average price P_0^N if near the future location of the quarry and P_0^F otherwise. (A numerical example is provided later.) For various reasons, these prices need not be equal. After quarry operations begin, the average, quality-adjusted prices for houses are P_1^N and P_1^F. The differences in the prices across time (P_1 - P_0) are δ^N and δ^F. Other things constant, the effect of the quarry operations can be measured as,

$$\Delta = \delta^N - \delta^F = \left(P_1^N - P_0^N\right) - \left(P_1^F - P_0^F\right), \tag{1}$$

where Δ is the difference-in-differences ("DiD") estimator.[9] The DiD estimator looks for a difference in outcomes after the treatment that is difference than the differences in outcomes before the treatment (thus, explaining the term difference-in-differences). Under certain conditions, the DiD estimator plausibly measures the causal effect of the quarry.

Many studies of the effect of amenities or disamenities on housing values looks only at the difference between *near* and *far* locations in the *post-treatment* period, or the difference in P_1^N and P_1^F (or δ_1). This post-treatment approach is the one used in the *Hite Report*, where all the data is from sales decades after the quarry operations began. If, however, there is a difference in prices before the quarry operations begin, this post-operations difference is clearly not a measure of the effect of proximity to the quarry. A numerical example may prove helpful.

B. *A Numerical Example*

Before a quarry opens, assume the average, quality-adjusted price for a home near the quarry site is $80,000, but the average price is $100,000 for homes far from the future quarry site. Thus, there is a $20,000 or 20% difference in prices prior to quarry operations, perhaps reflecting the lack of locational rents for homes far from residential density. Plainly, since quarry operations have not begun, this difference cannot be attributed to the quarry. In fact, the quarry site may have been chosen because of the lower property values or lack of residential housing in the area.

As a benchmark case, say that the quarry operations once initiated have *no effect* on property values and the sales prices of homes are unchanged after quarry operations begin ($80,000 and $100,000, respectively). If a researcher were to

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9 *See*, *e.g.*, B.D. Meyer, *Natural and Quasi-Experiments in Economics*, 13 JOURNAL OF BUSINESS & ECONOMIC STATISTICS 151-161 (1995); J.D. Angrist and A.B. Krueger, *Empirical Strategies in Labor Economics*, in HANDBOOK OF LABOR ECONOMICS Vol. 3A (eds., O. Ashenfelter and D. Card) (1999); S. Galiani, P. Gertler, and E. Schargrodsky, *Water for Life: The Impact of the Privatization of Water Services on Child Mortality*, 113 JOURNAL OF POLITICAL ECONOMY 83-123 (2005); D. Card, *The Impact of the Mariel Boatlift on the Miami Labor Market*, 13 INDUSTRIAL AND LABOR RELATIONS REVIEW 245-257 (1990).

simply compare prices based on distance from the quarry after operations begin, then a difference of 20% would be found. Yet, that difference existed prior to the quarry's opening, and thus the quarry did not *cause* that difference, implying any causal claim made about that difference is mistaken. The truth (by assumption) is that the quarry had *no effect*. The DiD estimator (Δ) is, in fact, zero, correctly identifying the causal effect of the quarry [= (80,000 – 80,000) – (100,000 – 100,000)].

Assume instead that the quarry does reduce prices for nearby homes. Let the post-quarry average prices be $70,000 near and $100,000 far from the quarry, other things constant.[10] Prices near the quarry fall by $10,000 and those far from the quarry are unchanged. The DiD estimator accurately quantifies the effect of the quarry, which is a $10,000 reduction in value [= (70,000 – 80,000) – (100,000 – 100,000)]. Looking at data after the quarry operations begin, alternately, which is the *Hite Report*'s approach, would find an effect size of $30,000 [=70,000 – 100,000], or three times the true effect. Selection bias accounts for the $20,000 error in the estimated effect.

Ideally, then, to properly identify the causal effect of a quarry operation, the researcher must observe prices both before and after the quarry may reasonably be expected to affect housing prices (among other considerations such as the similarity in pricing trends prior to the treatment). The analysis of transactions occurring well after the quarry opens offers little hope for quantifying the effect of the quarry, absent unique circumstances. Certainly, the empirical demands are considerable, and the identification of the causal effect must be explicitly set forth and proper empirical methods applied.

C. *Key Assumptions for Estimating Causal Effects*

With regard to the location of homes and quarries, we do not have the luxury of experimental data. Rather, the data is observational and the data generation process occurs over many decades. The observational nature of the data is crucial: quarry site and housing locations are non-random and not independent of economic activity near the site or each other. Thus, research on the price effects of quarry sites must pay careful attention to selection bias, which is caused by the non-random process by which sites are chosen to avoid residential density but still

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10 For instance, a large condominium complex may have built near the quarry. The researcher must adjust for the difference in average prices resulting from this changing mix of household types).

remain close to the point of demand for aggregates (i.e., sand, stone and gravel). Thus, the "treatment" and "outcome" are related through observed and potentially unobserved factors.[11]

As explained by Imbens and Wooldridge (2009), when estimating the causal treatment effect in observational studies the researcher must be alert to two key concepts stemming from selection bias: (1) unconfoundedness (or the conditional independence assumption) and (2) covariate overlap (or common support).[12] Unconfoundedness implies that, conditional on observed covariates *X*, the treatment assignment probabilities are independent of potential outcomes. If we have a sufficiently rich set of observable covariates, then regression analysis including the variables *X* leads to valid estimates of causal effects. Since the *X* must be observed to be included in the regression model, this approach is often referred to as *selection on observables*. It is difficult to know and impossible to test whether the observed and included *X* are sufficient to guarantee unconfoundedness (so the regression error and treatment are uncorrelated), though some guidance is available through pseudo-treatment tests (as applied later).

The conditional independence assumption (or *unconfoundedness*) implies that the observed factors included in the statistical analysis fully account for all the differences in the types of homes sold both near and far from the quarry (or other site of interest).[13] In quantifying the effect of education on income, for instance, it is not enough to simply compare the incomes of persons with and without a college education. Work ethic, for instance, affects both the probability that a person will obtain a college degree and his or her future income. A hard-working person may earn a higher income even without a college education. If work ethic cannot be observed, then a comparison of average incomes across those with and without a college degree does not measure the true value of a degree. The difference is a positively biased estimate of the payoff of education.

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11 In regression analysis, this problem appears as a correlation between the regression residual and the treatment variable.

12 *Supra* n. 8.

13 That is, the regression model includes all the regressors needed to make the conditional *near* and *far* prices equal prior to the treatment.

The second factor to consider for the measurement of the causal effect is covariate overlap, which Imbens and Wooldridge (2009) observe is, after unconfoundedness, the "main problem facing the analyst."[14] This condition implies that the support of the conditional distribution of X for the control group overlaps completely with the conditional distribution of X for the treatment group. That is, the covariate distributions for the treated and untreated groups are sufficiently alike, thereby lending credibility to the extrapolations inherent to regression analysis between groups. If the characteristics of untreated observations (home *far from* the quarry) are very different from the treated observations (homes *near to* the quarry), then the projections from the controls to the treated units will be a poor one.

Say, for instance, that a sample used to assess the effect of an experimental cancer treatment includes only persons over 65 years old in the experimental treatment group (or simply treatment group) and only persons below 45 years old in the non- treatment group (or control group). The purpose of the control group is not simply a counterweight to the treatment group. Rather, the control group measures the outcomes for the treated group if that group did not receive the treatment. To fix ideas, what we actually want to estimate is what would the treatment group have looked like had they not been treated, which is the sole purpose of a control group. It is unreasonable to expect, we believe, that the survival outcomes of 45 year-old persons provides an approximation of survival outcomes of persons 65 years and over that did not receive the experimental treatment. To extrapolate this discussion to the case of housing values, if the control group includes almost all homes in a golf course community with swimming pools and the treatment group—the properties near some dis-amenity—includes mostly one-bedroom condominiums, then the difference in sale prices between the two is a nearly meaningless statistic. Regression models are powerful tools, but they cannot make up of for such large differences in characteristics across treatment and control groups (even if observable and included in the regression model as explanatory variables), which is important given that the control group is being "projected" onto the treatment group.

A number of statistical techniques are used to address confoundedness and covariate imbalance in observational studies. In a housing study, for instance, a researcher may choose the control group by finding a group of homes comparable to the treatment group—that is, similar square footage, amenities, lot sizes—from a population of homes unaffected by the treatment. This approach, which we

14 Imbens and Wooldridge, *supra* n. 8 at 43.

employ here, ensures that the characteristics of homes in the treatment and control groups are sufficiently similar, adding credibility to the control group as a suitable "stand in" for the treatment group if it had not received the treatment.

The *Hite Report* is silent on both of these key assumptions, and there is good reason to suspect the analysis fails on both counts. All the pricing data is for home sales occurring long after the quarry operation began and the regression model is quite basic, so the experiment is almost certainly plagued with selection bias. As for covariate overlap, from what few descriptive statistics are provided in the *Hite Report* we observe that the range of home prices within 0.5 miles of the quarry has a minimum of $80.1 and a maximum of $178.9 (in thousands). In contrast, the range of prices for homes further from the quarry is $60 to $798.6. This difference in the maximum prices is sizable, suggesting that the homes near the quarry may be very much unlike those far from the quarry, thus risking biased results of the effect of distance.

III. Revisiting the *Hite Report*

In NIMBY campaigns challenging quarry development, the *Hite Report* is the sole empirical analysis supporting the claim that quarries reduce housing prices. Subsequent works by Erickcek (2006), the Center for Spatial Economics (2009), Smith (2014), among others, conduct no new empirical analysis, choosing instead to extrapolate the *Hite Report*'s results to different locations (a questionable practice on its own).[15]

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[15] G.A. Erickcek, *An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township*, W.E. Upjohn Institute for Employment Research (August 15, 2006) (available at: http://www.stopthequarry.ca/documents/US%20Study%20on%20the%20impact%20of%20pits%20quarries%20on%20home%20prices.pdf); *The Potential Financial Impacts of the Proposed Rockfort Quarry*, Center for Spatial Economics (February 26, 2009) (available at: http://wcwrpc.org/FinancialImpacts_RockfortQuarryCanada.pdf); G. Smith, *Economic Costs and Benefits of the Proposed Austin Quarry in Madera County*, Report (October 23, 2014) (available at: http://www.noaustinquarry.org/wp-content/uploads/2016/08/Austin-Quarry-Economics-Report.pdf). Other works relying on the *Hite Report* (directly or indirectly) include, *e.g.*, M. Conklin, *et al.*, *The Quarry Proposed by St. Marys Cement Inc. for a Location Near Carlisle, Ontario Should Not be Permitted: Proponents' Brief*, 5 STUDIES BY UNDERGRADUATE RESEARCHERS AT GUELPH (2011) (available at: https://journal.lib.uoguelph.ca/index.php/surg/article/view/1338/2345); *Business Suirvey and Economic Assessment of Locating a Quarry and Asphalt and Cement Plants within Aeortech Park*, Group ATN Consulting, Inc. (October 13, 2014) (available at: http://stopthefallriverquarry.com/wp-content/uploads/2015/10/GATN_Aerotech_Park_FINAL_Report_Oct_13_2015-2.pdf); M.A. Sale,

This uniform reliance on the *Hite Report* is somewhat surprising. On the face of it, the report is a seven-page document consisting of 1.5 pages of double spaced text (about 250 words) along with a few tables and figures. It is more an "abstract" than it is a "study." Moreover, even a brief review of the *Hite Report* points to a number of serious problems that should give any researcher pause. First, there are almost no details regarding model specification and few details on the data used. Not even descriptive statistics are provided. Second, the choice of model specification is entirely ad hoc, treating nearly identical variables (distance) differently with respect to functional form and using a non-standard and unnecessary estimation procedure. Such inconsistent, unconventional and inconvenient choices are symptomatic of ends-driven analysis. Third, no explanation is provided as to how the chosen model and analysis of transactions occurring decades after the quarry operations began might identify the effect of *that particular* quarry (or any new quarry) on housing prices. Selection bias is clearly a concern, but it is neither mentioned nor addressed. Fourth, no analysis is provided to suggest that the homes near the quarry are sufficiently similar to those distant from the quarry to provide reliable estimates of the effect of distance (i.e., covariate overlap). Comparing prices of the homes in rural areas on the outskirts of town to those near the local university risks confusing the vagaries of real estate development with the impact of the quarry.

Setting aside the question of causality for the moment, whether the relationship estimated in the *Hite Report* can be replicated is an important first step in evaluating the report's credibility and the suitability of the methods used to answer this policy-relevant empirical question. To that end, we collect data on home sales within five-miles of the same quarry in Delaware, Ohio, evaluated in the *Hite Report*.[16] It appears the data from the *Hite Report* was from the 1990's (though it is impossible to be certain given the lack of detail), so we collect data on

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Quarry Bad for Area, THE NEWS & ADVANCE (September 28, 2008) (available at: http://www.newsadvance.com/opinion/editorials/letters-to-the-editor-for-sunday-september/article_ca388ca4-14c7-534b-9b17-1b78d1cecc40.html).

[16] Data is obtained from www.agentpro247.com. For all our analysis, we limit the prices to greater than $25,000 and less than $1,000,000, and look only at the "full" sales of single-family homes not in distress. The National Lime & Stone Quarry near Delaware, Ohio, is located near Latitude 40.281005 and Longitude -83.135828.

sales over the ten-year period 1998 through 2007.[17] These data appear to immediately follow that used in the *Hite Report* but precedes the housing market crash in 2008 and the broader economic malaise that followed.[18] For further analysis, we also collect data on sales near a quarry outside of Murfreesboro, Tennessee, over the same ten-year period.

A. *A Review of Empirical Methods*

To reproduce the *Hite Report*'s analysis, we obtain transactions prices on 2,114 single-family homes between 1998 through 2007 that are located within five miles of the National Lime & Stone Quarry near Delaware, Ohio. Using latitude and longitude coordinates, distance from each home to the center the quarry (D) is calculated. Other explanatory variables used the *Hite Report* include, for each transaction, the sale date ($DATE$), the distance to Delaware City (DDC), the house-to-lot size ($H2L$), the number of bathrooms ($BATH$), and the number of total rooms ($TOTR$). We measure the sale date as the year of sale; the *Hite Report* does not indicate how the sale date is measured.[19]

The regression model of the *Hite Report* takes the following general form,

$$p_{it} = \exp(\delta_1 \ln D_i + \beta_0 + \sum_{j=1}^{k} \beta_j X_{j,i}) + \varepsilon_{i,t}, \quad (2)$$

where p_{it} is the transaction price (in thousands) for home i at time t, ln$D$ is the natural log of distance from the quarry (in miles), and X_j are the k regressors listed above (with coefficients β_j as coefficients).[20] For reasons unexplained in the *Hite Report*, only the distance from the quarry is transformed by the natural log

[17] *See also* D. Hite, *The Impact of the Ajax Mine on Property Values*, ARMCHAIRMAYOR.CA (March 5, 2015) (available at: https://armchairmayor.ca/2015/03/05/letter-the-impact-of-the-ajax-mine-on-property-values) (stating that the analysis was completed in 1996-1998).

[18] Our data source does not offer data in the early-to-mid 1990s, so we cannot replicate the same time period as the *Hite Report*. We are trying to obtain such data for further analysis.

[19] It is preferred to measure *DATE* as a fixed effects, as this specification requires prices to rise monotonically over time.

[20] The variables in the model are listed at *Hite Report*, *supra* n. 6 at p. 3. A similar specification is used in D. Hite, *A Hedonic Model of Environmental Justice*, Working Paper (February 14, 2006) (available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=884233).

transformation; distance from the city center (*DCC*) and the other regressors are not transformed. The specification seems purely ad hoc.

Equation (2) is non-linear in the parameters and must be estimated by Non-Linear Least Squares ("NLS"). This specification is highly irregular in econometric practice. Normally, hedonic models of housing prices are estimated by Ordinary Least Squares ("OLS"). A regression model quite similar to Equation (2) and very common in hedonic analysis is,

$$\ln p_{i,t} = \delta_1 \ln D_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i} + \upsilon_{i,t}, \quad (3)$$

where the dependent variable is the natural log of price and where the *X*s might be transformed to logs as well.[21] While Equation (3) is typical of hedonic price functions, we are unable to find the estimation of Equation (2) anywhere in the literature. In fact, we were unable to locate a single instance where even the author of the *Hite Report* estimates a hedonic price function using Equation (2), but plenty of instances where Equation (3) is used.[22] As detailed later, a test of functional form can inform us as to whether the natural log transformation of the dependent variable is a better approach and infinitely more common.

21 Note that Equation (3) is not simply the log transformation of Equation (2) because of the additive error term in Equation (2).

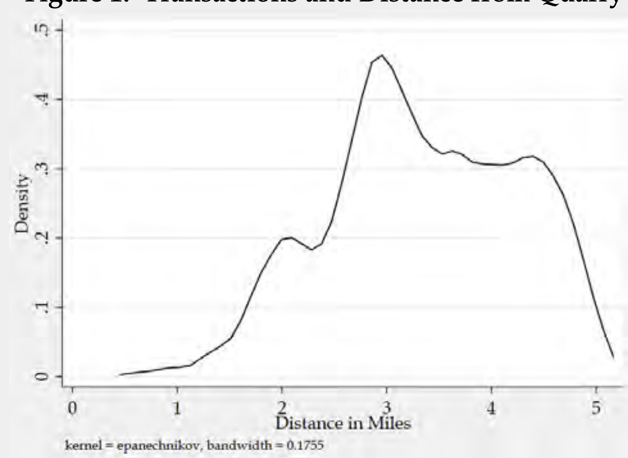
22 *See, e.g.,* D. Hite, W.S. Chern, F. Hitzhusen and A. Randall, *Property Value Impacts of an Environmental Disamenity*, 22 JOURNAL OF REAL ESTATE FINANCE AND ECONOMICS 185-202 (2010) (draft available at: https://ssrn.com/abstract=290292); D. Hite, A. Jauregui, B. Sohngen, and G. Traxler, *Open Space at the Rural-Urban Fringe: A Joint Spatial Hedonic Model of Developed and Undeveloped Land Values*, Working Paper (November 1, 2006) (available at: https://ssrn.com/abstract=916964); D.M. Brasington and D. Hite, *A Mixed Index Approach to Identifying Hedonic Price Models*, 38 REGIONAL SCIENCE AND URBAN ECONOMICS 271-284 2008 (August 5, 2006) (available at: https://ssrn.com/abstract=928252); E. Affuso, C. de Parisot, C. Ho, and D. Hite, *The Impact of Hazardous Wastes on Property Values: The Effect of Lead Pollution*, 22 URBANI IZZIV 117-126 (2010) (available at: https://ssrn.com/abstract=1427544); D. Hite, *Factors Influencing Convergence of Survey and Market-Based Values of an Environmental Disamenity,* Mississippi State University Agricultural Economics Working Paper No. 2001-011 (November 29, 2001) (available at: https://ssrn.com/abstract=292447); C. Ho and D. Hite, *Economic Impact of Environmental Health Risks on House Values in Southeast Region: A County-Level Analysis*, Working Paper (2005) (available at: https://ssrn.com/abstract=839211); D. Hite, *A Hedonic Model of Environmental Justice*, Working Paper (February 14, 2006) (available at: https://ssrn.com/abstract=884233).

The coefficient of primary interest in the *Hite Report* is δ_1, which measures the percent change in the transaction price for a percentage change in distance from the quarry (*D*), but only *after* the quarry operations began (see Eq. 1). In this specification (and also for Eq. 3), this elasticity is constant across the full range of distance. With data on 2,812 sales, the *Hite Report* estimates the coefficient δ_1 to be 0.125, where the positive sign indicates the average sale price of homes is higher the further away the homes are from the quarry (statistically significant at the 1% level). The *Hite Report* concludes, as do subsequent reports that adopt the result, that this positive coefficient implies quarries reduce the price of nearby homes. As detailed above, the positive sign on the coefficient δ_1 cannot reasonably be interpreted in this manner since the data is for sales occurring long after quarry operations began, among other concerns.

B. *National Lime & Stone Quarry in Delaware, Ohio*

Replication is the essence of science. Even if the estimated price-distance relationship from Equation (2) lacks a causal interpretation, it is worth evaluating whether the *Hite Report*'s findings can be confirmed. We do so by estimating Equation (2) using data on 2,114 transactions in the same area over the period 1998-2007. Figure 1 offers the kernel density of the distribution of transactions by distance from the quarry. The thinness of the market very near the quarry is plain to see, which is also apparent from a map of the area surrounding the quarry (see Appendix 1).

Figure 1. Transactions and Distance from Quarry



Regression results from Equation (2) are summarized in the first column of Table 1, along with descriptive statistics for the full sample and the sample divided into homes closer to the quarry than two miles and those further than that distance. The model has a Pseudo-R^2 of 0.25, which is very close to that reported in the *Hite Report* (0.254).[23] Five of the seven estimated coefficients (including the constant term) are statistically different from zero at the 1% level or better.

Table 1. Regression Results and Descriptive Statistics
National Quarry near Delaware, Ohio

	Coef (t-stat)	Mean (St. Dev)	$N = 0$ Mean (St. Dev)	$N = 1$ Mean (St. Dev)
ln*D* (δ_1)	-0.1413*** (-4.00)	1.166 (0.304)	1.227 (0.230)	0.518 (0.224)
DATE	0.0450*** (11.13)	2002.7 (2.952)	2002.5 (2.969)	2004.4 (2.125)
DDC	0.0409*** (5.92)	2.876 (2.139)	2.859 (2.207)	3.050 (1.207)
H2L	-0.102 (-0.81)	0.1498 (0.1110)	0.148 (0.111)	0.1668 (0.102)
BATH	0.0419 (1.09)	1.806 (0.584)	1.788 (0.597)	1.995 (0.384)
TOTR	0.1398*** (7.59)	5.099 (1.016)	5.065 (1.031)	5.099 (1.016)
Constant	-85.71*** (-10.57)	…	…	…
Pseudo-R^2	0.250			
Obs.	2,114	2,114	1,930	184

Statistical Significance: *** 1%, ** 5%, * 10%

Despite using exactly the same regression model and data on sales around the same quarry, we find that the transaction prices of homes *decrease* (not increase) as the distance from the quarry increases. The negative coefficient (-0.141) is similar in size *but different in sign* from that found in the *Hite Report* (0.125) and is statistically significant at the 1% level. The estimated coefficient implies a 1% increase in distance reduces home average, quality-adjusted home prices by about 0.14%. Since the coefficient is less than unity, the price-distance relationship is subject to diminishing marginal returns.[24] Figure 2 illustrates the relationship

[23] The Pseudo-R^2 is the squared correlation coefficient between the predicted value of the regression and the dependent variable.

[24] For any fixed change in mileage, the percentage change falls as distance increases.

between sale prices and distance from the quarry, revealing sizable reductions in average prices as distance from the quarry increases.

Figure 2. Price-Distance Relationship

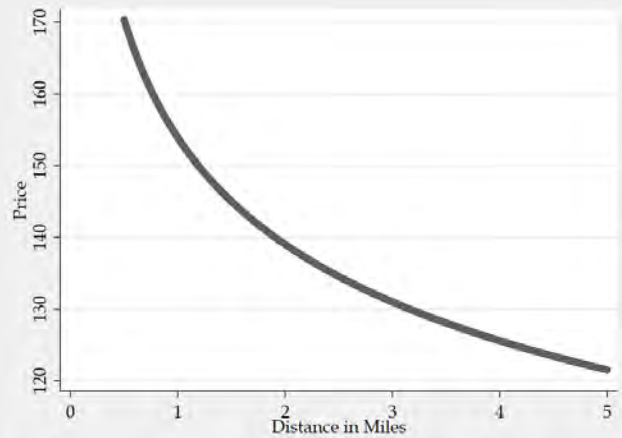


Table 2 summarizes the average predicted prices and price effects at varying distances from the quarry. Interpretation of the table is straightforward. A home sold 3 miles from the quarry will have a price 22% lower that of a home sold within 0.5 miles of the quarry, or 16% lower than the average home sold within 1.5 miles of the quarry. At two miles, the differences are 18% and 11%; at five miles, the differences are 28% and 22%. These are sizable effects.

Table 2. Home Values by Distance from Quarry

	Distance in Miles from Quarry							
	0.5	1.0	1.5	2.0	2.5	3	4.0	5.0
Avg. Price ('000)	169.8	153.9	145.4	139.6	135.2	131.8	126.5	122.6
Reduced Value (from 0.5 miles)	…	-9%	-14%	-18%	-20%	-22%	-25%	-28%
Reduced Value (from 1.5 miles)	…	…	…	-11%	-14%	-16%	-19%	-22%

These estimates and their predicted effect on prices are based on the estimation method (Eq. 2) used in the *Hite Report*. There are other equation specifications and estimation methods that are more consistent with standard practice in the analysis of housing prices (hedonics). In order to assess the robustness of the result, we offer alternative analyses below.

1. *Alternative Estimation Approaches*

As discussed above, Equation (2) is a non-standard method to estimate the relationship of interest. Normally, a researcher would avoid the non-linear Equation (2) and use the natural log of price to estimate Equation (3) by OLS. Statistical testing (such as the Box-Cox test of functional form) may be used to evaluate whether the linear or log-form of the dependent variable is preferred.[25] Other advantages of Equation (3) over Equation (2) is that the linear equation is amenable to estimation by Median Regression ("MReg") and Robust Regression ("RReg"), both of which are less sensitive to outliers in the data than is NLS or OLS.[26] Outliers are common in home sales data, so it is sensible to evaluate the effect on the estimates by these alternative estimation procedures, especially when the results are used in a policy relevant setting that may have significant financial implications.[27] We summarize the results from both methods.

Modern research on housing prices increasingly accounts for the spatial nature of real estate markets using new spatial methods.[28] We estimate the price-distance

[25] W.E. Griffiths, R.C. Hill and G.G. Judge, LEARNING AND PRACTICING ECONOMETRICS (1993) at pp. 345-7.

[26] *See*, *e.g.*, R. Koenker, QUANTILE REGRESSION (2005); B.S. Cade and B.R. Noon, *A Gentle Introduction to Quantile Regression*, 1 FRONTIERS IN ECOLOGY AND THE ENVIRONMENT 412-420 (2004) (available at: http://www.econ.uiuc.edu/~roger/research/rq/QReco.pdf); O.O. John, *Robustness of Quantile Regression to Outliers*, 3 AMERICAN JOURNAL OF APPLIED MATHEMATICS AND STATISTICS 86-88 (2015); P.J. Rousseeux and A.M. Leroy, ROBUST REGRESSION AND OUTLIER DETECTION (2005); R. Andersen, MODERN METHODS FOR ROBUST REGRESSION (2008); T.P. Ryan, MODERN REGRESSION METHODS (2008).

[27] C. Janssen, B. Söderberg and J. Zhou, *Robust Estimation of Hedonic Models of Price and Income for Investment Property*, 19 JOURNAL OF PROPERTY INVESTMENT & FINANCE 342-360 (2001); S.C. Bourassa, E. Cantoni and M. Hoesli, *Robust Hedonic Price Indexes*, 9 INTERNATIONAL JOURNAL OF HOUSING MARKETS AND ANALYSIS 47-65 (2016).

[28] Including papers by the *Hite Report*'s author. *See, e.g.*, D.M. Brasington and D. Hite, *Demand for Environmental Quality: A Spatial Hedonic Analysis*, 35 REGIONAL SCIENCE AND URBAN ECONOMICS 57-82 (2005) (draft available at: https://ssrn.com/abstract=491244); *see also* J.M. Mueller and J.B. Loomis, *Spatial Dependence in Hedonic Property Models: Do Different Corrections for Spatial Dependence Result in Economically Significant Differences in Estimated Prices?*, 33 JOURNAL OF AGRICULTURAL AND RESOURCE ECONOMICS 212-231 (2008) (available at: http://ageconsearch.umn.edu/bitstream/42459/2/MuellerLoomis.pdf); L. Osland, *An Application of Spatial Econometrics in Relation to Hedonic House Price Modeling*, 32 JOURNAL OF REAL ESTATE

relationship using a Spatial Regression Model ("SReg"). To do so, a spatial weighting matrix (*W*) is computed and spatially-weighted lags of the dependent and independent variables are included in the regression as well as an adjustment for autocorrelated errors.[29]

Table 3. Alternative Estimation Methods
National Quarry near Delaware, Ohio

	OLS Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)	*OLS-CEM* Coef (t-stat)
ln*D*	-0.2726***	-0.2021***	-0.1220***	-0.1558 ***	-0.147***
	(-7.31)	(-14.21)	(-5.59)	(-2.65)	(-3.00)
DATE	0.0433***	0.0342***	0.0367***	0.0440***	0.0453***
	(12.45)	(15.76)	(16.58)	(12.86)	(6.30)
DDC	0.0273***	0.0460***	0.0551***	0.0679***	0.0483***
	(3.90)	(8.64)	(15.00)	(5.09)	(3.31)
H2L	0.0794	-0.1131	-0.2591***	-0.1779	0.1812
	(0.68)	(-1.47)	(-3.74)	(-1.48)	(0.94)
BATH	0.0485	0.0997***	0.1499***	0.0166	-0.0092
	(1.46)	(5.41)	(7.94)	(0.56)	(-0.10)
TOTR	0.1540***	0.1523***	0.1508***	0.1497***	0.2047***
	(8.97)	(14.00)	(14.12)	(9.11)	(6.44)
Constant	-82.47***	-64.31***	-69.52***	-77.07***	-86.77***
	(-11.82)	(-14.80)	(-15.67)	(-11.25)	(-6.02)
Spatial Terms (χ^2)				242.3***	
Pseudo-R^2	0.246	0.216	0.243	0.265	0.214
Obs.	2,114	2,114	2,114	2,114	1,461
Statistical Significance: *** 1%, ** 5%, * 10%					

RESEARCH 289-320 (2010) (available at: http://pages.jh.edu/jrer/papers/pdf/past/vol32n03/03.289_320.pdf).

[29] D.M. Drukker, H. Peng, I.R. Prucha, and R. Raciborski, *Creating and Managing Spatial-Weighting matrices with the* spmat *Command*, 13 STATA JOURNAL 242-286 (2013); D.M. Brasington and D. Hite, *Demand for Environmental Quality: A Spatial Hedonic Analysis*, 35 REGIONAL SCIENCE AND URBAN ECONOMICS 57-82 (2005) (draft available at: https://ssrn.com/abstract=491244). We truncate the distance at 0.5 miles.

Results for the alternative estimation methods are summarized in Table 3.[30] Across all four alternatives, the price-distance relationship is negative and statistically different from zero at the 1% level or better. Plainly, the negative price-distance relationship is robust to estimation method. The price-distance elasticity is a good bit larger for OLS and MReg, but similar to that estimated by Equation (2) for both the RReg and SReg methods (in the full sample). Note that more of the regressors are statistically significance in MReg and RReg, suggesting these estimation alternatives are worth consideration.

2. *Coarsened Exact Matching*

Thus far, we have paid no attention to whether homes near the quarry are like those far from the quarry (i.e., covariate overlap). What evidence is available in the *Hite Report* suggests that in her sample the types of homes sold near the quarry may have been be very different than those sold at a distance from it. While distance from the quarry is a continuous variable, we can consider covariate overlap by comparing the characteristics of homes near to and those far from the quarry, using a two-mile cutoff. In Table 1, we do observe some meaningful differences between homes within two miles of the quarry and those further away especially in the year sold and the number of bathrooms and total rooms.[31] To ensure we are comparing like homes, we apply Coarsened Exact Matching ("CEM") to the data and match on these three variables.[32] All 184 transactions within two miles of the quarry are matched to 1,277 (of 1,930) homes further than

[30] The Box-Cox test statistic for the Delaware County data is 64.1, which is statistically significant at better than the 1% level. The test statistic is distributed $\chi^2(1)$ with a critical value of 2.71 at the 10% level. The natural log transformation, consistent with Equation (3), is preferred to the specification estimated in the *Hite Report*. Or, we might say the problem is not so much in the estimation by NLS rather than OLS but that the natural log transformation of the dependent variable is the better specification.

[31] Standardized differences (the absolute value of the means difference divided by the square root of the summed variances) are used. *See* Imbens and Wooldridge, *supra* n. 8 at p. 24. The rule of thumb for a large difference is a standardized difference exceeding 0.25. For the DATE variable, the standardized difference is 0.51, and about 0.30 for bathrooms and total rooms.

[32] S.M. Iacus, G. King. G. Porro, *Causal Inference without Balance Checking: Coarsened Exact Matching*, Working Paper (June 26, 2008) (available at: https://ssrn.com/abstract=1152391), later published *Causal Inference without Balance Checking: Coarsened Exact Matching*, 20 POLITICAL ANALYSIS 1-24 (2012) (available at: https://gking.harvard.edu/files/political_analysis-2011-iacus-pan_mpr013.pdf).

two miles from the quarry. The weights created by the CEM procedure are then used to estimate Equation (3) by weighted OLS.

Results for the CEM-weighted regression are reported in the final column of Table 3. The estimated coefficients are comparable in most respects to the other models.[33] Most significantly, the price-distance relationship remains negative (-0.147) and statistically different from zero. While we do not present the results in the table, we note that when estimated using the non-linear Equation (2) with CEM-weighted data the price-distance relationship is negative (-0.053) but not statistically significant, a difference we will return to later.

C. *Rogers Group Quarry near Murfreesboro, Tennessee*

It is reasonable to expect that the relationship of home prices to distance from a quarry might vary by location. Earlier research suggests this is so in other contexts.[34] To further evaluate the results reported in the *Hite Report*, we collect data on home sales around the Rogers Group Quarry near Murfreesboro, Tennessee.[35] Transaction data is again collected for years 1998 through 2007 and the sample includes 2,311 transactions. Given differences in data availability, we replace the total number of rooms with square footage (*SQFT*). Distance from the city center (*DCC*) is measured from Murfreesboro. We apply the same methods as before, estimating Equation (2) by NLS and then Equation (3) by OLS, MReg, RReg, and SReg. Results are summarized in Table 4. We do not observe large differences between the characteristics of home sold near to and far from the quarry, so we do not apply CEM for this quarry.

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[33] CEM-weighting often alters the coefficients and their significant levels since the data is better matched.

[34] *See supra* n. 7 and citations therein.

[35] The quarry is located at coordinates: 35.884699, -86.530625.

Table 4. Regression Results and Descriptive Statistics
Rogers Quarry near Murfreesboro, Tennessee

	NLS Coef (t-stat)	*OLS* Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)
ln*D*	-0.0655*** (-4.99)	-0.0383*** (-2.63)	-0.0320*** (-3.01)	-0.0327*** (-3.78)	-0.0222 (-0.72)
DATE	0.0522*** (27.09)	0.0443*** (20.36)	0.0407*** (31.73)	0.0404*** (35.55)	0.0444 (23.05)
DDC	-0.0035* (1.85)	-0.0006 (-0.26)	-0.0007 (-0.44)	-0.0011 (-0.84)	-0.0012 (-0.15)
H2L	-0.6590 (-1.11)	0.6404 (0.42)	-2.170*** (-4.47)	-2.676*** (-5.84)	0.3311 (0.42)
BATH	0.1395*** (17.65)	0.1666*** (13.44)	0.1811*** (24.06)	0.1759*** (28.87)	0.1344*** (12.17)
SQFT	0.00026*** (17.40)	0.00021*** (5.82)	0.00032*** (25.01)	0.00033*** (29.27)	0.00018*** (9.10)
Constant	-100.3*** (-17.40)	-84.59*** (-19.52)	-77.57*** (-30.57)	-76.87*** (-33.79)	-77.84*** (-20.17)
Spatial Terms (χ^2)					385.2***
Pseudo-R^2	0.692	0.590	0.529	0.678	0.605
Obs.	2,311	2,311	2,311	2,311	2,311

Statistical Significance: *** 1%, ** 5%, * 10%

The fit the regressions (R^2 is around 0.60) is much higher than for the Delaware data, but the negative coefficients on distance are seen again. For the NLS model, the price-distance relationship is -0.0655 and the coefficient is statistically different from zero at better than the 1% level. Across the alternative specifications and estimation methods, the price-distance relationship is consistently negative and statistically different from zero, save one exception. Only in spatial regression is the price-distance relationship not statistically significant, though the coefficient is negative and similarly sized to the other models.

Additional evidence also leads to questions about the negative views of quarries. If quarries were a disamenity, then we might expect people to avoid living around them. Figures 3A-3C in Appendix 3 demonstrate population movements for Rutherford County, Tennessee, with emphasis on the Rogers Group quarry. Population is measured using U.S. Census Bureau population data for years 1990, 2000, and 2010. These figures show population density increasing dramatically over this time period in the same census block as the Rogers Group quarry. These population movements toward the quarry in conjunction with the econometric results further indicate the Murfreesboro quarry is not a great disamenity, if a disamenity at all.

D. *Randomized Inference and the Implausibility of the Model*

Our analyses of home prices near the quarries in Delaware, Ohio, and Murfreesboro, Tennessee, find a negative and statistically significant relationship between home prices and distance from a rock quarry in most specifications and estimation methods. Consequently, we find no evidence that supports the findings of the *Hite Report*, despite using the same model and, in one instance, the same quarry from that earlier study. We fear, however, that these estimated relationships are mainly the consequence of the *Hite Report*'s poor experimental design than they are a measure of any real effect of the quarry. Indeed, we question whether the quantification of the effect of a disamenity or amenity can be plausibly estimated by a price-distance relationship. In Delaware County, for instance, it is not hard to find a statistically-significant price-distance relationship (using Eq. 2) from just about anywhere: the Church of the Nazarene off Highway 101 (δ_1 = -0.058, t = -2.79); The Greater Gouda gourmet grocery on North Sandusky Road (δ_1 = 0.268, t = 6.92); and the Foot & Ankle Wellness Center off South Hook Road (δ_1 = -0.043, t = -2.99).

Given patterns in real estate development, it seems plausible that a positive or negative price-distance relationship would be observed from almost any location. A sensible way to evaluate the reliability of the distance-based hedonic regressions is to apply the method of randomized inference (a type of pseudo-treatment).[36] In this procedure, the location of a "disamenity" or "amenity" is randomly chosen in the geographic area under study. Given the random assignment of location, we might expect the price-distance relationship to be statistically significant in proportion to the alpha-level of the statistical test (say, a 10% significance level) due to random variation. That is, a valid statistical test conducted at the 10% level

[36] R.A. Fisher, THE DESIGN OF EXPERIMENTS (1935); P.R. Rosenbaum, OBSERVATIONAL STUDIES (2002); M.D. Cattaneo, B.R. Frandsen, and R. Titiunik, *Randomization Inference in the Regression Discontinuity Design: An Application to Party Advantages in the U.S. Senate*, 3 JOURNAL OF CAUSAL INFERENCE 1–24 (2015); T. Fujiwara and L. Wantchekon, *Can Informed Public Deliberation Overcome Clientelism? Experimental Evidence from Benin*, 5 AMERICAN ECONOMIC JOURNAL: APPLIED ECONOMICS 241–255 (2013).

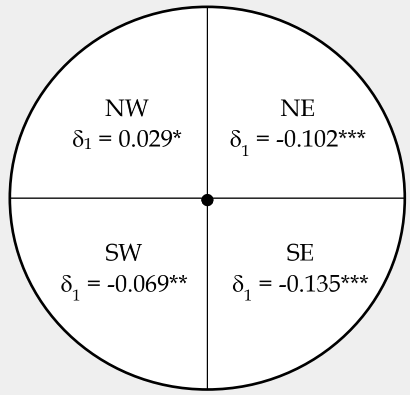
will reject the null hypothesis 10% of the time even if the null is true (e.g., Type I error).

We conduct such tests using the following simulation. First, a random location (latitude, longitude) within the Delaware area is chosen (see Appendix 4 for an illustration of the process). Second, the distances from this location to all home sales is computed. Third, we replace in the regression model the variable measuring distance from the quarry (D) with this alternate distance measure (D'). Fourth, we estimate a regression of price on the same variables as above, obtaining the coefficient, t-statistic and its probability on δ_1. Fifth, this process is repeated 1,000 times. Finally, from these 1,000 simulations, we can compute how often the null hypothesis of "no effect" is rejected.

At the threshold significance level of 10%, the null hypothesis is rejected in a whopping 67% of the simulations for the data from Delaware County, sometimes with positive and sometimes negative coefficients. Conducting the same simulation for Murfreesboro, the rejection rate is an even larger 93%. Given the random selection of locations in the simulation, this result is a powerful indictment against the sort of model employed in the *Hite Report*. A researcher may pick just about any location and find a statistically-significant price-distance relationship. We conclude based on this analysis that the addition of a distance variable to a hedonic model in an effort to identify the effect of a quarry on home prices is a poor experimental design with grossly inaccurate inference tests, especially when using asymptotic critical values for hypothesis testing and only data on post-operation transactions. In fact, we suspect many of the hedonic studies using distance from disamenities may be similarly unable to identify an effect of interest, but leave that question to future research.

Another problem with estimating the price-distance relationship is that unlike square footage, distance from a quarry is not unidimensional but occurs on a coordinate plane. A house may be located to the east or to the west, to the north or to the south, of a quarry, and moving closer to or away from the town center, a university, a landfill, or any other site that may influence prices. To see this, we divide the transaction data near Murfreesboro into four quadrants around the quarry (northeast, northwest, southeast, and southwest) and estimate a price-distance relationship unique to each quadrant (using Eq. 2). Results are summarized in Figure 3.

Figure 3. Price-Distance Relationship
Quadrants around Murfreesboro Quarry



From Figure 3, we see that the price-distance relationships are not equal across quadrants but rather differ substantially by the direction of the movement away from the quarry. From Table 4, we know that the average price-distance relationship from this quarry is negative (and statistically significant). Yet, from Figure 3, we see that the price-distance relationship is positive in the Northwest quadrant, but negative in all other quadrants. All the estimated price-distance relationships are statistically different from zero at the 10% level or better. It appears, therefore, that there is no "price-distance relationship" but many "price-distance relationships" from any given site. We believe these results are more evidence of the spurious nature of the price-distance relationship estimated using hedonic models of housing prices.

In light of our randomized inference procedure and additional evidence, we conclude, for now, that the type of model and experimental design used in the *Hite Report* is entirely unsuited to the task of identifying the price impact of quarries. Our results from replication efforts, which consistently find a negative price-distance relationship, are no less implicated by the defect than those of the *Hite Report*. Identifying the effects of quarries on housing prices requires a different experimental design, and careful attention to selection bias, covariate overlap, and the numerous ramifications of thin markets around the site. We attempt to offer some better evidence below.

E. *Spurious Regression and the Search for Results*

In light of the evidence that a statistically significant price-distance relationship is found for no less than seven-out-of-ten randomly chosen locations, we conclude the *Hite Report*'s experimental design is incapable of quantifying the effect of quarries on house prices. The results from such models are spurious. Consequently, we expect that the price-distance relationship will be sometimes positive, sometimes negative, sometimes statistically significant and sometimes not for any given quarry. Statistical significance is the flip of a coin heavily weighted toward the rejection of the null hypothesis. Our analysis also shows that the choice of estimation method may alter the estimated coefficient and its significance, a common trait of spurious regression.

The fact different quarries and different estimation methods produce different results advises caution in conducting and assessing such studies, especially in a policy-relevant context when economic development is at stake. Inference errors may be inadvertent, or an advocate may exploit the spurious nature of the relationship by searching for a location, model specification, and time period to produce an outcome supporting a favored policy position. We can demonstrate the risks of such an ends-driven search by looking at more recent data for Delaware, Ohio, using data on prices for the five-year period 2012 through 2016 (1,429 transactions). The models and variables are measured in the same way as above.

Table 5 summarizes the results from a few estimation methods. For expositional purposes, we present only on the price-distance relationship. Using the unconventional Equation (2) from the *Hite Report*, we find that the price-distance relationship for this period is positive—a statistically significant result (by asymptotic convention). The result is opposite of that estimated for the data from the 1998-2007 period, even though the location is the same. Without any constraint on the choice of time period to analyze, an unscrupulous advocate is free to choose data from different periods in search of results to support his or her position.

Table 5. Results Delaware Quarry, Years '98-07

	NLS Coef (t-stat)	*OLS* Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)
ln*D*	0.1285*** (3.45)	0.0192 (0.52)	-0.0065 (-0.32)	0.0412 (1.63)	0.0780 (1.10)
Spatial Terms (χ^2)					41.28***
Pseudo-R^2	0.392	0.332	0.263	0.377	0.347
Obs.	1,429	1,429	1,429	1,429	1,429

Statistical Significance: *** 1%, ** 5%, * 10%

Model selection and variable choice may also be used in an ends-drive search for results. As shown in Table 5, estimating Equation (3), a standard functional form for hedonic regressions, the positive coefficient is now a sixth the size of that estimated by Equation (2) and is no longer statistically different from zero at standard levels.[37] Also, Median, Robust and Spatial Regression do not find statistically significant price-distance relationships. In fact, the only model that produces a statistically-significant positive effect is the non-standard regression equation used in the *Hite Report*. Moreover, if we replace the *TOTR* variable with the *SQFT* variable in the NLS model, the price-distance relationship shrinks to 0.02 (one-sixth the size) and the coefficient is no longer statistically significant. Again, a researcher may pick-and-choose model specification, along with time period analyzed and regressors, to obtain a desired result. Skepticism is warranted for any analysis of the price effects of quarries (and amenities or disamenities generally) absent robustness analysis across time and model specifications.

Table 6. Results Delaware Quarry, Years '98-07 & '12-'16

	NLS Coef (t-stat)	*OLS* Coef (t-stat)	*MReg* Coef (t-stat)	*RReg* Coef (t-stat)	*SReg* Coef (t-stat)
ln*D*	0.10028 (0.11)	-0.1361*** (-5.04)	-0.0963*** (-6.33)	-0.0501*** (-2.89)	-0.1059** (-2.10)
Spatial Terms (χ^2)					41.28***
Pseudo-R^2	0.302	0.262	0.219	0.288	0.151
Obs.	3,543	3,543	3,543	3,543	3,543
Statistical Significance: *** 1%, ** 5%, * 10%					

As another check on robustness (or a lack thereof), we combine the data from 1998-2007 and 2012-2016, excluding those years when the housing market and economy generally were in turmoil (2008-2011). Results on the price-distance relationship are summarized in Table 6. Now, Equation (2) estimated by NLS reports a statistically insignificant (but positive) coefficient for the price-distance relationship. The other estimation methods, however, all confirm the negative and statistically significant relationship consistent with the results in Tables 1 and 3. It appears, therefore, whether or not quarries affect prices hinges on model selection and dates selected, which simply demonstrates the spurious nature of these sorts of experiments. Plainly, care must be given to model selection, and robustness analysis should be thorough and explicit. And, in light of the randomized

37 The Box-Cox test indicates a preference for the transformation ($\chi^2 = 40.7$).

inference and quadrant analysis above, the utility of the price-distance relationship for quantifying the effects of quarries and disamenities should be regarded as defective, at least until further research demonstrates otherwise.

The analyses presented here, we believe, offers compelling evidence that the *Hite Report*'s experimental design is a flimsy method, easily manipulated to produce nearly any desired result through the selection of location, model specification, estimation technique, and the time period analyzed. The *Hite Report*'s findings cannot be reliably replicated and conflicting results are readily obtained. The spurious nature of the price-distance relationship from such experiments is clearly demonstrated, and the defective approach allows for nearly any result imaginable. Using data long after a quarry opens poses no limits on the selection of time period, enhancing the risk of the exploitation of spurious regression for economic and political advantage.

IV. A Difference-in-Difference Approach

As detailed above, to quantify the effect of a quarry on home prices the researcher ideally needs pricing data both before and after quarry operations begin.[38] With this data, statistical analysis can determine how the relationship between price and distance from the quarry *changes* after the quarry opens, thus quantifying, under some well-known assumptions, a plausible causal effect.

There are some potential shortcomings with a simple before-and-after analysis, however. New quarries take years to get approval and normally we expect equity prices to reflect new information quickly, so price effects may precede that event. In this section, we offer two before-and-after analyses of the effect of a quarry on home prices. First, we evaluate pricing activity around the Vulcan quarry in Gurley, Alabama, which began operations in 2013. Gurley is a rural area not far from the city of Huntsville, Alabama. Consistent with the analysis above, we use the general format of the *Hite Report* (and several

[38] Another possible identification strategy involves exploiting policy experiments with respect to residential distance from a quarry. For example, if some states required houses to be a certain distance away from a quarry while other states did not, then a credible counter-factual could be constructed allowing the researcher to estimate the effect of quarry distance on home prices. A regression discontinuity design could be used to identify the price-distance relationship if regulations required potential home buyers to be informed of the quarry for homes within a certain distance. Homes just inside and just outside this cut-point would could be used as treatment and control units to identify the causal price-distance relationship.

alternatives) to test for a *change* in the price-distance relationship after the quarry opens.

Second, we evaluate the price effects of the contested Austin Quarry in Madera, California, which was approved in 2016.[39] Located in the southwest corner of the intersection of Highway 41 and Highway 145, the site is proximate to two subdivisions, one located on Highway 145 and the other on Highway 41. Thus, not only are the subdivisions proximate to the quarry, but both are expected to deal regularly with the quarry's traffic flow. Though first proposed in 2010, media coverage and public protest did not begin until 2013, at which time the new quarry might be expected to affect home prices through an announcement effect.[40] A control group is chosen using CEM from homes sales in subdivisions not too far from the quarry site but beyond the range of influence. We find no statistically significant effect of the quarry in either model, though in both cases the estimated coefficients indicate, if anything, the quarry raises property values.

A. *The Empirical Model*

For these analyses, we employ the standard regression model for the DiD estimator. Using a log-linear form common to hedonic regressions, the regression equation is,

$$\ln p_{it} = \Delta T \cdot N_i + \delta_0 N_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i} + \upsilon_{it} \ , \qquad (4)$$

where T is dummy variable equal to 1.0 after the treatment and N_i is a dummy variable for homes near the quarry site (or a continuous measure of distance from the quarry). The estimated coefficient δ_0 measures the difference in average sale prices for homes near the quarry (or the effect of distance from it) *prior to the treatment*. After the treatment, the difference in price between homes near and far from the quarry is $\Delta + \delta_0$. The difference between the two effects is Δ, which is the DiD estimator, as defined in Equation (1), or $\Delta = \delta_1 - \delta_0$. The t-test on the coefficient

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[39] J. Rieping, *Controversial Quarry Up for Vote*, MADERA TRIBUTE (July 16, 2016) (available at: http://www.maderatribune.com/single-post/2016/07/16/Controversial-quarry-up-for-vote); M.E. Smith, *Austin Quarry Approved in 3-2 Vote*, SIERRA STAR (July 20, 2016) (available at: http://www.sierrastar.com/latest-news/article90713132.html).

[40] Lexus-Nexus search conducted on February 20, 2018. B. Wilkinson, *Concerns Over Truck Traffic on Road*, SIERRA STAR (February 21, 2013).

Δ is, therefore, a direct test of the statistical significance of the effect of a quarry on home prices.

As an alternative, we estimate,

$$\ln p_{it} = \Delta T \cdot N_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i} + \lambda_t + \nu_{it} \ , \tag{5}$$

where the continuous *DATE* variable is replaced with year fixed effects (λ_t), which is a somewhat standard treatment of time in the DiD regression. Due to collinearity with the fixed effects, the $\delta_0 N$ term is no longer included in the regression, but the interpretation of Δ is unchanged.

For consistency with the earlier analysis, we also estimate the model specification of the *Hite Report*, adding as a regressor the interaction of a treatment dummy variable for years 2013 and later (T). The regression model is,

$$p_{it} = \exp(\delta_0 \ln D_i + \Delta \ln T \cdot D_i + \beta_0 + \sum_{j=2}^{k} \beta_j X_{j,i}) + \varepsilon_{it} \, , \tag{6}$$

where the variables are defined the same way as the Murfreesboro analysis (i.e., total rooms is replaced with square footage). The coefficient δ_0 quantifies the price-distance relationship prior to the initiation of quarry operations in 2013. Starting in 2013, the price-distance relationship is measured by $\delta_0 + \Delta = \delta_1$, where Δ measures the *change* in the slope of the price-distance relationship. If the quarry reduces home values near the quarry, then Δ should be positive and statistically significant. Equation (6) is estimated by NLS.

B. *Vulcan Quarry in Gurley, Alabama*

As with the earlier analysis, data is obtained on home sales within a five-mile radius of the quarry location in Gurley, Alabama. The quarry began operations in 2013, and our data spans 2005 through portions of 2017. The sample includes 593 transactions, but we note only 83 are for sales prior to 2013.[41] Since there is no "city

[41] The low samples are likely the consequence of the rural nature of the market and data collection in such areas. We cannot exclude the possibility the sample is peculiar in some respect.

center" in the area, the *DCC* variable is measured as the distance from the WalMart Supercenter in the nearby town of Big Cove.

Table 7. Regression Results and Descriptive Statistics
Vulcan Quarry in Gurley, Alabama

	NLS-Eq. 6 Coef (t-stat)	*OLS-Eq. 4* Coef (t-stat)	*OLS-Eq. 5* Coef (t-stat)	Mean (St. Dev)
ln*D*	0.0876 (0.97)	0.2723*** (3.64)	0.3679** (2.20)	3.445 (0.987)
T·ln*D*	-0.1205** (-2.41)	-0.0543 (-1.07)	-0.1587 (-0.88)	2.936 (1.50)
DATE	0.0162* (1.67)	0.0191* (1.85)	…	2014.1 (2.30)
DDC	-0.0456*** (-5.85)	-0.0529*** (-5.99)	-0.0512*** (-5.80)	4.484 (2.27)
H2L	-1.2185 (-0.79)	-0.2457 (-0.11)	0.1868 (0.08)	0.063 (0.029)
BATH	0.1752*** (6.92)	0.2672*** (8.84)	0.2655*** (8.71)	2.875 (0.932)
SQFT	2.2E-04*** (5.97)	2.0E-04*** (3.22)	1.9E-04*** (3.11)	2,870.3 (1,139.8)
Constant	-27.99 (-1.43)	-27.57 (-1.32)	10.61*** (36.57)	…
λ_t	No	No	Yes	…
Pseudo-R^2	0.641	0.602	0.608	…
Obs.	593	593	593	593

Statistical Significance: *** 1%, ** 5%, * 10%

Results are summarized in Table 7.[42] Many of the coefficients are statistically significant and similar to those estimated using the Murfreesboro data. First, for Equation (6) estimated by NLS, we find that housing prices rise as distance from the quarry increases (the coefficient on ln*D* is positive), but this positive effect is observed *prior to the beginning of quarry operations*. After the quarry opens, the positive (though statistically insignificant) price-distance relationship is attenuated; the estimated Δ coefficient is -0.103 and the null hypothesis of "no effect" for the DiD estimator is rejected at the 5% level. Prior to 2013, the price-

[42] Since we do not observe large differences in the characteristics of homes near to and far from the quarry, we do not apply CEM.

distance elasticity is 0.088 (δ_0), but after 2013 it is -0.033 (δ_1), a small effect that is statistically indistinguishable from zero (F-stat = 0.16, prob = 0.69).

Turning to Equation (4), the price-distance relationship is again positive (and much larger than with NLS) but is now statistically significant prior to the beginning of quarry operations. The Δ coefficient is -0.054, which while negative is no longer statistically different from zero at standard levels. The positive price-distance relationship is attenuated after the quarry began operating, but not to a statistically significant degree. The results are similar for Equation (5). Though not summarized in the table, we note that for MReg and RReg neither of the quarry-distance coefficients is statistically different from zero. The SReg results, also not presented in the table, are not wholly unlike the OLS estimates of Equation (4); the coefficient δ_0 is positive (0.331, t = 4.45) and statistically significant, but the Δ coefficient is negative (-0.055, t = 0.98) and not statistically different from zero.

The lack of robustness to specification leads us to conclude that the most likely effect of the quarry is no effect at all. Also, we acknowledge that the defects in the *Hite Report*'s empirical strategy is as relevant here as before: our randomized inference simulation computes a rejection rate on δ_0 of 65% and for Δ of 67% (at a nominal 10% significance level). While we recognize the limitations of the data and the methods, on whole the results are entirely at odds with the claim that quarries reduce housing prices. If anything, the effect is the opposite.

C. *Austin Quarry in Madera County, California*

Quarry sites often take years for approval. Our model of the Gurley quarry presumed that prices do not reflect the quarry operations until after the quarry is operational. A reasonable argument may be made, however, that home prices might adjust before the quarry opens when the local population becomes aware of the future quarry site. We consider that possibility now.

The Austin Quarry in Madera, California, was approved in September 2016 despite a substantial NIMBY effort.[43] A search of news outlets reveals that public attention to proposed quarry initiated in early 2013 and was very active is

[43] M. Smith, *Supervisors Approve Austin Quarry 3-2*, SIERRA STAR (September 12, 2016) (available at: http://www.sierrastar.com/news/local/article101492412.html).

subsequent years.[44] Thus, we define the treatment dummy *T* as having values of one in years after 2013 (and also consider other years). Data is collected for the ten years preceding the treatment date, so the data spans 2007 through 2016.

The Austin Quarry site is well outside of town, but there are two subdivisions proximate (less than three miles) to the site: Bonadelle Racheros-Madera Ranchos and Bonadelle Rancheros Nine. Both subdivisions abut the major highways (Highways 41 and 145) servicing the quarry site. If any homes are to be affected by the quarry, then these are the most likely candidates, and they represent our treatment group. The dummy variable *N* takes a value of 1 for these subdivisions (zero otherwise). Visual inspection of the area points to a number of subdivisions in the vicinity that are neither on the major highways serving the site nor within ten miles of the site: Madera Estates, Madera Country Club, Lake Madera Country Club, Chuk Chanse, Valley Lake Ranchos, Madera Acres, Madera Knolls, and Madera Highlands. A control group will be selected from home sales in these subdivisions.

Estimation of the DiD estimator employs Equation (5). Regressors include the age of the home at the sale data (*AGE*), square footage (*SQFT*), the number of bedrooms (*BED*) and bathrooms (*BATH*), a dummy variable indicating whether the home a two story home (*STRY*), a dummy variable indicating the presence of a fireplace (*FIRE*), a dummy variable indicating whether the home has a swimming pool (*POOL*). Year fixed effects are included.

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[44] B. Wilkinson, *Concerns Over Truck Traffic on Road*, SIERRA STAR (February 32, 2013); G. Smith, *Economic Costs and Benefits of the Proposed Austin Quarry in Madera County* (October 23, 2014) (available at: http://www.noaustinquarry.org/wp-content/uploads/2016/08/Austin-Quarry-Economics-Report.pdf); M.E. Smith, *Progress Continues on Austin Quarry*, SIERRA STAR (February 10, 2016) (available at: http://www.sierrastar.com/news/article87816032.html); B. Wilkinson, *Group Opposes Proposed Rock Quarry*, SIERRA STAR (November 12, 2014) (available at: http://www.sierrastar.com/news/article87802492.html); D. Joseph, *Quarry Issues Need to be Addressed*, SIERRA STAR (December 3, 2014) (available at: http://www.sierrastar.com/opinion/article87803072.html).

Table 8. Descriptive Statistics
Austin Quarry in Madera County, California

Variable	ALL Mean (St.Dev)	*N*=0 Mean (St.Dev)	*N*=1 Mean (St.Dev)	Stan. Diff.
AGE	16.13 (12.16)	16.50 (12.22)	15.21 (11.95)	0.075
SQFT	1811.6 (522.7)	1706.7 (490.6)	2072.9 (509.5)	0.518*
BED	3.32 (0.59)	3.27 (0.54)	3.43 (0.70)	0.179
BATH	1.99 (0.68)	1.83 (0.66)	2.38 (0.56)	0.639*
STRY	0.024 (0.15)	0.016 (0.12)	0.043 (0.20)	0.115
FIRE	0.632 (0.48)	0.730 (0.44)	0.390 (0.49)	0.515*
POOL	0.068 (0.25)	0.033 (0.17)	0.159 (0.36)	0.311*
Price	215.4	195.0	266.3	
Price/*SQFT*	120.8	116.4	131.9	
Obs.	887	633	254	

Descriptive statistics for the treatment and control pool are provided in Table 8. The homes are similar in some respects, but large standardized differences (> 0.25) are found for square footage, the number of bathrooms, and the presence of a fireplace or pool.[45] CEM based on *SQFT*, *BATH*, *FIRE*, and *POOL* reduces the standardized differences to acceptable levels for all the regressors. We are able to match 229 of 254 homes in the treated group to 450 of 633 homes in the control pool, for an estimation sample of 679 home sales.

[45] Imbens and Wooldridge, *supra* n. 8.

Table 9. Regression Results and Descriptive Statistics
Austin Quarry in Madera County, California

	OLS Coef (t-stat)	*CEM-OLS* Coef (t-stat)	*CEM-MReg* Coef (t-stat)	*SReg* Coef (t-stat)
N (δ_0)	0.1166**	0.1277**	0.1194***	0.1913**
	(2.47)	(2.08)	(4.99)	(2.11)
T·N (Δ)	0.1663***	0.1005	0.1161***	0.0878
	(2.95)	(1.21)	(3.14)	(1.32)
AGE	0.0017	0.0087***	-0.0003	-0.0055*
	(1.20)	(3.47)	(-0.35)	(-0.35)
SQFT	1.7E-04***	1.3E-04**	3.0E-04***	2.0 E-04***
	(3.40)	(2.05)	(12.68)	(4.39)
BED	0.0349	0.01205***	0.0450**	-0.0542
	(0.90)	(2.63)	(2.49)	(1.54)
BATH	0.0288	-0.0439	-0.0777***	-0.0218
	(1.08)	(-0.60)	(-2.60)	(-0.61)
STRY	-0.0878	-0.0408	0.0043	-0.1378
	(-0.70)	(-0.33)	(0.05)	(-1.29)
FIRE	0.0770**	0.0650*	0.0422***	0.0305
	(2.43)	(1.73)	(2.94)	(0.88)
POOL	0.1833***	0.1577***	0.0853***	0.2346***
	(3.71)	(4.03)	(3.68)	(3.63)
Constant	11.21***	10.92***	11.35***	11.62***
	(98.08)	(70.30)	(20.67)	(83.17)
λ_t	Yes	Yes	Yes	Yes
Spatial Terms (χ^2)				27.17***
Pseudo-R^2	0.482	0.491	0.361	0.186
Obs.	887	679	679	887

Statistical Significance: *** 1%, ** 5%, * 10%

Regression results are summarized in Table 9. For comparison purposes and to illustrate the important effects of covariate balance, estimates for both the full and CEM-weighted samples are provided. The models fit the data well for both samples. For the full sample, which we caution does not rely on balanced data, the estimated δ_0 coefficient (0.117) indicates that prices in the treated group were about 12% higher [exp(δ_0) - 1] in the pre-treatment period. After the treatment, the prices were even higher (Δ = 0.166), a statistically significant result of about an 18% increase. The remaining coefficients are sensibly sized and many are statistically different from zero. A swimming pool, for instance, raises price by about $38,000.

Turning to the CEM-weighted model, the price difference before the treatment is a bit larger (δ_0 = 0.128), and the difference is statistically significant at standard levels. As in the full sample, the DiD estimator Δ is positive (0.100), but now it is not statistically significant. For the balanced sample, we cannot reject the null hypothesis that the quarry's announcement effect is zero, though the coefficient is relatively large and the t-statistic is much larger than 1.00. In contrast, for the CEM-weighted MReg, prices are higher in the treated area during both the pre-treatment and treatment period, and both coefficients are statistically different from zero at better than the 1% level.

In the final column of Table 9, we summarize the results from SReg using the full sample. The spatial terms are statistically significant at the 1% level. The results are comparable to the others. Prices are higher in the treated area before the treatment, but we do not see a statistically significant change is seen after the treatment. The DiD estimator Δ is positive and relatively large (0.09), but statistically significant only at the 20% level.

Table 10. Regression Results, Annual Treatment Effect
Austin Quarry in Madera County, California

	2013 Coef (t-stat)	2014 Coef (t-stat)	2015 Coef (t-stat)	2016 Coef (t-stat)
$T \cdot N$ (Δ)	0.2721*** (2.65)	0.0018 (0.01)	0.0322 (0.42)	0.3949 (1.41)

Statistical Significance: *** 1%, ** 5%, * 10%

Finally, we can estimate the Δ coefficient for each year beginning with our chosen treatment date (2013), thereby assessing whether that choice is influencing the estimate.[46] The results by year are summarized in Table 10. Large positive coefficients are observed in years 2013 and 2016 (the latter close to being statistically significant), and smaller positive coefficients for the other years. These results are consistent with those reported in Table 9.

Notably, we do not estimate a price-distance relationship in these equations. Distance from the quarry site is not a regressor. Unlike the distance-based model, the rejection rates for randomized inference (assigning the homes in the treatment group randomly from those in the sample) are very close to the nominal level of the test (11% rejection rate versus 10% nominal test level). The statistical reliability

46 The coefficients are year specific and do not quantify the average after the treatment year, as do the results from Table 9.

of this approach is much superior to the price-distance approach used in the *Hite Report*.

Taken together, we conclude from these results indicate that the effect of the quarry may very well be zero, at least in the form of an announcement effect. If there is any effect, it is positive. Whether or not the quarry will affect prices, either positively or negatively, after operations begin (assuming they do) is unknowable at this time. In light of the evidence presented here and in prior research, the expectation must be that there will be little to no effect on home prices and, if anything, that effect may be positive.

V. Conclusions

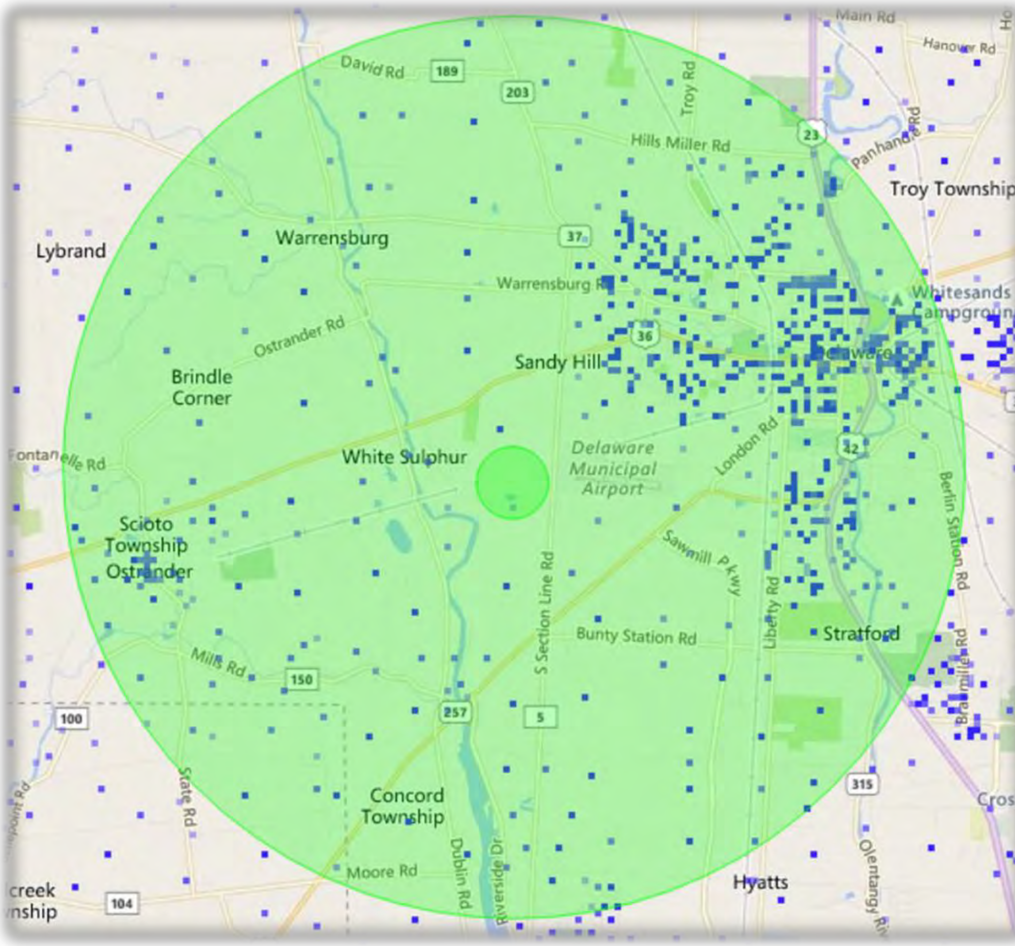
We estimate the effect of rock quarries on home prices with data from four quarry locations across the United States, a wide range of econometric specifications and robustness checks, and a variety of temporal circumstances from the lead-up to quarry installation to subsequent operational periods. We find no compelling statistical evidence that either the anticipation of, or the ongoing operation of, rock quarries negatively impact home prices. While our study extends the literature on estimating the effects of "disamenities," primarily as a critique of existing methods, the empirical problem is difficult and likely requires advanced research methods beyond what we provide here. The primary obstacle to estimating these effects is the lack of data and that lack of data is actually driven by the quarry site selection process, which limits our ability to infer a causal relationship. Thin markets and a subsequent lack of sales data are a serious problem since quarries are today (and typically in the past) located, by design, away from residential density.

Our study highlights a number of shortcomings in the empirical methodologies generally used to estimate the effect of disamenities on real estate prices. First and foremost, the vast majority of studies do not (or even attempt to) identify the causal effect of disamenities. That is, existing studies are naïve as to the empirical conditions necessary to identify a causal relationship and do not establish credible strategies to estimate the counter-factual outcome—i.e., how the real estate around quarries would have looked, on average, without a landfill or other disamenity. To evaluate the credibility of existing studies and their methodologies, we first employ permutation tests to examine whether or not the existing methodologies yield higher than expected rejection rates of the null hypothesis. We accomplish this by randomly assigning a location in our sample space with a "disamenity" (i.e., a placebo quarry) and then estimate the effect on surrounding home prices. The null hypothesis of "no effect" of the placebo quarries is rejected in no less than 7 out of 10 simulations, and at a rate as high as 9 out of 10 simulations.

In an attempt to produce a meaningful counter-factual we employ a difference-in-differences estimation strategy which exploits the timing and placement of a quarry. We use this strategy in two different contexts: (1) before and after operations of a quarry in Gurley, Alabama; and (2) before and after local debate (and subsequent approval) of a quarry in Madera County, California. The first exercise estimates the effect of quarry operations on home prices and the second exercise estimates the anticipatory effect of a quarry on home prices. Neither exercise yields evidence of a negative impact on home prices. Given a number of data concerns and model limitations (since our interest is primarily in replication), further research is advised.

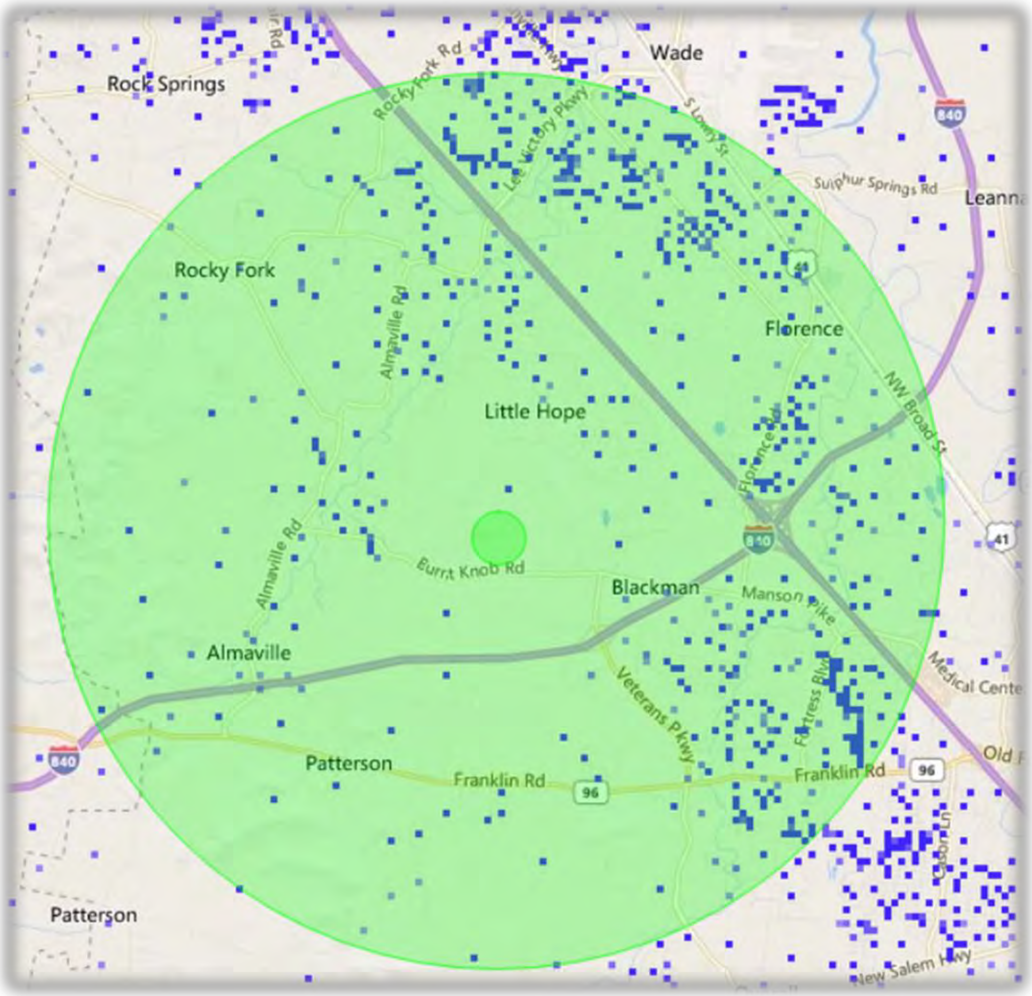
APPENDIX 1. MAP OF NATIONAL LIME & STONE QUARRY NEAR DELAWARE, OHIO

Notes: The small, inner green circle marks the National Lime & Stone Quarry near Delaware, Ohio. The larger green circle is a five-mile radius around the quarry location. The blue dots mark areas of population density using 2010 census data. Map generated using censusviewer.com.



APPENDIX 2. MAP OF ROGERS GROUP QUARRY NEAR MURFREESBORO, TENNESSEE

Notes: The small, inner green circle marks the Rogers Group Quarry near Murfreesboro, Tennessee. The larger green circle is a five-mile radius around the quarry location. The blue dots mark areas of population density using 2010 census data. Map generated using censusviewer.com.



APPENDIX 3. CENSUS BLOCK POPULATION GROWTH NEAR ROGERS GROUP QUARRY NEAR MURFREESBORO, TENNESSEE

Notes: Figures 3A-3C demonstrate population movements for Rutherford County, TN, with emphasis on the Rogers Group quarry. Population is measured using U.S. Census Bureau population data for years 2000, 2010, and 2016. Darker blues imply greater population.

Fig. 3A: Rutherford County, TN, 1990 Population Density

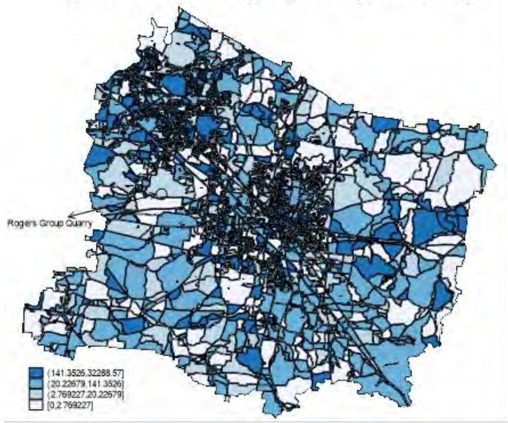


Fig. 3B: Rutherford County, TN 2000 Population Density

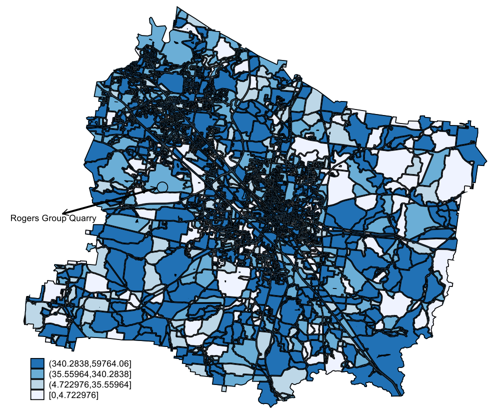
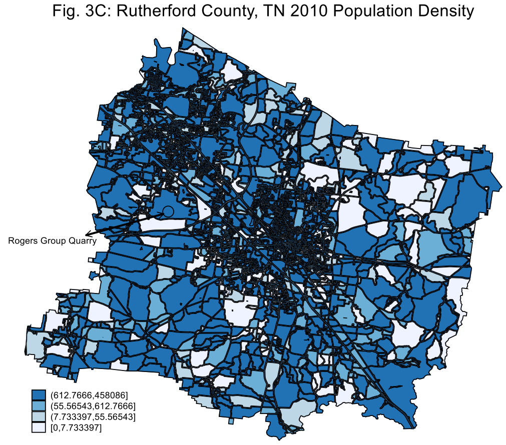
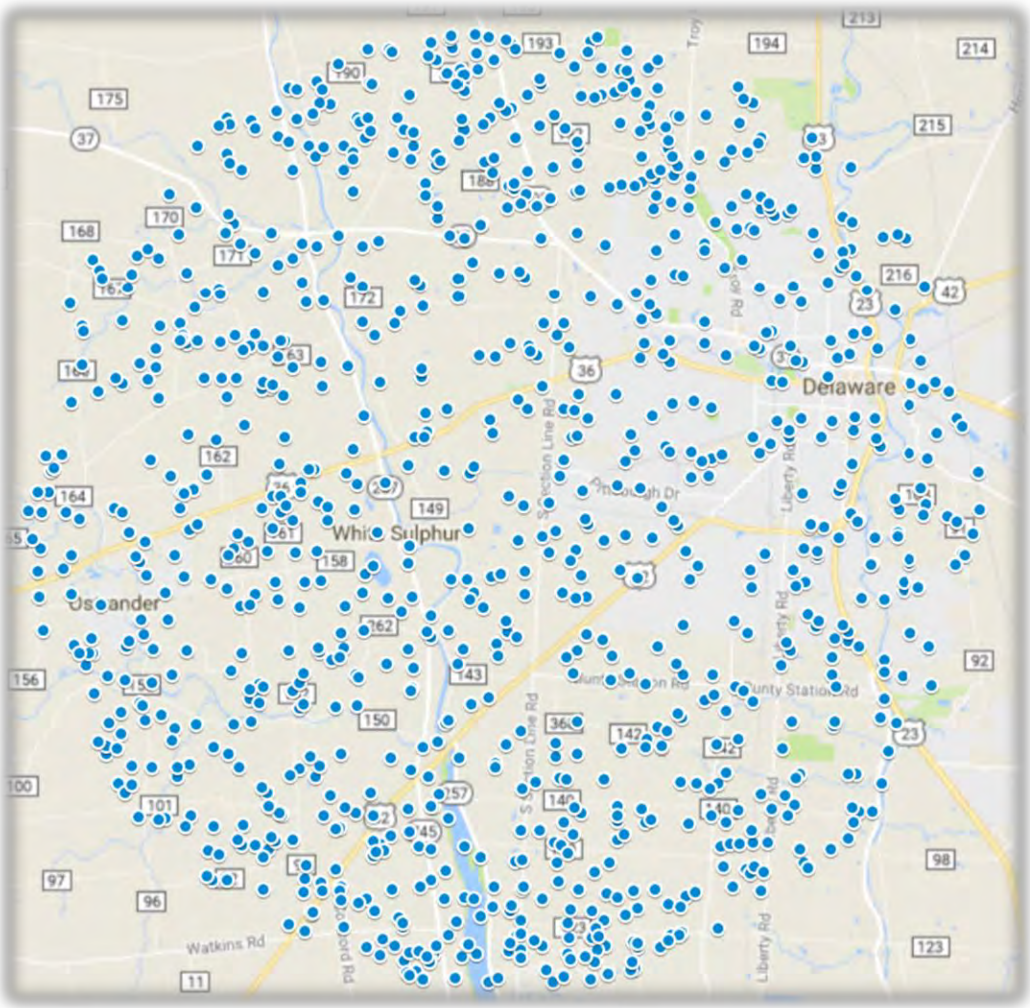


Fig. 3C: Rutherford County, TN 2010 Population Density



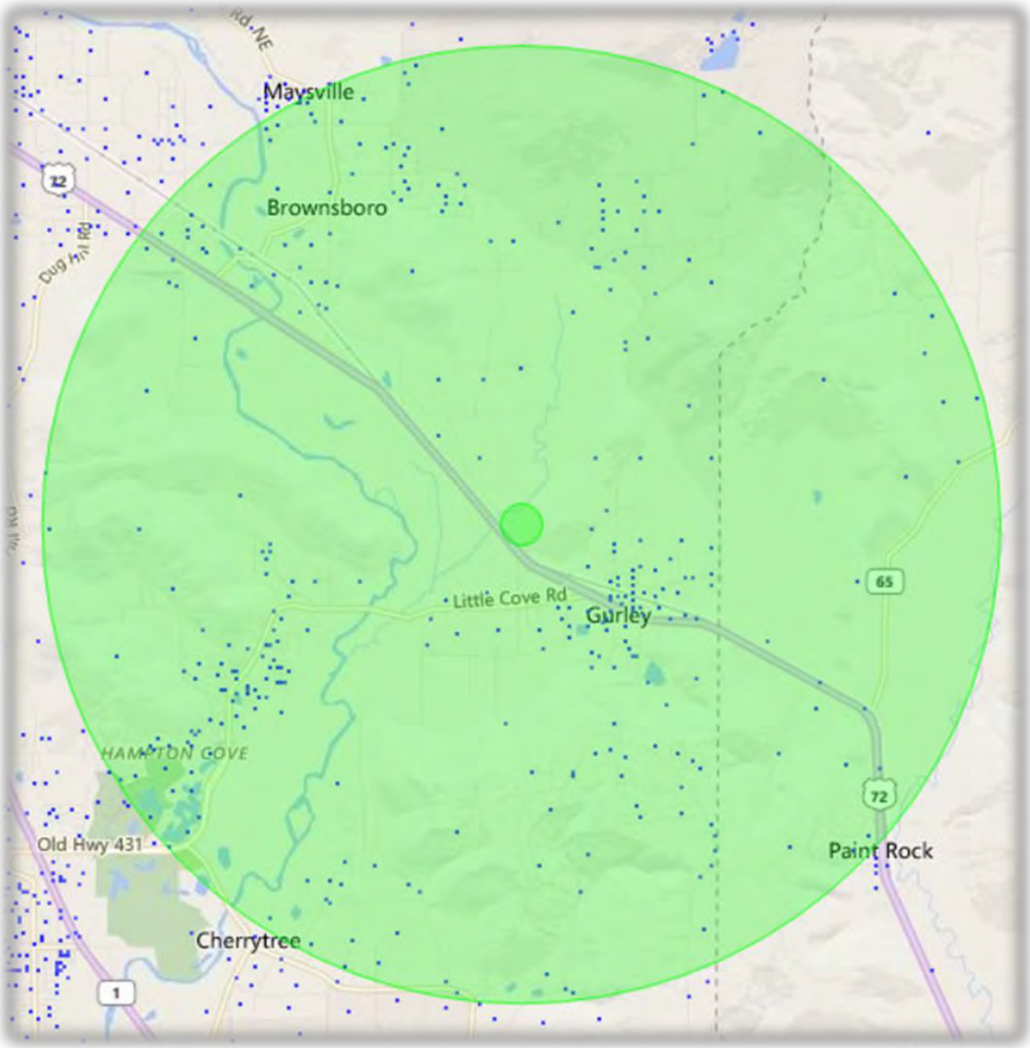
APPENDIX 4. ILLUSTRATIVE MAP OF RANDOM LOCATIONS USED FOR RANDOMIZED INFERENCE ANALYSIS FOR DELAWARE COUNTY

Notes: The blue dots represent the random locations chosen by the randomized inference simulation for Delaware County, Ohio. Map generated using Google maps.



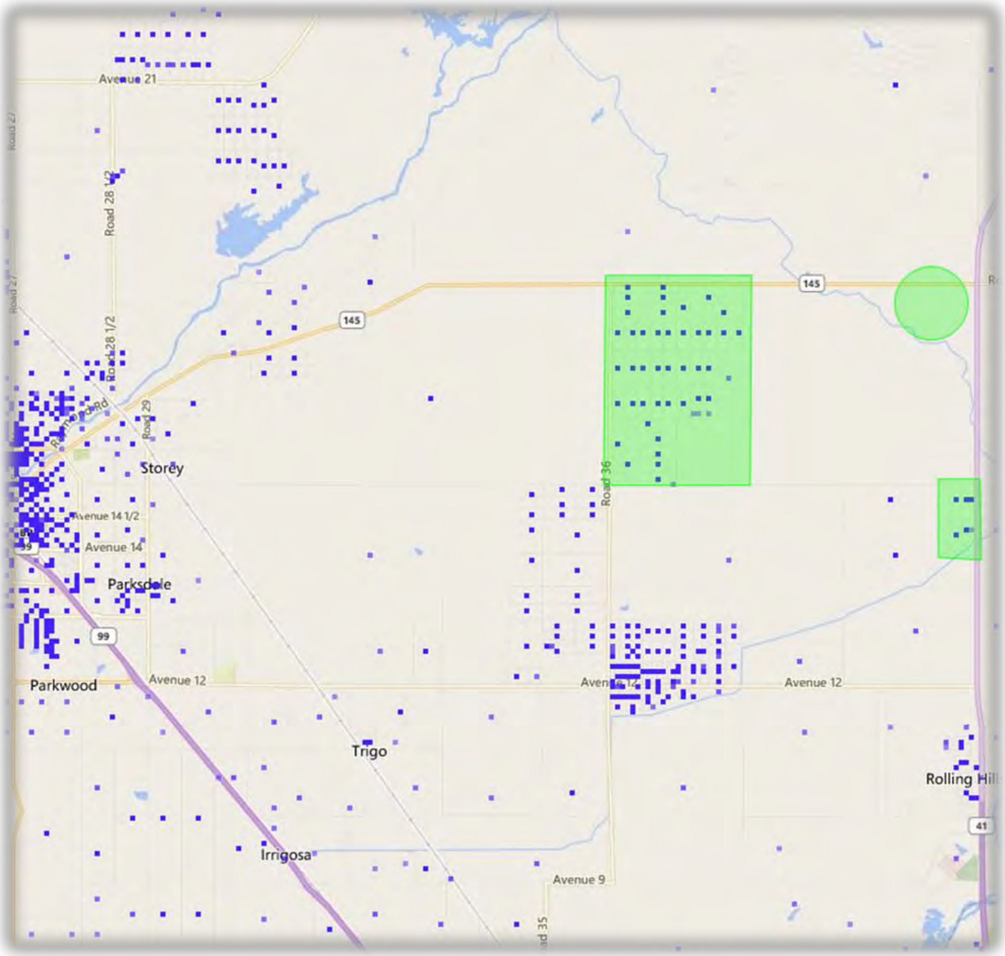
APPENDIX 5. VULCAN QUARRY NEAR GURLEY, ALABAMA

Notes: The small, inner green circle markets the Vulcan Quarry near Gurley, Alabama. The larger green circle is a five-mile radius around the quarry location. The blue dots mark areas of population density using 2010 census data. Map generated using censusviewer.com.



APPENDIX 6. MAP OF AUSTIN QUARRY SITE IN MADERA COUNTY, CALIFORNIA

Notes: The green circle marks the site of the proposed Austin Quarry in Madera County, California. The immediate two areas of population to the South and West of the quarry site—marked in green rectangles—are the "treated" areas. The blue dots mark areas of population density using 2010 census data. The control group is chosen from areas further west and north of Highway 145 toward Madera. Map generated using censusviewer.com.



2017 GRANT THESIS

Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach

by

Alison Grant

A Thesis

presented to

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ABSTRACT

Estimating the Marginal Effect of Pits and Quarries on Rural Residential Property Values in Wellington County, Ontario: A Hedonic Approach

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University of Guelph, 2017

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"Aggregate" material – i.e., sand, gravel, clay, and bedrock – are extracted from pits and quarries throughout Ontario. Aggregates are the number one resource extracted (by value) and used by Ontarians, and approximately $1.2 billion of aggregate material was extracted in Ontario in the last year.

While aggregate is a valued resource, the extraction of aggregate is often identified as a negative externality. Similar to other environmental disamenities mentioned in the literature – such as shale gas exploration sites, wind turbines and landfills – residents near aggregate extraction identify a host of events that can be categorized as negative externalities. Residential concerns include noise and visual disamenities, as well as environmental concerns, such as diminished water quality.

In this study, I assess the potential impacts of aggregate sites. First, I briefly introduce the perceived impacts of aggregate sites by quoting residents' concerns through newspaper articles and lobby group websites. I then utilize the hedonic model to test these claims made by residents: namely, the negative effect on property values. I estimate average changes in property values (or marginal implicit prices) in close proximity to these sites as a proxy for aggregate site

impact. When estimating these marginal implicit prices using the hedonic model, conventional covariates that describe housing and land quality are used. I also include covariates that describe the aggregate site (e.g., activity, licensed area, site type) and spatial attributes that might influence the relationship between the site and the residence (e.g., distance to nearest highway, distance to Toronto).

The data set utilized in this thesis includes over 9,000 arms-length sales of rural residential properties in Wellington County in Ontario. These property sales occur over a 12 year period: 2002-2013. Data on the 107 individual pits and quarries in Wellington County were collected through the 2013 Ministry of Natural Resources (MNR) database on licensed aggregate sites.

Across various models to test for sensitivity (i.e. flexible functional forms, varying model commands, and focused analysis on the most active sites), I do not find evidence that aggregate sites have a strong negative effect on property values in Wellington County. The empirical evidence found in this study does not support the public claims that aggregate sites are negatively affecting neighbouring property values.

DISCLAIMER

This research is based, in part, on data provided by the Municipal Property Assessment Corporation (MPAC). Any findings or recommendations expressed in this thesis are those solely of the author, Alison Grant, and not necessarily the views of MPAC.

ACKNOWLEDGEMENTS

I would like to thank many people that helped with the progress of this thesis, not just with feedback on the writing and statistics, but with the creativity and moral support to complete it.

Firstly, my advisor Brady Deaton and my committee members, Richard Vyn and Jessica Cao. These three all contributed greatly to my learning, and I can leave this degree knowing I gained invaluable knowledge useful to my future. I can't say I've learned more in such a short amount time in any period of my life. I thank these three greatly for that.

To the professors that aided me in my applications for future education, and always made themselves available to help in any of my decision-making processes - Brady, John, and Glenn - I appreciate your time, advice, and support. I also thank you for the confidence you have all given me moving forward in the world of applied economics.

To those that made themselves available to listen to me for hours about the (exciting!) details of aggregate sites, extraction levels, and the complexities of statistical techniques - Mom, Dad, Mark, and Jenn, to name a few - thank you! I would not have been able to complete this without your moral support.

Lastly, the entire FARE department has made my time here an educational yet enjoyable one. All of the office staff, faculty, and graduate students make this a very hard place to leave!

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CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 Use of Aggregate Materials in Ontario

Aggregate materials are used for infrastructural development in the province of Ontario, and come from pits and quarries.[1] Sand, gravel, clay, and bedrock extracted from pits and quarries are used in the construction of roadways, water mains, dams, subway infrastructure, and foundations in commercial buildings. Roads and highways account for the greatest share of aggregate material uses. Figure 1A shows the uses for aggregate resources in Ontario (TOARC, 2015). For every 1 kilometre of highway built, approximately 1760 truckloads[2] are needed in its construction. One kilometre of subway line uses approximately 4,560 truckloads, and structures such as industrial buildings (like hospitals) use approximately 3,760 truckloads. On average a single person makes use of 14 tonnes of sand and gravel each year (TOARC, 2015), for example in their yard, driveway, or the construction of their home or office. The operation of aggregate pits and quarries are essential in the development of these key sources of physical infrastructure in the province.

Aggregate materials are also used in a number of manufacturing processes, including the processing of iron, steel, aluminum, and plastic. Aggregates are also key materials in manufactured products such as glass, paint, pharmaceuticals, fertilizer, floor coverings, and toothpaste. In the 2010 *State of the Aggregate Resource in Ontario Study* by the Ministry of Natural Resources (SAROS, 2010), it was estimated that the economic value of aggregate

[1] Loose material, such as sand and gravel comes from pits. Solid bedrock, such as limestone and granite, comes from a quarry. 'Aggregate sites' and 'pits and quarries' will be used interchangeably throughout this thesis.
[2] A truckload holds approximately 13 metric tonnes of gravel (TOARC, 2015).

production was $6.1 billion in gross output in 2010. The aggregate production process - including processing, transportation, and secondary industries that use processed aggregates to create new goods (such as concrete) - generated $1.8 billion in labour income, and created approximately 34,900 full-time jobs. Additionally, $3.2 billion of GDP was generated by aggregate production (SAROS, 2010). Taking this one step further, if the whole aggregate value chain is analyzed (i.e. all industries that use some form of aggregates in the production of their output goods), it is found that aggregate use generates $44.7 billion in gross production, $13 billion in labour income, 245,000 full-time jobs, and a $22 billion contribution to Canada's GDP (SAROS, 2010). The economic value of aggregate production not only is a strong contributor to GDP, it is also a large source of employment.

Primary aggregate consumption in Ontario in 2007 was 171 million tonnes. This is compared to aggregate production, which was 173 million tonnes. Most aggregates that are produced in Ontario are consumed in Ontario, meaning little aggregate primary materials are imported or exported (SAROS, 2010). In the past 20 years, Ontario has consumed over 3 billion tonnes of aggregate materials, and consumption is predicted to rise by 13 percent over the next 20 years (SAROS, 2010). In the present day, there are few known viable substitutes for aggregate materials (SAROS, 2010).

1.1.2 Concerns for Aggregate Development

Aggregate sites can also be a cause of disturbance to surrounding areas. For example, a content analysis was conducted in the 2010 *State of the Aggregate Resource in Ontario Study* of reported public comments from Ontario Municipal Board (OMB) hearings and from 31 Ministry of Natural Resources aggregate license applications. This analysis cited the three most frequently reported public complaints from property owners near aggregate sites as: truck traffic, noise, and air pollution (dust) (SAROS, 2010). When surveying a larger portion of the Ontario population (a sample including more people living far from pits or quarries), "environmental effects" emerged as the main social cost of aggregate production (SAROS, 2010). Across the 31 sample licenses, the most significant loss of land use was agricultural land. A net shift was found in land use within the sample of 31 MNR licenses. Over time, the aggregate extraction process has shifted land use from terrestrial to lake habitats (SAROS, 2010). Two of the largest impacts cited in the study analysis were bi-products of aggregate processing and the impact of physical infrastructure (i.e. buildings, roads, and dams) on the developed landscape (SAROS, 2010).

The current aggregate application review around Hidden Quarry in Rockwood, Ontario has brought forth a group called the Concerned Residents Coalition (CRC). The Wellington Advertiser newspaper (2015) cited the residents' concerns of Hidden Quarry as "hydrogeology, species at risk, traffic, haul route, noise and blast vibrations, archeology and agriculture." One common issue of debate is whether these aforementioned externalities influence nearby residential property values. Many people believe the sites to be loud and visually displeasing. The trucking routes can disturb school and business commuters. Bedrock quarries use blasting techniques that can be very loud and disturbing. Many residents fear that extraction activities below the water table will affect water and soil quality.

A list of concerns put out by the Concerned Residents Coalition reflects the issues discussed above (CRC, 2016). This group lists eleven concerns on their website: 1) groundwater contamination, 2) household water wells lowered, 3) blasting damage and noise, 4) potential for rocks to be launched outside designated extraction area, 5) extermination of wetlands, 6) diminished air quality, **7) decline in property values**, 8) wildlife habitat destruction, 9) traffic increase and truck haulage routes impacted, 10) visual disamenity, and 11) impact on Rockwood cultural heritage and natural landscape (CRC, 2016).

The research conducted in this thesis is particularly concerned with assessing one of the concerns (number 7) listed above: the effect of aggregate extraction on surrounding property values. There is some evidence to support this concern. For example, in some counties, the Municipal Property Assessment Corporation (MPAC)[3] reduces the assessed values of properties that are abutting aggregate sites (J. Moore, MPAC, personal communication, 2017). This reduction is based on market evidence of property value changes due to aggregate site activities, and is meant to adjust the assessed value to reflect what the property should sell for on the open market at the valuation date that MPAC uses (MPAC, 2017).

When MPAC (2017) analyzes residential properties, they look at many different site variables. Some of these include abutting or being in proximity to a railway line, a commercial property, a busy street, an industrial property, etc.[4] Aggregate sites are considered industrial properties in these analyses. Abutting and proximity to an industrial property enters significantly in MPAC's market models, so properties abutting or in proximity to a pit or quarry will receive an adjustment to the assessed value in most parts of the province. This amount will vary by market based on the sales analyses. In Wellington County, the adjustment was -3% for abutting an industrial property and -2% for proximity in 2016. The definition of proximity can vary based on the characteristic being measured and the location. In Wellington County, MPAC used a definition of: "one property removed from a pit site or across the road," for proximity. In some

[3] MPAC is the mass appraisal agency in Ontario that determines assessed value of properties for taxation purposes.
[4] Abutting is a term referring to the attribute (e.g. industrial site) sharing a common boundary with the subject property. The definition of proximity is flexible across MPAC models, but in this case it refers to the attribute being directly across or diagonally across from the subject property (MPAC, 2017).

parts of the province the definition is wider and can go as far as within one kilometer of a gravel pit. The only unique deviation from this method in Ontario occurred for the Regional Municipality of Halton and Regional Municipality of Peel property assessments. MPAC included some proposed future pits when they did their assessments (J. Moore, MPAC, personal communication, 2017). These adjustments in assessed value support the argument that some property values are diminished as a result of their proximity to pits and quarries. The reduction in assessed value for taxation is performed as a form of compensation for living nearby the pits, or for having one developed near existing property.

Zhang and Hite (2016)[5] state that pit operations include mechanical excavating, sorting, and crushing of materials. Further, they state that the environmental issues arising from gravel pit operations are the release of sediment into the waterways and air. Zhang and Hite (2016) also argue that a noise disamenity results from the use of heavy equipment and vehicles to transport materials. If the disamenities created from pits and quarries are perceived by residents living in the area, the perceptions can translate into a discount of property values. The prices of nearby houses would be reduced to compensate the buyers for accepting the disamenity.

Currently, there are few studies in Ontario with empirical work on property value changes for those residing near pits and quarries. Presently, to my knowledge, there are no peer-reviewed publications examining the effect of aggregate sites on property values. There is unpublished research by Lansink Appraisals (2014) arguing that the effect of aggregate sites on property values ranges between -8.57 and -39.36 percent in property value losses. This market study analysis looked at 19 individual property sales after the creation of a nearby pit, quarry, or haul route in southern Ontario.

[5] This study is currently available online as a conference presentation for the 2016 Southern Agricultural Economics Association Meetings, but is not yet published in the peer-reviewed literature.

1.1.3 The Case Study Area: Wellington County

The area of focus in this study is Wellington County. A list of current licensed pits and quarries in Wellington County is provided in Table A1. The Ontario Aggregate Resources Corporation (TOARC) publishes a production report listing total aggregate production by municipality. Wellington County had 107 licensed aggregate sites as of 2011, and approximately 6.5 million metric tonnes in production of aggregate material in 2015 (TOARC, 2015). Out of all the municipalities in Ontario, only 5 municipalities have more sites (by production volume) than Wellington, the largest being the Municipality of Ottawa (TOARC, 2015). Comparatively, approximately 3 million more metric tonnes were produced in the Municipality of Ottawa in 2015. Five percent of Ontario's aggregate sites are located within Wellington County (TOARC, 2015).

1.2 Research Question

The primary research question of this thesis is whether aggregate sites influence nearby property values. There are important empirical challenges that this research question raises. For example, pits differ by level of activity, and properties differ by proximity to the sites. These are key factors analysed and assessed in the empirical analysis. Municipal governments in Ontario, the Ontario Municipal Board (OMB), and rural residential[6] property owners are interested in the impacts arising from the development of pits and quarries, specifically on property values surrounding these sites. The municipal governments and OMB may utilize this information to inform the decision-making process of approval or selecting location of aggregate development

[6] Rural residential properties are those properties located in an area zoned for residential use but are located in a less densely populated area. No urban properties are designated in this group. Most aggregate sites are located in rural areas, hence why rural residential properties are used in this study.

projects. Rural residential property owners may be interested in the valuation of their home (if surrounding an aggregate site), or the valuation of surrounding properties in their township or county that are neighbouring these sites (e.g. if they are possibly deciding to move elsewhere). If there are negative and large impacts of aggregate sites on property values, this may mean that current assessments are overvalued. But, as mentioned above, MPAC already assumes this. Property appraisals performed by MPAC are adjusted according to proximity or abutting industrial property (aggregate sites are within this category). This study could provide insight into the property appraisal process for properties abutting or in proximity to aggregate sites specifically.

This study seeks to estimate any potential rural residential property value effects of living nearby an aggregate site(s), specifically in Wellington County. The findings of this research can also assist the Ontario Municipal Board (OMB) in making decisions on future development of aggregate sites in the province of Ontario. The results of this study attempt to inform municipal governments, MPAC, the OMB, community groups, and the aggregate industry. This study provides information that all of these groups can use to clarify and measure the effects of aggregate development on property values.

1.3 Method

Details of the theory and empirical methods used to answer the primary research question are fully developed in the theoretical and empirical model sections of this thesis (Chapters 3 and 4). In this section, I provide a brief summary of my methods. I estimate the hedonic price function using cross-sectional data on property sales in Wellington County between the years 2002-2013. The hedonic price function includes a dependent variable on market sales data, distance variables to identify proximity from the pit or quarry to the property, as well as all of the independent variables used to describe the value of each property. The data comes from property sales data gathered by MPAC over the 12-year period. Pit and quarry identification and location coordinates come from the Ministry of Natural Resources 2011 census data. Distance data was derived using Geographical Information Systems (GIS) linking each parcel or property sale to the nearest pit, highway 401, closest urban area, and Toronto. A key variable in the hedonic price function will be a measure of the proximity of a rural residential property to the nearest aggregate site. From this, the marginal implicit price of being located further away from a site can be estimated. A key empirical issue is addressing the extraction activity of the pits and quarries, as there is large variation in extraction levels between different pits and quarries in Wellington County.

1.4 Hypotheses

Two key hypotheses are analyzed and tested using the above outlined empirical methods:

1. Rural residential properties experience a decline in value within close proximity (i.e. three kilometres) to aggregate sites.
2. The effect of proximity to an aggregate site depends on its level of activity.

1.5 Thesis Synopsis

Chapter 2 contains a literature review; this review first addresses three prior studies on the effect of pits (gravel pits specifically) on housing values, and then more broadly addresses research on the effect of various environmental disamenities on housing values. A discussion of the novelty of this thesis is specified. Chapter 3 provides the theoretical framework of the hedonic property model that I use for measuring the property value effect, and discusses the preliminary hypotheses that I test. Chapter 4 explains the data: how it was collected, analyzed, and used. This chapter also outlines the methods used to estimate the effect of aggregate sites on surrounding property values, and the empirical model used to do so. Chapter 5 communicates the summary statistics and the results of the empirical models. Chapter 6 provides a summary and analysis of the results, as well as the implications and usefulness of these results for policy applications. I also address limitations of the data and analysis here, and suggest next steps for future research in this area.

CHAPTER 2: LITERATURE REVIEW

This literature review provides a critical assessment of prior literature in two categories: 1) studies examining the effect of gravel pits on surrounding property values, and 2) studies using the hedonic model to estimate the impact of environmental disamenities on property values. In the first section, emphasis is placed on four studies: two studies with identical hedonic models performed in Ohio and Michigan that assess the effect of gravel pits on nearby property values, and then a recent study that assesses residential property impacts of gravel pits and landfills in Ohio. These are the only known academic empirical studies that measure the effect of gravel pits on property values. This is an important discussion, because it will inform the empirical analysis described in Chapter 4. These studies were not published in a peer-reviewed journal. Hereafter, non-peer-reviewed publications are referred to as "grey literature." The last study on gravel pits that I review does not use the hedonic model, but looks at the effect of aggregate operations on property values. In the second section I provide an overview of literature examining the effect of environmental disamenities on nearby property values, and trends in the findings across studies are presented. There is a wealth of studies that observe the effect of various environmental disamenities on property values, and only a few are chosen for this literature review. These specific studies are chosen either because the model is similar to the one used in this thesis, or because the area being studied is regionally similar.

2.1 Studies Examining the Effect of Gravel Pits on Nearby Property Values

Currently, there is anecdotal and appraisal information about changes in property values near aggregate sites but no statistical evidence at a county-wide level of such effects. Therefore, there is a lack of empirical evidence as to whether a negative property value effect occurs when an aggregate site is created and operated. Although there is a plethora of empirical analyses and research on the effects of environmental disamenities in Ontario, Canada, and worldwide (the next section provides examples of some empirical analyses and research on the effects of other environmental disamenities on property values), no peer-reviewed literature addresses the effects of aggregate pits and quarries on nearby property values in Ontario or elsewhere. To the best of my knowledge, there are four studies that look at the effect of gravel pits on property values. There are two grey literature studies that use the hedonic model to examine the effect of pits on nearby properties that I will briefly discuss: Hite (2006) and Erickcek (2006). Zhang and Hite (2016) is the third study I discuss. The authors use the horizontal sorting model to estimate effects of gravel pits and landfills on surrounding property values. I will also discuss a grey literature study that does not use the hedonic model by Lansink (2014) that assesses the effect of aggregate sites on property values in the Ontario context.

Hite (2006)[7] estimated the effect of gravel pits on nearby property values in Ohio, and found that gravel pits diminished surrounding property values. The decrease in property values that she found was observed far from the sites, exceeding two miles, indicating that the gravel pits provided a disamenity large enough to affect property values at a greater distance than two miles from a site. There are some important limitations to Hite's study. First, it was not stated in the paper whether the researcher visually checked to confirm that all of the pits included in the analysis were active during the time period studied. This is important, as some aggregate sites can be licensed, but not necessarily active in extraction activities. Second, Hite (2006) did not control for proximity to urban areas or major highways, and her broad area of study in Ohio contained both. Third, Hite (2006) specifically looks at only gravel pits (excluding quarries),

[7] This white paper study cannot be found online in the present day.

which do not provide the noise disamenity or loud blasting that bedrock quarries do. There were bedrock quarries in her study area that were not included in her investigation. I attempt to address each of these three shortcomings in my analysis: a measure of aggregate activity for each site is collected to confirm that it is indeed physically active, nearby major urban areas and major highways are taken into account, and *all* aggregate sites – from sand and gravel pits, to bedrock quarries – are examined. Lastly, this thesis provides a county-level analysis; this smaller-scale analysis pays greater attention to individual aggregate sites, as will be discussed in Chapter 4.

In the same year, Erickcek (2006) replicated Hite's (2006) hedonic property model in Richland Township, Michigan. This second study found similar property value losses from aggregate operations. Erickcek (2006) found that gravel quarrying operations had a significant negative impact on 60% of the town of Kalamazoo's properties. He noted a time factor: that the properties only declined in value at the time the quarry was established or establishing, and once a quarry had been operating for some time the effect was diminished. Erickcek's findings are consistent with those of Hite's, although he does stress the importance that the effect on property values diminishes over a pit's lifetime.

The third study on gravel pits was performed by Zhang and Hite (2016). The authors used a horizontal sorting model[8] to estimate the effect of landfills and gravel pits on surrounding residents. This study was performed in Franklin County of Ohio state and included 1592 housing transactions over a one-year period (2010). To complement this data, the authors also included household-level characteristics, such as household size, race, and income. The authors attempted to see if these household characteristics affect whether or not individuals choose to live in proximity to landfills or gravel pits. The authors found that wealthy white households live further

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[8] A horizontal sorting model uses location choice as the unit of analysis (dependent variable) rather than the change in property values.

away from pits and landfills than wealthy black households. Additionally, the authors founds that a longer distance to landfill sites increased the fixed utility[9] of the household. Lastly, the authors determined that households prefer to live further away from gravel pits, yielding a 13.9% increase in willingness to pay for every additional mile away from the pit.

Lansink (2014) from Lansink Appraisals and Consulting performed a series of market price study analyses on the effect of aggregate sites in Ontario, contributing to the popular debate on this issue in the grey literature. Lansink (2014) looked at 19 hand-picked property sales in Ontario – located in the communities Beachville, Braeside, Burlington, Caledon, West Montrose, and London – that were within the geographic influence of a pit, quarry, or haul route. The diminution in price was calculated as a percentage difference in the original price and the sold price of the property, adjusted only for the passage of time. Lansink (2014) found a diminution in price between -8.57% and -39.36% for the 19 properties studied. There are shortcomings to this study, as the 19 properties were chosen, which could lead to selection bias. In contrast to Lansink (2014), I use regression analysis to examine the effect of pits and quarries on property values. Regression analysis has the advantage of explicitly controlling for other variables that may influence price. It also diminishes any selection bias, as all property sales in close proximity to aggregate sites between the years 2002-2013 are included (and not chosen by the researcher).

The results across all of these studies listed above are consistent in that negative impacts of gravel pits are found on property values. In the next section, I discuss key literature on the effect of other possible environmental disamenities – hazardous waste sites, shale gas exploration sites, wildfire occurrence, landfills and wind turbines – on property values.

[9] Fixed utility is the fixed preferences over some bundle of goods. The preferences are fixed because these preferences were not intertemporal, but were measured at one point in time.

2.2 Studies Using the Hedonic Model to Estimate the Impact of Environmental Disamenities on Property Values

There is vast known literature regarding the impact of environmental disamenities on property values. I focus on studies that use the hedonic model. Another focus of this section is a discussion of studies performed in areas that are regionally similar to Ontario (wind turbine studies), or may provide a disamenity that could be similar to aggregate operations (such as toxic waste sites, shale gas exploration sites, wildfire occurrence, and landfills). This section is split into two parts: the first section discusses studies that found a negative impact on property values. The second section describes studies that found no statistically significant impacts on property values.

2.2.1 Negative Impacts Found

Kohlhase (1991) uses the hedonic property model to analyze the effect of hazardous waste sites on property values. Her study was performed in Houston, Texas using 6,374 housing sales near 10 various toxic waste sites. She analyzes three time periods: 1976 (before the Superfund[10] list was created), 1980 (when the Superfund list was established) and 1985 (once the sites located on the Superfund list were made available to the public). Kohlhase finds that once the public was made aware that the sites were on the Superfund list, housing prices were estimated to increase at a decreasing rate up to 6.2 miles from the toxic waste site. Her findings demonstrate that toxic waste sites provide a disamenity to nearby property owners, and thus pose a negative effect on nearby property values.

[10] The United States' Environmental Protection Agency (EPA)'s Superfund program is responsible for cleaning up or restoring contaminated land and responding to environmental emergencies (EPA, 2017). Eligible sites are ranked by priority and placed on a list in the order of clean-up.

Gopalakrishnan and Klaiber (2014) also use the hedonic property model to estimate the effect of shale gas exploration sites on property values. The data came from housing market transactions from 67 municipalities in Pennsylvania. They discover a decrease in home values of 21.7% within 0.75 miles (approximately 1.2 kilometres) of the shale site. The authors find evidence that households are negatively impacted by shale gas exploration activity, but that impact depends on the proximity and intensity of the shale activity. They also identified that this effect diminishes over time, coinciding with the cessation of exploration activity.

Xu and van Kooten (2013) use the hedonic property model to determine the effects of wildfire occurrence on property values in Kelowna, British Columbia. The authors examine 10 years (2000-2010) of home sales (yielding 6, 496 observations) and the number of fires that occurred within 1, 5, and 10 kilometers from the housing parcels. The authors discover that historical wildfire occurrence has a statistically significant impact on property values, but fire size has a more significant impact than frequency (with a decrease in value of $47 per metre squared). Xu and van Kooten conclude that home buyers discount the impact of fire on their purchase if large fires occurred nearby.

Hite (2001) analyzes the effect of landfills on nearby residential real estate prices in Franklin County, Ohio, using the hedonic property model. The author identifies significant property value declines in close proximity to 4 landfills, and her results also suggest that closing a landfill would not necessarily mitigate property value impacts. Particularly, her dataset includes 2, 913 observations and indicates a 19-20% increase in average annual welfare as a result of a move 3.25 miles away from a landfill. In a similar study, Ready (2010) estimates the effect of three landfills in Berks County, Pennsylvania, that differed in size and prominence in the landscape on property values, also using the hedonic model. He includes 11,090 property sales and notes an average decrease in property value of 13.7%, and diminishes further away from the landfill. His results vastly differed across the three different landfills. Notably, the smallest landfills yielded no statistically significant effect on property values, giving rise to the question of whether landfill size plays a role in the effect on property values.

Of the environmental disamenities discussed above (toxic waste sites, shale gas exploration sites, wildfire occurrence, and landfills), negative effects on property values were found across studies. The effect varies in magnitude and scale.

2.2.2 No Effects Found

Vyn and McCullough (2014) use the hedonic property model to estimate the effect of proximity and visibility of wind turbines on rural residential and farmland property values. The study was performed in Melancthon Township, Ontario using approximately 7,000 housing market sales from 2001-2010. The authors found no statistically significant results to support the claim that property values decline with proximity or visibility of wind turbines.

Another study examining wind facilities with similar results was a paper published by Hoen, Brown, Jackson, Thayer, Wiser & Cappers (2015). The authors use the hedonic property model and data from 50,000 home sales from 2000-2014 across 9 different U.S. states. Although Hoen et al. did not use the visibility variable that Vyn and McCullough (2014) used, they also did not find statistically significant effects of wind turbines on property values. The authors find no property value effects before, after, or during construction of a wind facility. These two studies on the effect of wind turbines show no statistically significant impacts of wind facilities on property values.

2.3 Summary

In this chapter, I reviewed some of the previous empirical literature that examines the effect of disamenities on surrounding property values. Although there is a wealth of literature on environmental disamenities using the hedonic model, there are too many studies to include in this literature review. Specific studies chosen for this literature review provided some relation to this thesis. For example: the wind turbine studies were performed in an area regionally similar to the area in my study, and the shale gas exploration and toxic waste site articles include similar methods. Across all studies examined, the findings are varied: some studies find a negative impact from the environmental disamenity and others find no impact.

Across all analyses on *gravel pits* examined, the findings were quite similar: a large effect of aggregate sites on property values is identified. Four studies have been reviewed that find gravel pits as an environmental disamenity. All studies reviewed on gravel pits find a statistically significant negative effect of gravel pits on surrounding property values.

Despite the consistent findings in previous studies, there are significant shortcomings. These shortcomings, and the lack of research on this issue for aggregate sites in Ontario, are what this thesis aims to address. My study addresses the shortcomings of previous literature on the effect of gravel pits in four ways. First, I confirm that the aggregate site is indeed physically active, and provide a measure of aggregate activity. Second, nearby major urban areas and major highways are taken into account. Third, *all* aggregate sites are examined – from sand and gravel pits, to bedrock quarries. Finally, my county-level smaller-scale analysis pays greater attention to individual aggregate sites. I believe that addressing these shortcomings in prior literature, and studying this issue in a previously unstudied geographic area, will contribute novel findings to the literature on this issue.

CHAPTER 3: THEORETICAL FRAMEWORK - THE HEDONIC MODEL

3.1 Hedonic Property Model

Freeman (1993) provides a detailed explanation of hedonic demand theory. Hedonic demand theory uses revealed preferences to estimate the value of – or demand for – an item. The theory is called 'hedonics' because it encompasses the hedonistic elements, or the variables that derive a level of pleasure (utility), with respect to the dependent variable in question. This variable can be anything from property values, to wages, to willingness to pay for a specific rice variety. The specific item being researched is broken down into its independent variables - its utility-bearing attributes or constituent characteristics.

From hedonic demand theory comes the hedonic price model, which is the overarching term that explains all hedonic models that use price (of some item) as the dependent variable. A specific type of hedonic price model is the hedonic property model. In the hedonic property model, the utility-bearing attributes are categorized by the structural, neighbourhood, and environmental characteristics of the item. The structural utility-bearing attributes consist of different fixed elements of the property, such as: age, type of construction, square footage of building(s), number of bedrooms, baths, etc. The neighbourhood characteristics encompass the local property factors, such as distance to an urban area or major highway. The environmental component of the utility-bearing attributes are characteristics such as: beach-front access, forested area, or air quality.

The hedonic property model in this thesis specifically examines the influence of aggregate sites (and the possible disamentities associated with them) on property values. To see this relationship more clearly, Freeman (1993) examines the relationship between a utility maximizing individual and the marginal implicit price of an attribute. Marginal implicit prices are developed fully in section 3.2.

The theory of rents states that the value or stream of rents gained through asset (property) ownership in the future are capitalized into the present day value. Put simply, the expectations about the present and future value of the asset, or property in this case, are capitalized into the present value of the property. Freeman (1993) states that the productivity of the land - the structural, neighbourhood, and environmental attributes - determines the land's value. A utility maximizing individual is assumed to consider the value of the attributes when buying a property including positive and negative traits. Rents derived from property ownership are greater when these three attributes that determine positive productivity of a property are larger.

$$U = U(X, S_i, N_i, E_i) \quad (3.1)$$

This utility-maximizing equation assumes that demands for characteristics are independent of the prices of other goods. This utility maximizing equation can be transformed into the following equation:

$$P_{hi} = P_h (S_i, N_i, E_i) \quad (3.2)$$

The individual is denoted by "h," and the property is denoted by "i." This equation shows that the price or observed sale price of the property depends on these characteristics of the property.

An assumption is made that the rural residential area as a whole is treated like a single market for housing. The individuals in this market have information on all alternatives and are free to choose a property anywhere in the open housing market. The individual's purchase decision of rural residential location fixes for them the whole bundle of housing services that the purchased property provides. Individuals can increase the quantity of any utility-bearing characteristic by finding another location alike in all other respects but offering more of the desired characteristic. Furthermore, it is assumed that all individuals make their utility-maximizing rural residential choices given the prices of alternative housing locations (and the bundle of characteristics attached). These housing prices just clear the market given the existing stock of housing and its characteristics.

Individuals then maximize their utility subject to a specific and individual budget constraint. The budget constraint is a function of how much income an individual has (M), the specific price of the property (P_{hi}), and the price of all goods other than the asset (composite good) (P_x). This is represented in Equation (3.3).

$$M - P_{hi} - P_x = 0 \tag{3.3}$$

Property values will reflect the choices of individuals in the market, satisfying their individual utility maximization problems subject to their individual budget constraints. The first order condition (FOC) is calculated from the utility maximization problem. The environmental amenity, E_j, will be used as the example to be illustrated in the marginal implicit price equation below. The FOC of the environmental amenity (or of any characteristic) is the partial derivative of the hedonic price function, or marginal implicit price.

3.2 Marginal Implicit Prices

Hedonic modelling will be used to examine the effect of an environmental attribute by interpreting the derivative of the cross-section[11] regression equation with respect to the environmental attribute as a *marginal implicit price*, i.e. the marginal value of living further away from an aggregate site(s).

The FOC or partial derivative denotes the marginal implicit price of the specific attribute.

[11]Cross-section refers to the nature of the data, which is the observation of many characteristics (attributes of the property) at the same point in time (when the property was sold).

The marginal implicit price is the additional amount that an individual pays to move to a greater amount (or unit) of that attribute, other things being equal. The environmental attribute in question for the purpose of this thesis is the distance away from an aggregate site. Therefore, the marginal implicit price is the willingness to pay of an individual to move one unit further away from an aggregate site, other things being equal. Utility maximizing individuals allocate the structural, neighbourhood, and environmental characteristics of their property where marginal implicit price equals their marginal willingness to pay. This can be denoted by the following equation:

$$(\delta U/\delta E_j)/(\delta U/\delta X) = \delta P_{hi}/\delta E_j \qquad (3.4)$$

The partial derivative with respect to E_j gives the marginal implicit price of that characteristic. An individual maximizes their utility by simultaneously moving along each price schedule, until they reach a point where their marginal willingness to pay for an additional unit of that attribute equals the marginal implicit price of that attribute.

Figure 3.1 shows the partial relationship between P_{hi} and E_j as estimated from Equation 3.2.

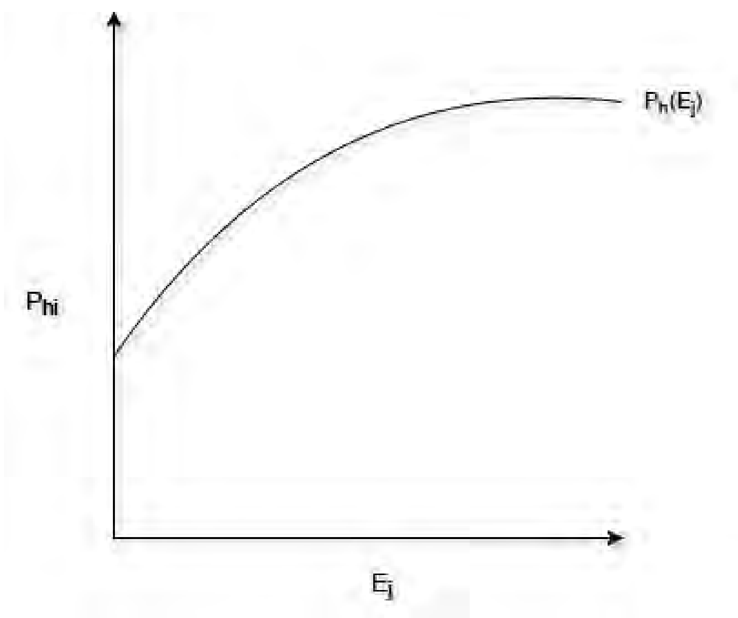


Figure 3.1: Relationship between price and the amenity

The individual's willingness to pay for an environmental attribute increases at a decreasing rate, as demonstrated in Figure 3.1 above. This means that an individual is willing to pay more for an additional unit of the environmental attribute, but as their consumption increases that willingness to pay for each additional unit decreases, until it eventually plateaus. A priori reasoning is used when depicting the slope of this curve, as it is assumed individuals are willing to pay a certain amount for a desirable attribute, but then this amount diminishes as the individual surpasses their optimal amount of that specific attribute. For example, an individual may be willing to pay some amount of money as they move further away from an aggregate site. However, this effect could diminish the further the individual moves away from the site, until the effect is no longer capitalized into the buyer's decision or some upper limit is reached.

Figure 3.2 below shows the marginal implicit price of E_j ($\delta P_{hi} / \delta E_j$), and also reflects the marginal willingness to pay curves for two individuals – k and m – who each have utility maximizing bundles of housing attributes $B_k(E_j)$ and $B_m(E_j)$.

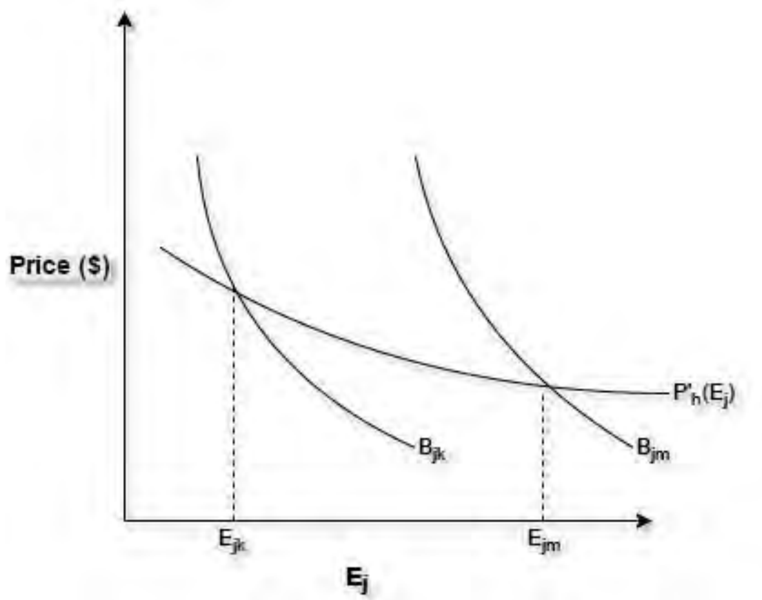


Figure 3.2: Marginal Implicit Price and Marginal Willingness to Pay

These individuals' marginal willingness to pay curves depict changes in the characteristic E_j, holding utility constant at the level achieved by maximizing utility (shown in Equation (3.3)) subject to their budget constraint (represented in Equation (3.4)). Let this maximum level of utility be at the point where both individuals have chosen property locations where their marginal willingness to pay for E_j is equal to its marginal implicit price (i.e. where the curves intersect at E_{jk} and E_{jm}). Marginal implicit prices are denoted by the partial derivative curve P'h(Ej) above.

Marginal implicit prices are estimated in this study using a hedonic price function, which will be discussed in the empirical model section. Specifically, for this thesis the hedonic model is used to estimate the marginal implicit price of residing a unit further away (or closer to) to a nearby pit or quarry.

Two hypotheses were mentioned in Chapter 1. These hypotheses are based off the theoretical framework mentioned above. The graph shown in Figure 3.1 represents my first hypothesis that rural residential properties may experience a decline in value within close proximity to aggregate sites and that this effect may diminish over time (concavity of the curve). The x axis represents the distance away from the aggregate site and the y axis represents the sale value of the property. Therefore, according to Figure 3.1, the sale price of a property rises with distance away from an aggregate site, but this effect diminishes over time after reaching a turning point. This is consistent with the prior literature mentioned in Chapter 2.

My second hypothesis states that the effect of proximity to an aggregate site may depend on its level of activity. This would involve the slope of the curve, and the turning point to which the effect diminishes. If a site had higher extraction activity, I would expect the slope of the curve to be steeper, and the effect to diminish with greater distance away from a site (the larger the extraction activity, the greater the effect on property values). In other words, the turning point of Figure 3.1 may be located further to the right on the x-axis. These hypotheses will be tested throughout the remainder of the thesis. The next chapter begins with a comprehensive review of the data used to estimate marginal implicit prices, and follows with a specification of the empirical model used to test this theory and hypotheses.

CHAPTER 4: METHODS – EMPIRICAL MODEL & DATA

This chapter outlines the data and empirical model used to evaluate the hypotheses discussed in Chapter 3. Firstly, I present a comprehensive overview of the data: how the datasets were obtained, a full description of variables used within those datasets, and definitions of specific aspects of the data. Two main datasets were used for this thesis. The first dataset consists of property sales in Wellington County and their corresponding attributes, and it was obtained from the Municipal Property Assessment Corporation (MPAC). The second dataset consists of data for all the aggregate sites in Ontario, and was obtained from the Ontario Ministry of Natural Resources (MNR). Second, the empirical model is introduced using the data previously presented. The last section of this chapter provides a description of the summary statistics.

4.1 Data

In this section, I outline a description of the data, as well as the collection process methods (if applicable). I review the data in 4 parts below: key GIS variables, property sales and attributes, aggregate sites, and the activity variable construction process.

4.1.1 Key Geographic Information Systems Variables

Geographic Information Systems (GIS) was used in this study because it allows the research to include a spatial aspect. If, for example, a property is abutting Ontario Highway 401, the property value will likely be lower than a characteristically similar home further away (because of a noise disamenity). Alternatively, because the highway 401 provides an amenity because it facilitates commuting, property values close to this highway, but far enough away to avoid noise (in close proximity but not abutting) may experience an increased home value.

Therefore, it is important to include distance variables in this type of analysis, as these variables are capitalized into a property's value. Heywood, Cornelius & Carver (2011) mention the multiple uses for GIS: capturing, storing, checking, integrating, manipulating, displaying, and analyzing geographic earth data. GIS employs computer software to pinpoint spatial components on a geographic map. GIS was used in this thesis to record the distance between the property sales and four major features: the Ontario 401 highway, the city of Toronto, the nearest urban area, and the individual aggregate sites. All distances were measured "as the crow flies," or by straight-line distance, rather than by road or trail distance. Below, I discuss each of the distance variables.

4.1.1.1 Distance from the MPAC parcel to the Nearest Aggregate Site

ArcGIS was used to measure the straight-line distance between the centroid of the MPAC parcel to the edge of the boundary of the nearest aggregate site. This was performed using the Euclidean Distance tool in ArcGIS. The location of MPAC parcels and the location of licensed aggregate sites using GPS coordinates of each parcel and site were overlaid on top of 2011 satellite imagery of Wellington County and surrounding areas to retrieve these distance variables. Distance bands using this measure were used for the main analysis in this thesis.

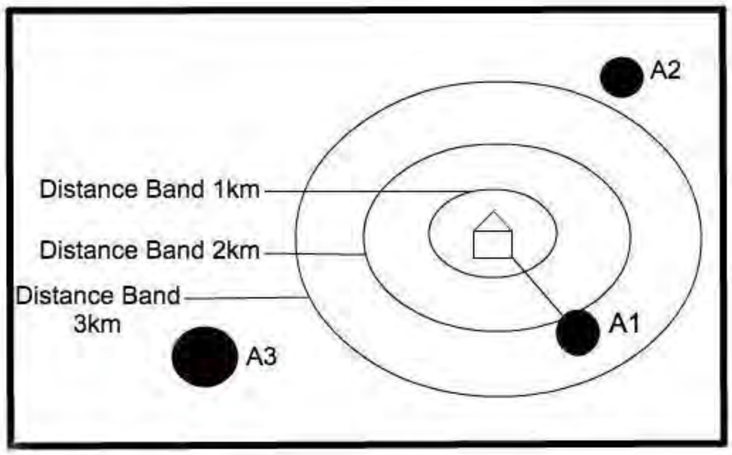
The potential impacts of aggregate sites on property values are accounted for through proximity measures. The main variables for analysis in this study are the proximity measures, as impacts are hypothesized to diminish with distance from a site. The straight-line distances from the property parcel to the closest aggregate site were grouped into distance bands using dummy variables (listed below).

Distance bands were chosen for the main analysis, instead of a continuous distance variable, because the band approach is more flexible and does not restrict the data to any functional form. Kuminoff et al (2010) study whether omitted variables seriously undermine the hedonic method's ability to accurately identify economic values. Their results suggest that large gains in accuracy can be realized by moving from the standard linear specifications (like continuous distance variables) to a more flexible framework that uses spatial fixed effects (such as distance bands). Thus, distance bands were chosen for the main analysis in this study, but a continuous distance variable, quadratic, and inverse distance measure were other functional forms used in sensitivity analysis. Distance bands of half a kilometre radii were created, with sets: 0-0.5 kilometers, 0.5-1 kilometers, etc. up to a 2.5-3 kilometers.[12] Creating these distance bands allows for varying ways to look at the data without restricting the analysis to a continuous distance variable.

All of the distance bands were constructed as dummy variables (categorized as zero or a one). For example, if an MPAC parcel was located 2.2 kilometers from an aggregate site, the distance band variable would yield a "1" for the 2-2.5 km band, and a "0" for 0-0.5, 0.5-1, 1-1.5, 1.5-2, 2.5-3, and 3+ kilometer bands. Figure 4.1 depicts a visual representation of this MPAC parcel, relative to the distance bands, with examples of aggregate sites marked A1, A2, and A3. The MPAC parcel is depicted here in the centre of the figure at a distance of 2.2 kilometers away from the aggregate site, A1. Only three 1 kilometer distance bands are drawn here to give an idea of what these bands look like conceptually. Aggregate sites A2 and A3 are drawn to show that more sites could be located in close proximity to the MPAC parcel.

[12] Number of observations within each band are provided in the summary statistics section.

Figure 4.1: Visual Representation of Distance Bands and Proximity to Aggregate Site



A density variable was not included in this analysis to supplement the distance variables. This was because the pits, once geographically clustered[13], were too far apart from one another to warrant the usefulness of a pit density variable. For example, in the figure above, A1, A2, and A3 would be included as 3 sites located within a 5km radius of the MPAC parcel, which does not occur in this dataset.

I also estimate the distance relationship in a number of other ways, including: continuous measures of distance away from the site and an inverse distance measure (indicating distance to the site). I also examine distance bands of 1 kilometre widths (as compared to 0.5km widths) and assess the sensitivity of the results. I also focus a regression to the first 3 kilometres (bands up to 3km) where the effect is expected to be most pronounced, but alternative number of bands (up to 11km)[14] are also tested. Previewing the results section, these alternative approaches yielded similar quantitative results.

[13] Clustering of the aggregate sites is discussed in the activity variable construction section.
[14] 11km is approximately the furthest distance away that the property sales extend from the aggregate sites in this analysis. An approach with bands up to 11km is tested to include all observations within bands. The results are similar to the model with bands up to 3km, so this specific analysis on bands up to 11km is not further discussed in this thesis.

4.1.1.2 Distance to the Ontario Highway 401

The computer software program ArcGIS 10.2.1 was used to measure the straight-line distance between the centroid of the MPAC parcel to the closest edge of the Ontario Highway 401. This was performed using the Euclidean Distance tool in ArcGIS. The location of MPAC parcels (each property sale in the dataset) using Global Positioning System (GPS) coordinates was overlaid on top of a 2011 satellite image to more accurately measure the centroid of the MPAC parcel to the highway.

4.1.1.3 Distance to the City of Toronto and Closest Urban Area

ArcGIS was used to measure the straight-line distance between the centroid of the MPAC parcel to the edge of the boundary of the Toronto municipal area or other nearby urban area. This was performed using the Euclidean Distance tool in ArcGIS. The location of MPAC parcels using GPS coordinates was overlaid on top of 2011 satellite imagery to more accurately measure the centroid of the MPAC parcel to the boundary of the city of Toronto.

4.1.2 Property Sales and Attributes

The Municipal Property Assessment Corporation (MPAC) provides a uniform, province-wide system of data collection of property sales in Ontario. This agency is funded by taxpayers and has a board of directors appointed by the provincial Minister of Finance. This agency provides a useful dataset on property sales and housing characteristics. This includes a record of the property sale, as well as a follow-up survey on the property's characteristics. Observed market sales are collected by MPAC, which reflect the market value of the land and its structural improvements at a specific point in time.

MPAC has provided the dataset for arms-length property sales over a 12-year period, which includes key housing characteristics assigned to each sale. Arms-length sales are those transactions that occur on the open market between a willing buyer and seller who have no prior relation to one another. Arms-lengths transactions omit any sales that occur between a father and son, for example, or a consolidation of property between relatives. It is important to only include arms-length transactions, as closed market sales may not reflect a real representation of what the property is worth in a competitive and open market. Transactions between relatives may sometimes not reflect the individual's purchase decision, as there are many other factors that can be involved with an individual purchasing a relative's property.

Twelve years (2002-2013) of rural residential property sales in Wellington County in Ontario, Canada were collected by MPAC. Wellington County was chosen for this study because a small, county-wide scale was preferred. An additional reason for focusing on Wellington County was that I live in Guelph, Wellington County, making it accessible to visit, confirm site extraction activity, and talk to the people at some of the aggregate site locations.[15]

In total this dataset includes 9,095 arms-length rural residential property sales. There are over 1,200 housing and other property characteristics in the dataset, but not all were included in the econometric analysis. Those included were attributes that were believed to contribute most to the value of a property. MPAC lists seven factors that, on average, accounted for more than 75% of a property's value in 2016 Ontario appraisals (MPAC, 2016). These key features are: location, lot dimensions, living area, age of property, quality of construction, number of bedrooms and number of bathrooms. These variables that make up 75% of a property's value were considered when choosing which variables should be used in this analysis, as described in Table 4.1. The variable names and the short-form terminology used in the econometric analysis are included in

[15] I was able to visit the Rockwood Conservation Area, where I was able to talk to some residents who live in a naeighbouring area to a pit. I was also able to discuss Wellington County aggregate sites with an MNRF (now Ministry of Natural Resources and Forestry) Aggregates Specialist for Wellington County specifically.

column 1 and 2 of Table 4.1. Column 3 provides a short definition of each property characteristic variable. All of these variables are also listed in order of placement for the regression analysis.

Table 4.1: Variable Names with Definition and Short-Form Model Label

Variable	**Short-Form**	**Short Definition**
Property Sale ($)	sale_amt	Property sale amount
Area of Structure(s) (square feet)	area_tot	Total floor area of home/structure
Lot Size (Acres)	lotsize_ac	Total lot size of the property
Distance to 401 Highway (km)	edist_carto_1	Distance from the MPAC parcel to the closest major highway (400 series or expressway)
Distance to Toronto (km)	cdst_pc_2011_toronto	Distance from MPAC parcel to the city of Toronto
Distance to Closest Urban Area	cdst_pc_2011_gte_100k	Distance from MPAC parcel to the closest urban area (as defined by the 2011 census)
Number of Bathrooms	baths	Variable indicating the number of bathrooms within the structure (half baths included)
Number of Fireplaces	fireplcs	Variable indicating the number of fireplaces located in the structure
Number of pools	pool	Dummy variable indicating whether or not there is a pool (including indoor and outdoor) located on the property
Age of structure(s)	age	Age of the structure(s)
House Quality Index	quality	Quality of structure rated by MPAC 0-10
Finished Basement	finbsmt	Dummy variable: finished basement = 1, absence of finished basement = 0
Air conditioning	aircond	Dummy variable: air conditioning = 1, absence of air conditioning = 0
Year the Structure(s) was sold	sy2003, sy2004, sy2005, sy2006, sy2007, sy2008, sy2009, sy2010, sy2011, sy2012, sy2013	Dummy variables indicating the property sale year (dummy variable omitted is sale year 2002)
Distance Bands	band_0km_halfkm, band_halfkm_1km, band_1km_1halfkm, band_1halfkm_2km, band_2km_2halfkm, band_2halfkm_3km	Distance bands indicating the straight-line distance (radii) from the nearest aggregate site, in distance categories (3+ km category dummy omitted)
Distance from Aggregate Site (km)	distancekm	Distance from MPAC parcel to the closest proximal aggregate site
Squared Distance from Aggregate Site (km^2)	distancekm2	Squared distance from MPAC parcel to the closest proximal aggregate site
Distance to Aggregate Site (km)	invdistance	Inverse distancekm (1/distancekm)
Township Fixed Effects	Erin, WellN, Mapleton, Puslinch, Guelph-Eramosa, Well	Dummy variables indicating the township the property was sold in (Erin Township, Wellington North, Mapleton Township, Puslinch Township, Guelph-Eramosa Township, and Wellington Centre). The Township of Minto was omitted.

Distance variables (distance to nearest highway, distance to Toronto, distance to the closest urban area, and distance to a pit/quarry) are measured through GIS. Fixed effects are included to account for yearly changes in property values (year dummy variable) and the township the property was sold in (township dummy variables). This is to account for any changes within property sales specific to individual townships.

4.1.3 Aggregate Sites

There are 107 aggregate sites in Wellington County. The sites were collected from the 2011 MNR census data, and are included in order of ALPS ID (pit identifier number) in Table A1 in the Appendix. This table provides a pit and quarry inventory of all of the licensed pits as of 2011 in Wellington County. It provides the ALPS ID, as well as the characteristics of each site, including: the adjoining sites that make up the cluster, location, license type, and license area. The average individual pit or quarry license size is 336,734 square metres, while the maximum individual site license size is 1,882,271 square metres and the minimum individual site license size is 13,645 square metres. It is important to note that these values are the licensed areas, not the actual extraction areas. [16] The activity variable provides a measurement of aggregate site activity which can be used instead of the licensed area. The reasons for this are outlined in the next section: activity variable construction.

4.1.4 Activity Variable Construction

Aggregate extraction levels vary depending on the location, aggregate company, available aggregates and available area. Knowing this, it can be hypothesized that property

[16] Licensed area provides a very different average, max, and min, than the actual active area (shown in the next section). The average active area is approximately 151,000 square metres (compared to 337,000 in licensed area), the maximum active area is 600,000 square metres (compared to the 1.9 million in licensed area), and the minimum active area is 0 metres squared (compared to approximately 14,000 in licensed area). This further highlights the importance of a providing aggregate site activity in the analysis, rather than licensed area. (It is important to note that these values are the aggregate sites before they are clustered by geographical proximity.)

values may experience different impacts, depending on the level of extraction activity that is present within an aggregate site. This activity measure is an attempt to differentiate the pits by size or extraction area, instead of treating all pits equally or using their license sizes to differentiate them. Below, I explain why license sizes may not be the best measure of aggregate site extraction activity, and how extraction area might be a better measure when predicting actual site activity. Previewing the empirical model section, I am able to specify smaller subsamples of property sale observations in proximity to the most highly active pits in Wellington County.[17]

The Ministry of Natural Resources (MNR) data on all aggregate site licenses provided maximum tonnage allowances for each of the aggregate sites. This information on licenses does not give specific insight into the measure of actual extraction activity, only the size of the license area and maximum activity – or output tonnage – that is allowed. These variables may be proxy measures of activity, or they may not. The Ontario Aggregate Resources Corporation (TOARC) collects tonnage and revenue data from aggregate companies, as the tonnage of aggregates being removed from each site is taxed. Unfortunately, this data is confidential and not publicly available. To remedy this, an alternate method to estimate extraction activity was used: geospatial satellite imaging.

In this section I discuss the construction of a measure of aggregate activity for each pit and quarry. As I detail below, this activity measure identifies the average loose gravel or bedrock area exposed on a pit or quarry over the period of analysis. While using an overlaid map[18] of 2011 MNR registered aggregate sites, I compiled the actual disturbed land areas of those registered pits over the 12-year time period of the MPAC dataset: 2002-2013.

In many cases, a subset of pits and quarries are in close proximity to each other. As

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[17] Identified in the results as Model 2.

[18] The boundaries of 2013 aggregate sites were placed on top of the AAFC Annual Crop Inventory satellite images to show the exact location of the licensed area compared to the actual disturbed land area.

discussed below, I cluster pits and quarries that are abutting each other, allowing me to identify aggregate sites by a cluster of pits and/or quarries. Given these two measures, I then identify the degree of activity by cluster by adding up all of the areas of the pits abutting each other. This method – i.e., exposed area and size – is used as a measure of actual area of activity that is present in Wellington County. Additional detail on the process of obtaining the average area is provided in the following sections: 4.1.3.1 Average Aggregate Site Areas using GIS, and 4.1.3.2 Clustering Geographical Areas to Depict Actual Extraction Activities.

My empirical approach, discussed in the next section, takes advantage of this measure to focus analysis towards prices of rural residential houses that are located close to *highly active clusters*: pits and quarries in close proximity to each other with a relatively high average area of gravel and bedrock exposed over the time period analyzed. After providing analysis that utilizes all property sales and aggregate sites in Wellington County, I specifically focus analysis towards property sales observations where the nearest site is one of the eight most active clusters of pits in Wellington County.

Obtaining a measure of activity was crucial: of the 58 geographical clusters in Wellington County, 6 of those clusters were considered to have no activity present. The most active cluster was over 2.7 million square metres and the least active (not including zero activity) was only 20 square metres.[19] There is large variation in aggregate activity in Wellington County. Below, I go into detail on how I collected the areas of these each of these sites, and further, their corresponding geographical clusters.

4.1.3.1 Average Aggregate Site Areas using GIS

The AAFC geospatial satellite imaging from the Annual Crop Inventory provides images

[19] I visited both of these sites to confirm this information.

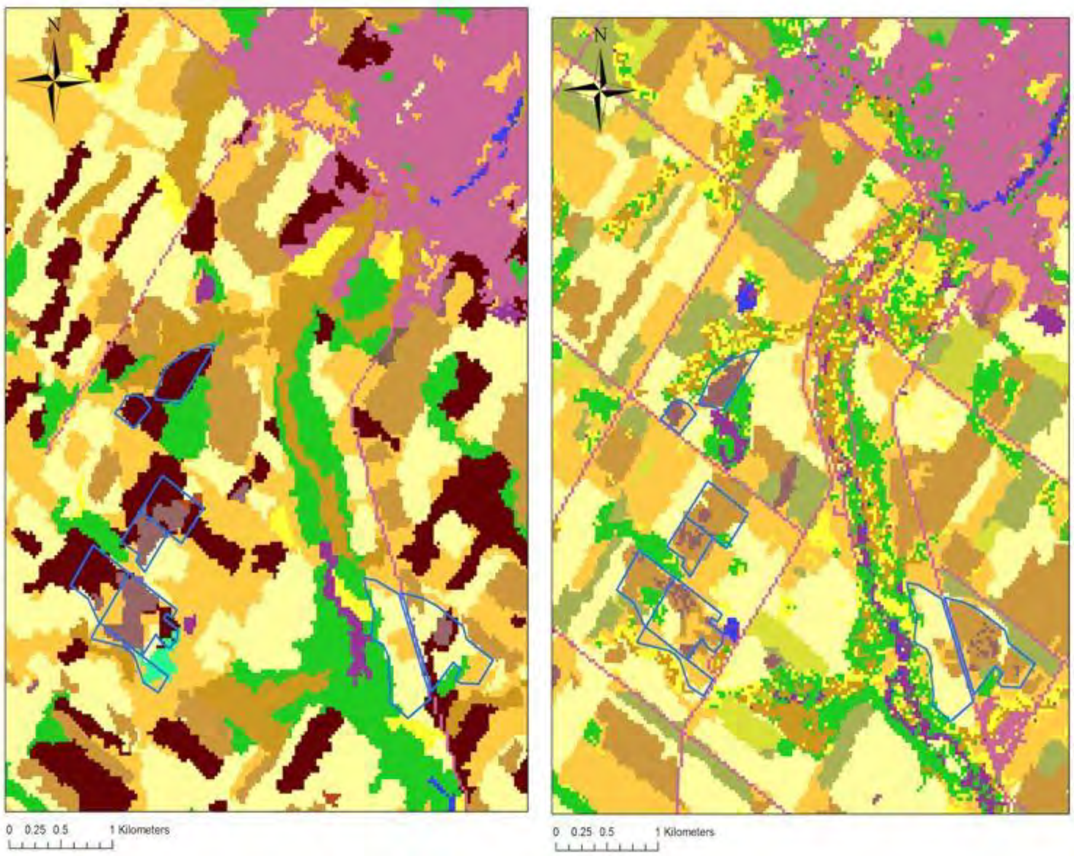
time-stamped in 2011, 2012, 2013, 2014, and 2015 (and will be provided yearly after) for all of Wellington County. This satellite map shows all the different types of crops in different colours, as well as urban areas, buildings, forests, and grasslands coverage. This is important when looking at aggregate sites to see the land's official use. Specifically, the land use under which pits and quarries are identified is "Exposed Land/Barren", and is a light brown colour. "Exposed Land/Barren" is the classification for land that is predominately non-vegetated and non-developed by structures. This includes: glacier, **rock, sediments**, burned areas, rubble, mines, and other naturally occurring non-vegetated surfaces. This land-use classification excludes fallow agriculture. Upon visual examination of the sites in Wellington County, I concluded that an aggregate site disturbed area is most likely listed under the classification of "Exposed Land/Barren". The other colours provide information regarding the crop, forest, or grassland around the site. This information is located in the legend provided in the "Data Product Specification of the AAFC Annual Crop Inventory" (AAFC, 2015).

Two geospatial imaging systems were used to measure activity. The use of two systems was necessary because together they cover the period of 2002-2013. (This is the period I examine in my empirical analysis of rural residential sales.) The AAFC Annual Crop Inventory provides data beginning in 2011, so a separate data collection system was needed for the time preceding this. The Agricultural Resource Inventory for Southern Ontario provides the same detail as the Annual Crop Inventory, but the satellite images are time-stamped at times between 2000 to 2002. Because the arms-length property sales MPAC dataset provides housing transactions from 2002-2013, the 2000-2002 Agricultural Resource Inventory provides images from approximately the beginning of the MPAC dataset, and the 2011, 2012, and 2013 Annual Crop Inventories provide the images from the end of the MPAC dataset and two years after. Therefore, if a pit or quarry is seen to be actively extracting aggregates in the 2011 images, but not in the 2000, it can be confirmed that the pit became active within that time period. If a pit shows activity in both images, it can be confirmed that it has been generally active within the entire period of the MPAC dataset. If a pit shows no activity but farming, forestry, or grassland in all images, then the pit is deemed inactive in extraction, and was therefore grouped in a category of pits with zero activity.

An overlay of the registered aggregate sites licensed area from the 2011 Ministry of Natural Resources and Forestry (MNRF) data was placed on top of the Annual Crop Inventory map. This overlay is seen using borders, which are in blue, shown in Figure 4.2 below. By placing the boundaries of the sites in our MNRF dataset over top of this map, the growth, shrinkage, or inertness of pits over time can be viewed, and can then be compared to the active licensed area. A measurement of the classified land area "Exposed Land/Barren" was calculated using the map's ruler[20] for each time period 2000-2002, 2011, 2012, and 2013. Once the land area was calculated, an average area calculation was executed over 2002-2013, which matches the property sales and characteristics dataset given by MPAC.

[20] The map's ruler is a GIS term, and is what calculates the distance between two given points. An area calculation can be given by connecting multiple points together.

Figure 4.2: Southwest of Elora, Wellington County, 2011 vs. 2015



Legend: Dark Grey: “Cereals”, Light Grey: “Exposed Land/Barren” or pit/quarry

It is important to note in the figure above that these sites within the blue boundaries had active licenses in 2011, which does not necessarily mean that the licensed area had any extraction activity occurring at the time. The licensed aggregate sites with no activity are listed as “0” for extraction activity area. For instance, if an aggregate site listed under the MNR data is considered “ACTIVE” in its licensing, the Annual Crop Inventory geospatial imaging provides the detail of what type of land use is occurring at the point of time that the imaging was created. For example, in Figure 4.2 above, the two top left “ACTIVE” pits in the MNR database are depicted as corn farms in the 2011 Annual Crop Inventory. The land use transforms from cereal crop production to barren land (gravel and sand). The best example of this is the top left grouping of two pits, which transformed from farms to extraction sites within a few years, and may provide information into the possible effect on property values in a specific time period. These pits, which are obviously not active in production (i.e. no sand or gravel is being extracted), can then be listed as "0" for average extraction area, or "activity," as it is listed in the analysis.

This method of visually confirming site activity was used after visiting a few aggregate sites that were listed as "ACTIVE" in the dataset (meaning the license was active) but where companies or government agencies had yet to develop the land, or extract from the site in any way.[21] For example, I traveled to one aggregate site that had an active license, but when I arrived (in May of 2016) I found that the entire parcel of land was under farming operations. In my analysis this parcel would be identified as having zero activity.

Table A1 in the Appendix shows the licensed area of each pit or quarry, and this can be compared to average pit size. The license sizes for individual sites (not clustered) ranged from approximately 14,000 square metres to almost 2 million square metres, whereas the average size of a site (not clustered) using this activity method ranged from 0 square metres to only 600,000 square metres. This confirms further that there are large range differences in pit activity area and license area, even though a correlation calculation shows aggregate site active area and licensed area to share a correlation coefficient of 0.71.

There are shortcomings of this method of identifying activity. One potential shortcoming is that the satellite images do not give information on other effects that may vary by activity. These include, noise level, truck traffic, the time of day that extraction occurs, etc. In addition, if

[21] I visited a number of sites to assess this method. Specifically, using this method, I identified 3 sites that were inactive. When I visited each of these sites, I was able to visually confirm that there was no aggregate activity on the site.

an aggregate company took a break from extraction for a few years but left rock piles on the land a site with little activity might be identified as having high activity.[22]

4.1.3.2 Clustering Geographical Areas to Depict Actual Extraction Activities

Many of the aggregate sites in Wellington County are in close proximity to each other. For this reason they are "clustered" according to geographic proximity. Prior to clustering, there were 107 individual aggregate sites in Wellington County. Following this procedure, this number is effectively reduced to 58. The range of numbers of individual aggregate sites that were combined to form clusters were 2-14 sites. There were many remaining individual sites that were not clustered or were not in close proximity to other sites. In the remainder of this section, I provide additional details on the 58 clusters of licensed sites. A visual example of a specific cluster is provided in Figure 4.3. These are pits located in Aberfoyle, which are owned by the same company, but have 14 different licenses.[23] Aggregate companies extract different areas at different times, and this is the broad reasoning for holding separate licenses in different areas and time periods.

[22] I visited 5 out of the 8 highest activity clusters to ensure that they were active.

[23] The triangles in Figure 4.3 depict the number of sites within that area. The claim that fourteen different licenses are present comes from adding the triangles together: 5 + 3 + 3 + 3 = 14.

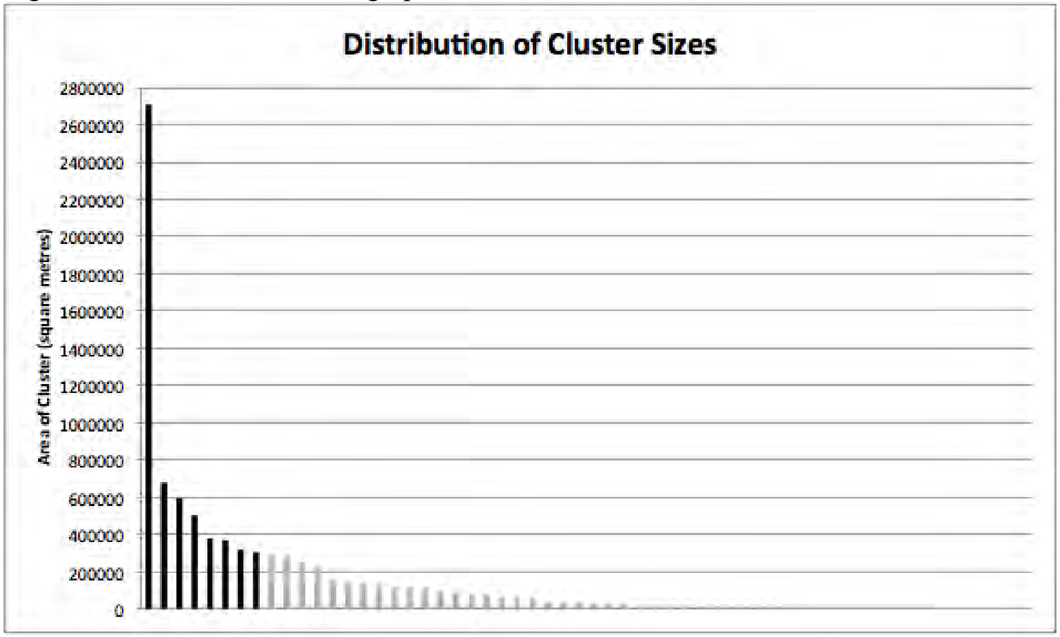
Figure 4.3: Most Active Cluster in Wellington County: Aberfoyle.

Table A2 in the Appendix shows the geographical clusters, noting their total areas, once all individual pits or quarries are added together, and the rank from large to small of all geographical clusters in Wellington County. The mean size of aggregate sites, by cluster, is approximately 151,000 square metres, but the median is approximately 33,000 square metres. The standard deviation is approximately 371,000. The minimum cluster size is 0 and the maximum is approximately 2.7 million square metres. Given this information, it is known that the distribution of average extraction area, or activity, is highly skewed or right-tailed.[24] Most aggregate clusters have smaller average areas, with the highly active clusters being large outliers.

[24] "Right-tailed," means that the right side of the distribution is longer than the left side. More observations (e.g. aggregate site active areas) are located to the left of the distribution (e.g. smaller active areas). Right-tailed distributions have a mean located to the left of the peak, whereas a normal distribution (equal tails) has a mean located in the centre of the peak.

This was confirmed by graphing the distribution of activity. This graph is provided in Figure 4.4 below. The top 8 most active clusters are shown in bold on the graph.

Figure 4.4: Distribution of Geographical Cluster Sizes



The top eight geographic clusters of pits and quarries were chosen for this study because the distribution of average extraction area is right-tailed. Only pits that were above 300,000 square meters were selected (high outliers), which presents a sample of the most highly active pits. The purpose of selecting only these highly active pits is to provide comparative analysis to the full sample. After providing results for the full sample, I test whether the highest extraction activity has an effect on property values when focusing the analysis to only these most active pits and quarries. The geographic clusters shown in bold in Table A2 in the Appendix are those 8 clusters with the highest extraction activity areas. It is also very important to note that the pit and quarry clusters were not distributed in close proximity to one another. Hence, a rural residential property would most likely not be affected by more than one geographical cluster.

The summary statistics for the subsample (properties for which the closest aggregate site is one of the top 8 most active pits or quarries) are listed in Table 4.4. The analysis of the top 10 and 12 most active clusters are also modeled in the sensitivity analysis section for comparison, and produce similar results. Focusing on the top 8 clusters removed many observations in the analysis, so top 10 and 12 cluster regressions were performed and produced very similar results. The top 10 and top 12 models use only observations in proximity to pits or quarries that are greater than 250,000 or 200,000 square metres, respectively. These are also points on the right tail of the distribution of activity graph, seen in Figure 4.4, meaning that these clusters also represented high activity aggregate sites. Eight clusters were selected for the main analysis in order to focus on a smaller number of the most highly active pits. They were also sites that were visited, so a confirmation of extraction activity in 2015 was given, to add another level of accuracy.

Previewing the results section, two models are used. One model uses the entire dataset (9,095 observations) and the second model incorporates extraction activity: using only those property sales where the nearest pit or quarry is in one of the top 8 clusters (796 observations). More detail on this restricted analysis is provided in the empirical model section. This is how the activity variable, or extraction activity, is incorporated into the analysis.

4.2 Empirical Model

4.2.1 Regression Analysis

Regression analysis is a statistical technique used to analyze data with a dependent variable and one or more independent variables (Greene, 2012). Equation (4.1) shows the format of a basic regression function. Y is the dependent variable and is a function of the independent variables. The independent variables are X_1 through X_k, where k can be any number of independent variables that are needed to explain the dependent variable. ε denotes the error term, or residual disturbance, and encompasses anything that the independent variables cannot explain about the dependent variable. This can also be explained as the combined effect of any omitted variables. There will always be an error term because no equation can include every single factor that describes it. Equation (4.2) shows the regression written in a different form, where the betas, β, are included. Beta is a coefficient that specifies the relationship between the variable X, and the dependent variable, Y. For instance, β_2 specifies the relationship between the variable X_2 and Y. This basic regression forms the basis for the hedonic property model to be used for this thesis.

$$Y = f(X_1, X_2, \ldots, X_k) + \varepsilon \quad (4.1)$$

$$Y = \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon \quad (4.2)$$

Using the hedonic property model, I can estimate marginal implicit prices. The hedonic model developed for the purpose of estimating the impact on property values of aggregate site proximity and activity is specified by Equation (4.3):

$$PRICE_i = \alpha + \beta_1 PROP + \beta_2 LOC + \beta_3 TIME + \beta_4 TOWN + \beta_5 BANDS + \varepsilon_i \quad (4.3)$$

Where:
PRICE = sale price for property i
PROP = vector of property structural attributes, including number of bathrooms, square footage of house, acreage of property, fireplace, pool, etc.
LOC = vector of distances to provincial highway 401, Toronto, and closest urban area
TIME = sale year dummy variables
TOWN = township dummy variables
BANDS = vector of distance bands: 0-0.5km, 0.5-1km, 1-1.5km, 1.5-2km, 2-2.5km, 2.5-3km
α = intercept term
β = estimating coefficients
ε = error term

The alpha ('α') term is the constant added to the regression to allow for flexibility. Essentially, there is value in the property existing, even in the absence of all of the explanatory variables (such as bedrooms, bathrooms, or any other value-adding attributes). The coefficients

β_1, β_2, etc. explain the relationship between, for example, the number of bathrooms and the sale price of the property. The 'number of bathrooms' variable is an example of a structural attribute. If the coefficient or beta in this example is positive, this means that property values increase when the number of bathrooms are increased. In this regard, the number of bathrooms would be a value-added attribute of the property. In contrast, if the coefficient or beta was negative, the independent variable would be considered a value-reducing attribute. For example, the age of the property is hypothesized to have a negative sign: the older a property, the smaller the property value. There are many more independent variables than this simple example, as my model seeks to control for as many factors that affect a property's value as possible. The specifics of all variables used in the empirical model, and the attribute groupings seen in Equation (4.3) are all discussed above in the data section, and further in the table of summary statistics below.

I estimate two models in my primary analysis, which include (1) Model using distance bands, and (2) Focused model on a subsample of sales in close proximity to the 8 most active aggregate sites. More detail on the specifics of these models are outlined in Chapter 5.

A logarithmic functional form is used for these models,[25] which is consistent with hedonic models in the literature (e.g. Vyn and McCullough 2014; Deaton and Vyn 2010; Irwin 2002). This is a flexible functional form that has performed well in the literature, particularly for models where spatial fixed effects are used to control for omitted variable bias (Kuminoff, Parmeter, and Pope 2010). Multiple functional forms were tested (i.e. log, semi-log, no logs) and from these tests it was concluded that sign, magnitude, and significance of the coefficients were very similar across forms, noting that results are not sensitive to functional form. From this, a

[25] Not all explanatory variables are logarithmically transformed, including the distance variables in question. Decisions about which variables to leave in their original form follow the general rules of thumb outlined in Woolridge (2006). The variables that have been transformed with ln() are noted in Table 5.1 of Chapter 5.

logarithmic transformation was selected to most easily report the results.

All of the models listed above are also median or quantile regressions. While the method of least squares produces results that estimate the conditional mean of the dependent variable given certain values of the explanatory variables, quantile regression produces results that estimate the conditional median, or other quantiles of the dependent variable. The reason for using the median regression is the high amount of skewness and kurtosis in the data. Kurtosis measures the heaviness of the tails in the distribution, and a value greater than 3 (which is a normal distribution), depict data that possesses heavy tailed distributions. The sales data for this study has a kurtosis value of 16.49, which is extremely high. Mean regressions are more affected by outliers, which is why a median regression approach was chosen. A mean regression using a robust command was also performed, and is detailed in the sensitivity analysis section. In conclusion, the primary qualitative results are unchanged across different functional forms or estimation approaches.

4.3 Summary of Descriptive Statistics

Table 4.2 and Table 4.3 describe the summary statistics; 4.2 includes the entire dataset and 4.3 focuses in on the observations included in the model for the top 8 most active clusters of aggregate sites.

Table 4.2 lists the dependent variable and each independent variable used in the regression analysis. The mean, standard deviation (SD), minimum value, and maximum value are also listed. The average value of rural residential properties sold in Wellington County between the years 2002-2013 was approximately $281, 000. Summary statistics for property and location variables, sale year dummy variables (with 2002 omitted)[26], township fixed effects (with Minto Township omitted), and distance bands (with everything above 3km omitted) are depicted in Table 4.2. It can be noted that the furthest property sale away from an aggregate site was approximately 11 km. The analysis of these variables will be discussed in Chapter 5.

Table 4.2: Summary Statistics of Variables included in the Hedonic Model (Full Sample n=9,095)

		Description	MEAN	MEDIAN	SD	MIN	MAX
Dependent Variable							
	Sale Price	Sale price of property ($)	$281,045.40	$243,000.00	$159,367.70	$203.00	$2,900,000.00
Property and Location Variables							
	Total Area	Total floor area of house (square feet)	1621.0840	1433.50	656.6263	192.0000	5981.0000
	Lot Size	Size of property (acres)	1.6119	0.2523	5.4298	0.0000	116.1600
	Distance to Hwy 401	Distance to Hwy 401 (km)	26.3548	24.2430	13.2150	0.0000	61192.0000
	Distance to Toronto	Distance to Toronto (km)	60.7580	61.9681	22.3237	15.7987	112.0212
	Distance to Urban	Distance to nearest city or town (km)	25.7753	17.6751	18.6218	0.0000	76.6584
	Bathrooms	Number of bathrooms	1.7464	1.5	0.7615	0	10.5
	Fireplaces	Number of fireplaces	0.5172	0	0.6564	0	4
	Pool	*=1 if pool exists on property	0.0631	0	0.2432	0	1
	Age	Length of time from when structure was built (years)	40.6841	28	39.1629	0	188
	Quality	House quailty index (0-10)	6.1309	6	0.5249	1	9
	Basement	*=1 if there exists a furnished basement	0.3957	0	0.4890	0	1
	Air	*=1 if house is air conditioned	0.3265	0	0.4689	0	1
Time Variables							
	SY2003	*= 1 if property sold in the year 2003	0.1175	0	0.3221	0	1
	SY2004	*= 1 if property sold in the year 2004	0.1218	0	0.3271	0	1
	SY2005	*= 1 if property sold in the year 2005	0.1160	0	0.3203	0	1
	SY2006	*= 1 if property sold in the year 2006	0.1109	0	0.3140	0	1
	SY2007	*= 1 if property sold in the year 2007	0.1210	0	0.3262	0	1
	SY2008	*= 1 if property sold in the year 2008	0.0955	0	0.2939	0	1
	SY2009	*= 1 if property sold in the year 2009	0.0808	0	0.2848	0	1
	SY2010	*= 1 if property sold in the year 2010	0.0412	0	0.1987	0	1
	SY2011	*= 1 if property sold in the year 2011	0.0312	0	0.1740	0	1
	SY2012	*= 1 if property sold in the year 2012	0.0308	0	0.1728	0	1
	SY2013	*= 1 if property sold in the year 2013	0.0129	0	0.1128	0	1
Township Variables							
	Erin	*= 1 if property is in the township of Erin	0.1482	0	0.3553	0	1
	Wellington North	*= 1 if property is in the township of Wellington North	0.1191	0	0.3239	0	1
	Mapleton	*= 1 if property is in the township of Mapleton	0.0459	0	0.2095	0	1
	Puslinch	*= 1 if property is in the township of Puslinch	0.0765	0	0.2658	0	1

[26] In order to account for differences in sale years, a sale year dummy variable was created. This attempts to account for any changes that occur over time, such as inflation. As an extra robustness check, a regression was run with month categories, to account for both changes in sale month and year over the entire time period of 2002-2013. The results yielded similar findings to the main findings in this thesis.

	Guelph-Eramosa	*= 1 if property is in the township of Eramosa	0.1258	0	0.3315	0	1
	Wellington Centre	*= 1 if property is in the township of Wellington Centre	0.3796	0	0.4853	0	1
Aggregate Distance Bands							
	0-0.5km	*= 1 if property is within 0-0.5km of an aggregate site	0.0464	0	0.2104	0	1
	0.5-1km	*= 1 if property is within 0.5-1km of an aggregate site	0.0538	0	0.2257	0	1
	1-1.5km	*= 1 if property is within 1-1.5km of an aggregate site	0.0798	0	0.2710	0	1
	1.5-2km	*= 1 if property is within 1.5-2km of an aggregate site	0.0982	0	0.2976	0	1
	2-2.5km	*= 1 if property is within 2-2.5km of an aggregate site	0.0997	0	0.2996	0	1
	2.5-3km	*= 1 if property is within 2.5-3km of an aggregate site	0.0926	0	0.2899	0	1

Note: Omitted dummy variables in the time, township, and distance band categories are 2002, Town of Minto, and 3+ km, respectively.

The accuracy of the estimated effects within each band, as well as the likelihood of detecting significant impacts, is affected by the number of observations. In order to demonstrate that there are sufficient observations within each band, I provide the number of observations within each distance band in Table 4.3. This is compared with the number of observations within each distance band in the subsample, which will be explained following the table.

Table 4.3: Observations within each distance band in the Full Sample and Subsample

Distance Band	Number of Observations	Distance Band	Number of Observations
0-0.5 km	426	0-0.5 km	90
0.5-1 km	494	0.5-1 km	119
1-1.5 km	732	1-1.5 km	182
1.5-2 km	901	1.5-2 km	118
2-2.5 km	915	2-2.5 km	132
2.5-3 km	850	2.5-3 km	101
3+ km	4777	3+ km	54
Whole sample (n = 9,095)		(Subsample n = 796)	

Eight geographic clusters of pits and quarries were chosen for model 2 (the subsample) because the distribution of average extraction area was right-tailed.[27] Only pits that were above 300,000 square meters were chosen, which presents a sample of the most highly active pits. This

[27] "Right-tailed," means that the right side of the distribution is longer than the left side. More observations (e.g. aggregate site active areas) are located to the left of the distribution (e.g. smaller active areas). Right-tailed distributions have a mean located to the left of the peak, whereas a normal distribution (equal tails) has a mean located in the centre of the peak.

is explained in further detail in the data section above. It is also important to note again that – other than the geographical clusters – the pits and quarries were not distributed in close proximity to one another. Hence, a rural residential property is not expected to be affected by more than 1 geographical cluster. The summary statistics for properties for which the closest aggregate site is one of the 8 most active pits are listed in Table 4.4. The analysis of this top 8 cluster will be explored in Chapter 5.

Table 4.4: Summary Statistics of Variables included in the Hedonic Model (Top 8 Cluster n=796)

		Description	MEAN	MEDIAN	SD	MIN	MAX
Dependent Variable							
	Sale Price	Sale price of property ($)	$221,191.80	$204,000	$90,208.15	$85,000.00	$625,000.00
Property and Location Variables							
	Total Area	Total floor area of house (square feet)	1962.9280	1732.00	875.7119	550.0000	5414.0000
	Lot Size	Size of property (acres)	2.1545	0.75	6.6027	0.0000	85.7200
	Distance to Hwy 401	Distance to Hwy 401 (km)	13.9001	8.318	15.2054	0.0000	53.9270
	Distance to Toronto	Distance to Toronto (km)	41.0162	33.5495	21.1633	21.4167	98.5007
	Distance to Urban	Distance to nearest city or town (km)	19.0981	11.4183	17.3126	0.0000	67.1073
	Bathrooms	Number of bathrooms	2.0169	2	0.9226	1	7.0
	Fireplaces	Number of fireplaces	0.7553	1	0.7263	0	4
	Pool	*=1 if pool exists on property	0.1223	0	0.3279	0	1
	Age	Length of time from when structure was built (years)	37.1136	27	36.6983	0	161
	Quality	House quailty index (0-10)	6.4101	6	0.7181	4	9
	Basement	*=1 if there exists a furnished basement	0.4250	0	0.4947	0	1
	Air	*=1 if house is air conditioned	0.4869	0	0.5001	0	1
Time Variables							
	SY2003	*= 1 if property sold in the year 2003	0.1136	0	0.3175	0	1
	SY2004	*= 1 if property sold in the year 2004	0.1311	0	0.3377	0	1
	SY2005	*= 1 if property sold in the year 2005	0.0911	0	0.2880	0	1
	SY2006	*= 1 if property sold in the year 2006	0.0999	0	0.3000	0	1
	SY2007	*= 1 if property sold in the year 2007	0.1236	0	0.3293	0	1
	SY2008	*= 1 if property sold in the year 2008	0.0774	0	0.2674	0	1
	SY2009	*= 1 if property sold in the year 2009	0.0674	0	0.2509	0	1
	SY2010	*= 1 if property sold in the year 2010	0.0537	0	0.2255	0	1
	SY2011	*= 1 if property sold in the year 2011	0.0637	0	0.2443	0	1
	SY2012	*= 1 if property sold in the year 2012	0.0487	0	0.2154	0	1
	SY2013	*= 1 if property sold in the year 2013	0.0237	0	0.1523	0	1
Township Variables							
	Erin	*= 1 if property is in the township of Erin	0.3271	0	0.4695	0	1
	Wellington North	*= 1 if property is in the township of Wellington North	0.0855	0	0.2798	0	1
	Mapleton	*= 1 if property is in the township of Mapleton	0.0025	0	0.0498	0	1
	Puslinch	*= 1 if property is in the township of Puslinch	0.4771	0	0.4998	0	1
	Guelph-Eramosa	*= 1 if property is in the township of Eramosa	0.0372	0	0.1893	0	1
	Wellington Centre	*= 1 if property is in the township of Wellington Centre	0.0446	0	0.2066	0	1
Aggregate Distance Bands							

	0-0.5km	*= 1 if property is within 0-0.5km of an aggregate site	0.1115	0	0.3150	0	1
	0.5-1km	*= 1 if property is within 0.5-1km of an aggregate site	0.1475	0	0.3548	0	1
	1-1.5km	*= 1 if property is within 1-1.5km of an aggregate site	0.2255	0	0.4182	0	1
	1.5-2km	*= 1 if property is within 1.5-2km of an aggregate site	0.1462	0	0.3535	0	1
	2-2.5km	*= 1 if property is within 2-2.5km of an aggregate site	0.1636	0	0.3701	0	1
	2.5-3km	*= 1 if property is within 2.5-3km of an aggregate site	0.1252	0	0.3311	0	1

Note: Omitted dummy variables in the time, township, and distance band categories are 2002, Town of Minto, and 3+ km, respectively.

Again, the number of observations within each distance band are important to the accuracy of the results. A full description of the number of observations within each band in the top 8 cluster are located in Table 4.3.

The observations within each band decrease by approximately 300-800 observations from the full sample to the subsample. Each band in the subsample has at least 90 observations within it, and each band has between 90-190 observations. The bands are consistent in that no band has a considerably large amount of observations comparatively to another band.

The full sample and subsample are referred to as Model 1 and Model 2, respectively, in the next chapter. The differences in these two model specifications are discussed and subsequently, the implications of the differences in these two models' results are discussed in Chapter 6.

CHAPTER 5: RESULTS

This chapter presents the results of the two hedonic property models discussed in Chapter 4. The chapter will be broken down into four sections: one section for each model, a section on sensitivity analysis and robustness checks, and a final section for misspecification discussion.

Two separate hedonic models are analyzed for rural residential properties: (1) Model using distance bands, and (2) The same model limited to properties located closest to one of the 8 most active pit or quarry clusters.

5.1 Model 1 & 2 Results and Interpretation

The regression results shown in Table 5.1 identify the coefficients on each variable, and their corresponding significance. Robust standard errors are also reported. Two additional statistical measures are reported, which are the adjusted R^2 and the sample size. The adjusted R^2 for the first regression is 0.6260, which means that approximately 63% of the total variation in the property sales dataset is accounted for in this specific model. Greene (2012) notes that R^2 measures the total proportion of the total variation in the dependent variable that is accounted for or explained by variation in the independent variables. Adjusted R^2 is used instead of regular R^2 because it is more precise - when more variables are added, the value decreases. The sample size is also reported to depict the change in sample size across models.

Table 5.1. Estimated Coefficients for the hedonic models

	Model 1: Base		Model 2: Activity	
	Coefficient	Robust Std Err	Coefficient	Robust Std Err
Variable				
Property and Location Variables				
ln(Total Area)	0.3112***	0.0087	0.3009***	0.0273
ln(Lot Size)	0.1195***	0.0018	0.0999***	0.0059
ln(Distance to Hwy 401)	-0.0210**	0.0067	0.0340***	0.0045
ln(Distance to Toronto)	-0.1073***	0.0137	-0.0051	0.0742
ln(Distance to Urban)	-0.0300***	0.0042	-0.0200	0.0169
Bathrooms	0.0322***	0.0037	0.0325**	0.0102
Fireplaces	0.0262***	0.0030	0.0204*	0.0088
Pool	0.0468***	0.0083	0.0317	0.0173
Age	-0.0014***	0.0001	-0.0009***	0.0002
Quality	0.1446***	0.0055	0.1963***	0.0157
Basement	0.0463***	0.0037	0.0610***	0.0126
Air	0.0314***	0.0038	0.0168	0.0115
Time Variables				
SY2003	0.0593***	0.0076	0.0865***	0.0194
SY2004	0.1520***	0.0075	0.1364***	0.0259
SY2005	0.2348***	0.0083	0.2085***	0.0326
SY2006	0.2918***	0.0070	0.3100***	0.0223
SY2007	0.3544***	0.0071	0.3462***	0.0250
SY2008	0.3894***	0.0071	0.3802***	0.0243
SY2009	0.3738***	0.0079	0.3823***	0.0212
SY2010	0.4653***	0.0099	0.4613***	0.0365
SY2011	0.4880***	0.0152	0.4875***	0.0346
SY2012	0.5122***	0.0148	0.4913***	0.0684
SY2013	0.5719***	0.0172	0.5375***	0.0329
Township Variables				
Erin	0.3371***	0.0193	0.3848**	0.1398
Wellington North	0.0825***	0.0097	-0.0705	0.1047
Mapleton	0.2222***	0.0129	0.3270*	0.1612
Puslinch	0.3005***	0.0275	0.4307***	0.1306
Guelph-Eramosa	0.3174***	0.0182	0.3082*	0.1285
Wellington Centre	0.3176***	0.0118	0.2066	0.1067
Aggregate Distance Bands				
0-0.5km	0.0320***	0.0082	0.0210	0.0255
0.5-1km	0.0470***	0.0072	0.0111	0.0251
1-1.5km	0.0484***	0.0074	-0.0081	0.0247
1.5-2km	0.0424***	0.0073	0.0218	0.0281
2-2.5km	0.0411***	0.0078	0.0333	0.0272
2.5-3km	0.0486***	0.0068	-0.0053	0.0264
Constant	9.5345***	0.1060	8.3625***	0.4332
R-squared	0.6260		0.6894	
Number of Sales	9,095		796	

Notes: Asterisks (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Omitted dummy variables in the time, township, and distance band categories are 2002, Town of Minto, and 3+ km, respectively.

All models listed were run with robust[28] commands, creating a regression that provides standard errors adjusted for heteroscedasticity.[29] A robust regression adjusts the value of the standard errors to take into account issues concerning heterogeneity and lack of normality, and was used in this case to account for these issues. This particular robust command used specifies how to estimate the variance-covariance matrix corresponding to the parameter estimates and reported standard errors are the square roots of the variances (diagonal elements).

The disamenity effects of pits and quarries is hypothesized to be increasing with both proximity to the site and activity of the site. Therefore, the coefficient for the distance variables representing aggregate site impacts is expected to be negative. The band closest to the aggregate site (0-0.5 km) was predicted to have the highest negative effect, and that negative effect was expected to diminish as the distance bands went further out. This negative effect was expected to be greater across all bands for the more active pits (top 8 most active geographical clusters).

Based on the results, this hypothesis was rejected; significant negative price effects on properties in close proximity to aggregate sites in Wellington County are not found. Further, within close proximity (half a kilometer) to these sites, significant positive price effects are found. In the first band (0-0.5 km), the effect is +3.2% in property value. These effects across all bands are approximately an increase in 3-4% of the property's value, as shown in Table 5.1. When focusing the model on only the top 8 most active pits in the county, the coefficients either lose strength in the positive effect or flip signs to become negative; however, these results are not statistically significant. This direction of the change in the coefficients is consistent with theory: if it is expected that pits and quarries have an effect on property values, then when site activity is

[28] The command in Stata is vce(robust).
[29] Heteroskedasticity occurs when the variability of a variable is unequal across the range of values of a second variable that predicts it (i.e. there could be sub-populations that have different variabilities from others).

considered, the change in the coefficients moves in a direction that removes the positive effect.

The results for the property, location, time, and township variables are consistent across all models. The variables that positively impacted price were total area of the structure(s), lot size of the property, number of bedrooms, fireplaces, pools, higher quality index of the house, finished basement, and air conditioning. The variables that negatively impacted price were distance to highway 401, distance to Toronto, distance to urban area, and age of the house. The exception of consistent results across models is two distance variables becoming insignificant once the model is restricted to the top 8 most active sites: distance to Toronto and distance to nearest urban area. These two variables were tested for correlation – which yielded approximately 0.76 – which could influence their results. If independent variable coefficients are highly correlated, one variable could be explaining variation encompassed in another, and vice versa.

An examination of variance inflation factors (VIF) was run to test the possible issue of multicollinearity. Most variables did not indicate a VIF value greater than 10, which is the turning point where there is cause for concern (Gujarati 1995). The variables that possessed a VIF value greater than 10 were three township variables and distance to Toronto. The three township variables were used as fixed effects to control for properties located in different townships. These townships are Erin, Puslinch, and Guelph-Eramosa.

The results of the other township fixed effects variables indicate some variation in prices across these townships for rural residential properties, which may account for any influence of spatially varying omitted variables. The time variables are consistent with what was expected: an increase in price for each sale year.

This analysis highlights the importance of including site activity when assessing the effect of aggregate sites on property values. The first model can be termed "naïve," because there is an omitted variable – the measure of aggregate site activity. The actual disturbed land area is quite different from the licensed aggregate area provided in the MNR data set. Out of 58 geographic clusters of aggregate sites in Wellington County, 6 of those clusters were considered to have no activity present from 2002-2013. The most active cluster was almost 3 million square metres and the least active (not including zero activity) was only 3,800 square metres. There is very large variation in aggregate activity in Wellington County, and that is why it is so important to include this when attempting to model the effect on property values.

To address some of the model limitations and their potential influence on the sensitivity of the results, a number of alternate model specifications were examined, including: tests for robustness and heteroskedasticity, differing sizes of high activity geographic clusters, constraining the regression to a 3km radius, and 1km distance bands (as opposed to 0.5km). Each of these alternate specifications is discussed below, following a discussion of the results of the 2 main models.[30] The results for the sensitivity analysis are shown in the next section.[31]

5.2 Sensitivity Analysis

Attempting to address a number of issues and limitations in the data set and the empirical approach, several alternate model specifications were used for sensitivity analysis. The results of each specification are compared to those of models 1 and 2 in Table 5.2.[32] The alternate model

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[30] Sensitivity analysis shown here is only focused on model 1, as alternate specifications of the other models yielded very similar results.

[31] Sensitivity beyond what is shown in section 5.2 was performed. Some other model specifications performed were distance bands up to 11km (max), constraints at 1km, 2km, and 5km, as well as an interaction variable between activity and distance. These models are not shown for simplicity purposes, as all mentioned provided consistent results with the main models.

[32] Only the results of the distance variables are shown in these tables, as the results for all other variables are consistent with those from the original models.

specifications were specifically chosen to test the robustness of the results, and are listed below:

(1) a. Functional Form: Quadratic,
    b. Functional Form: Quadratic with Activity,
(2) a. Functional Form: Inverse Continuous Distance,
    b. Functional Form: Inverse Continuous Distance with Activity,
(3) Mean Robust Regression,
(4) a. Top 10 Geographical Clusters,
    b. Top 12 Geographical Clusters,
    c. Aberfoyle Cluster,
(5) 1km Discrete Distance Bands,
(6) Constraining the regression at 3km, and
(7) Narrowing the regression to only active pits (removing zero activity).

These are all discussed in detail following Table 5.2.

Table 5.2. Comparison of the coefficients for the distance variables across alternate model specifications (standard errors in parentheses)

Distance Variable	Primary Model 1 (No Activity)	Primary Model 2 (Activity)	(1a) Functional Form: Quadratic	(1b) Quadratic with Activity	(2a) Functional Form: Inverse	(2b) Inverse Distance with Activity	(3) Mean Robust	(4a) Top 10 Cluster	(4b) Top 12 Cluster	(4c) Aberfoyle Cluster	(5) 1km Bands (larger band width)	(6a) 3km Constraint	(6b) 3km Constraint with Activity	(7) Only Active Pits
0-0.5km Band	0.0320***	0.0210					0.0835***	0.0269	0.0147	0.0563	0.0378***	-0.0263**	0.0213	0.0265*
	(0.0082)	(0.0255)					(0.0196)	(0.0227)	(0.0203)	(0.0464)		(0.0101)	(0.0194)	(0.0109)
0.5-1km Band	0.0470***	0.0111					0.01073***	0.0043	-0.0141	-0.0666	(0.0068)	-0.0178	0.0144	0.0322***
	(0.0072)	(0.0251)					(0.0175)	(0.0192)	(0.0171)	(0.0443)		(0.0102)	(0.0205)	(0.0092)
1-1.5km Band	0.0484***	-0.0081					0.0654***	0.0106	-0.0185	0.0132	0.0457***	-0.0127	0.0023	0.0464***
	(0.0074)	(0.0247)					(0.0140)	(0.0200)	(0.0184)	(0.0388)		(0.0090)	(0.0186)	(0.0086)
1.5-2km Band	0.0424***	0.0218					0.0657***	0.0263	-0.0145	-0.0099	(0.0060)	-0.0250**	0.0261	0.0430***
	(0.0073)	(0.0281)					(0.0127)	(0.0199)	(0.0190)	(0.0426)		(0.0088)	(0.0202)	(0.0088)
2-2.5km Band	0.0411***	0.0333					0.0590***	0.0364	-0.0009	0.0109	0.0453***	-0.0120	0.0421*	0.0437***
	(0.0078)	(0.0272)					(0.0129)	(0.0202)	(0.0204)	(0.0419)		(0.0092)	(0.0203)	(0.0088)
2.5-3km Band	0.0486***	-0.0053					0.0561***	0.0305	0.0303	0.0031	(0.0058)			0.0495***
	(0.0068)	(0.0264)					(0.0134)	(0.0202)	(0.0168)	(0.0422)				(0.0066)
Distance			-0.0172***	0.0154										
			(0.0036)	(0.0191)										
$Distance^2$			0.0009	-0.0049										
			(0.0004)	(0.0052)										
Inverse Distance					0.0020*	0.0052								
					(0.0010)	(0.0040)								
R-squared	0.6260	0.6858	0.6258	0.6888	0.624	0.6887	0.6297	0.6648	0.5626	0.6318	0.6260	0.6558	0.6952	0.6246
n	9,095	796	9,095	796	9,095	796	9,095	1,161	1,460	403	9,095	4,287	737	6,998

Note: Asterisks (***, **, *) indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.2.1 Functional Form: Quadratic and Quadratic with Activity

Using a quadratic regression (with one variable measuring the continuous distance away from a pit and another squaring this distance) produces similar results to the distance bands approach. This functional form was used for sensitivity in order to see if functional form changed from the main results. A 1.72% decrease in property value is found when moving each kilometer further away from a pit, which is consistent with the main models. When focusing the model on only the top 8 most active pits in the county, no statistically significant results of any price effect are found.

5.2.2 Functional Form: Inverse Continuous Distance with and without Activity

Like the quadratic functional form, this functional form was used for sensitivity in order to see if using an inverse distance variable changed the results. Using a regression with an inverse distance variable (distance to the pit) produced similar results to the distance bands approach. A 0.2% increase in property value when moving one unit (a kilometer) closer to a pit was found, which is consistent with the main models. The result indicates that property values increase slightly with proximity to the nearest pit. When focusing the model on only the top 8 most active pits in the county, the coefficients lose strength in the positive effect; but these results are not statistically significant. This direction of the change in coefficients is consistent with theory: if it is expected that pits and quarries have an effect, then when activity is considered the coefficient moves in a direction that removes that positive effect.

5.2.3 Mean Robust Regression

As mentioned in the last chapter, the method of least squares produces results that estimate the conditional mean of the dependent variable given certain values of the explanatory variables. The median or quantile was used in the main models above, which produced results that estimated the conditional median (rather than the mean). This alternate model specification was used to compare to the main models. The results were similar to the median regressions, but provided more positive property value effects (between a 5-10% increase in value).

5.2.4 Top 10 and 12 Geographical Clusters and Aberfoyle Cluster (Most Active Site)

Realizing that focusing on the top 8 clusters removed many observations in the analysis, top 10 and 12 cluster regressions were performed and produced very similar results. Both clusters yielded no statistically significant results in all bands. The top 10 and top 12 models use only observations in proximity to pits or quarries that are greater than 250,000 or 200,000 square metres, respectively. These are also points on the right tail of the distribution of activity graph, seen in Figure 4.4, meaning that these clusters also represented high activity aggregate sites. The Aberfoyle cluster was also modeled in order to focus on one large cluster; this is the most active aggregate site in Wellington County.[33] No statistically significant impacts were found in all distance bands, which is consistent with the result that, once accounting for activity, aggregate sites have no statistically significant effects on property values.

[33] Since the Aberfoyle cluster has high property values in close proximity, as well as a rehabilitation plan underway, it is hypothesized that possibly Aberfoyle could be providing an amenity value in some areas, rather than a disamenity. A regression was also run with all observations with the omission of properties nearby Aberfoyle. The result was similar to the main findings; a slight positive increase in property values in proximity to aggregate sites.

5.2.5 1km Discrete Distance Bands

As an alternative to the discrete distance bands of a half-kilometre width, distance bands using a one kilometre width were also used, up to 3 kilometres. The bands were 0-1, 1-2, and 2-3 km for the nearest aggregate site. Assuming that aggregate sites have a negative effect on property value, and this effect diminishes further away from the site, the distance bands were expected to be negative, with declining magnitudes with distance from the nearest aggregate site. However, as with the half-kilometre distance band width model, the price effects are actually positive – with approximately a 3-4% increase in property values in each band.

5.2.6 Constraining the regression at 3 kilometres

A regression constrained at 3km is used to test my hypothesis that no effects should be present after 3km, from personal experience.[34] The only occurrence of statistically significant negative price effects are found when constraining the model to a 3km radius away from the aggregate sites. This is only found when modeling the entire dataset, and not restricting the model to just those 8 highly active pits. Within the 0-0.5 km band and the 1.5-2 km band, an approximate 2.5% decrease in property values is found. This negative price effect is relative to prices in the 2.5-3 km band, which is the omitted band. All other distance bands also have a negative sign, but lack statistical significance.

5.2.7 Narrowing regression to only active pits (removing zero acitvity)

This regression was conducted to test the hypothesis that possibly only active pits and quarries may have an effect on property values. The results from this model are consistent with

[34] My personal experience is that I could no longer hear or see a pit or quarry from 3 kilometres away.

the narrative presented by the data in the original model: slight positive effects, but these effects are smaller (approximately 2-3%) once removing those observations in proximity to the 6 geographic clusters that had no activity on site.

5.3 Misspecification Analysis/Robustness Checks

5.3.1 Heteroskedasticity - Bootstrapping

A bootstrapped standard errors regression was also performed to further account for heteroskedasticity[35] in the models. Bootstrapping is essentially random sampling with replacement. Taking many random samples may account for the sub-populations that have different variabilities from others. Bootstrapping the standard errors assigns a measure of accuracy to the original estimates.

The estimated results are robust to some types of misspecification and to heteroskedasticity of the errors. This may account for issues concerning heterogeneity and lack of normality. The result of the bootstrapped standard errors regression were consistent with the main model results.

[35] Heteroskedasticity occurs when the variability of a variable is unequal across the range of values of a second variable that predicts it (i.e. there could be sub-populations that have different variabilities from others).

CHAPTER 6: DISCUSSION

This chapter summarizes the findings of chapter 5 and discusses the implications of those findings. Any potential errors, omissions, or limitations of the study are addressed here. The section includes a short discussion on the possibilities for future research stemming from this study.

6.1 Major Findings

In response to concerns raised by various organizations regarding the potential effects of aggregate sites on neighbouring property values, and to a lack of peer-reviewed literature on this issue, this thesis estimates the impacts of pits and quarries on rural residential property values in Wellington County.

While aggregate is a valued resource, the extraction of aggregate is often identified as a negative externality. Similar to other resource extraction issues – such as shale gas exploration sites studied in Gopalakrishnan and Klaiber (2013) and gravel pits assessed in Zhang and Hite (2016) – nearby residents identify a host of events associated with aggregate extraction that can be categorized as negative externalities. Residential concerns include noise and visual disamenities, as well as environmental concerns, mainly around water quality. The conflict of interests between aggregate extraction and residential interests often results in disagreement. As a result, there has been media attention and lobby groups forming around some aggregate sites in Wellington County.

Currently, there is only anecdotal and appraisal information about changes in property values near aggregate sites in Ontario (Lansink 2014). Despite the anecdotal nature, this study features heavily into specific individual examples of property sales near pits where the property values have changed. The Lansink (2014) study assesses several stand-alone sales nearby different pits, rather than average pit impacts over large areas. Unfortunately, there is very little literature outside Ontario examining this issue.

This thesis adds to the literature on the effects of aggregate sites by utilizing a hedonic approach, which has not been used for all types of aggregate sites (pits and quarries). I am aware of only four studies that estimate the impact of gravel pits: Hite (2006), Erickcek (2006), Zhang and Hite (2016), and Lansink (2014). The novelty of my study is threefold: (1) Distance to major urban areas, Toronto, and a major highway are controlled for in the model, (2) county-level analysis, as well as individual aggregate site analysis is performed, and most importantly, (3) a measure of aggregate extraction activity is included in my analysis.

The main narrative that these results address is the importance of including an aggregate site's activity when analyzing their impacts. The Ministry of Natural Resources and Forestry main database for licensed aggregate sites include all pits and quarries that are under an active license, however an active license does not necessarily mean that a pit is active in extraction activities. This analysis presents a "naive" model (where no pit identifiers or activity is included in the model), which is then compared with a model that includes a measure of activity. Once activity is accounted for, and once the model focuses on only those pits that are under high extraction activities, the results provide no evidence of aggregate site impacts on rural residential property values. This result of no property value impacts is further confirmed when constraining the model to the most active geographical cluster in Wellington County: Aberfoyle.

Two hypotheses were mentioned in Chapter 1, and further in Chapter 3. My first hypothesis is that rural residential properties may experience a decline in value within close proximity to aggregate sites and that this effect may diminish over time. My second hypothesis states that the effect of proximity to an aggregate site may depend on its level of activity. If a site had higher extraction activity, I would expect the slope of the willingness to pay curve in Figure 3.1 to be steeper, and the effect to diminish with greater distance away from a site (the larger the extraction activity, the greater the effect on property values). These hypotheses were tested, and were effectively rejected, as small positive effects (instead of negative) were seen in the full sample, and no statistically significant effects were found in the subsample of high activity clusters. There is no evidence in this analysis to support the claim that properties within Wellington County experience a decline in close proximity to aggregate sites.

The results in Chapter 5, which included the primary models and sensitivity analysis, were conclusive. The primary models indicated no statistically significant impacts within 3 kilometres away from aggregate sites once aggregate activity was accounted for. The sensitivity analysis was consistent with these results.

6.3 Implications

In the first chapter, I stated that the results of this study attempt to inform municipal governments, community groups, MPAC, the OMB, and rural residential property owners. This research can benefit each of these stakeholder groups. The municipal governments and OMB may utilize this information to inform the decision-making process of approval of aggregate development projects in specific locations. Rural residential property owners may be interested in the valuation of surrounding properties in their township that are neighbouring these sites. Further, MPAC already assumes that property owners experience a disamentity abutting or in proximity to pits. This study could provide insight into the property appraisal process for properties nearby aggregate sites. This is outlined in further detail below.

The community group that opposes the Hidden Quarry, the Concerned Residents Coalition (CRC), in Rockwood, Ontario, lists "decline in property values," as a major concern on their website. The research conducted in this thesis is particularly concerned with assessing this concern – the effect of aggregate extraction on surrounding property values. If the disamenities created from pits and quarries are perceived by residents living in the area, the perceptions can translate into a discount of property values. The prices of nearby houses would be reduced to compensate the buyers for accepting the disamenity.

A form of compensation is already given through property taxes. MPAC currently adjusts property appraisal values for taxation purposes for those who are abutting or in close proximity to sites. In Wellington County, the adjustment was -3% for abutting an industrial property and -2% for proximity in 2016. My study seems to suggest that these adjusted values could be unnecessary in Wellington County specifically, as significant negative effects are not found from being located nearby aggregate sites. The extraction activity measure used in my study could be useful to MPAC to include in their models that determine property appraisals around these sites. This study provides some insight into the property appraisal process. As five percent of Ontario's aggregate sites are located within Wellington County alone, this is an important contemporary issue. The large number of sites within Wellington County, and the current pending proposals for even more development in the county, suggest that the property appraisal process surrounding these sites may have to be periodically refined and approved to support the individual circumstances – time, location, and nature of the development.

The primary research question of this thesis was whether aggregate sites influence nearby property values. Pits differ by level of activity, and properties differ by proximity to the sites. A key empirical issue is addressing the extraction activity of the pits and quarries, as there is large variation in extraction levels between different pits and quarries in Wellington County. Geographical clusters added in the models are an attempt to improve this estimate of aggregate site impact. This method of using average area of activity from mapping systems, as well as clustering individual sites abutting each other, can be used in other studies looking at the impact of these sites. This method provides useful insight to the actual extraction activity present. This method also adds confidence in the results, as extraction activity is hypothesized to play a role in any effect on property values.

This study provides information that some stakeholder groups – Municipal governments, the OMB, community groups, MPAC, and rural residential property owners – can use to understand the effects of aggregate development on property values, as outlined above. In addition to this, the methods for obtaining aggregate site activity can help inform future research in this area as it attempts to remedy the issue in the empirical analysis of companies holding licenses, but choosing not to extract.

6.2 Limitations and Areas of Future Research

Several areas for future research can be proposed from the findings of this study. Due to some sensitivity of results when using differing functional forms, and the strength in statistical significance varying with alterations to the model, pragmatic research in this area is recommended. Looking at pits and quarries on a case-by-case basis, rather than looking at an average effect across an entire county or province may produce more accurate results. This specified analysis may be tedious to do in practice for mass appraisal purposes. In my study, I was able to test one model that included only those observations that were proximal to the Aberfoyle geographical cluster. I realized that it takes time to test and run regressions for each individual site.

One potential area for future research is that this public perception of future development could have affected property values around licensed aggregate sites that had zero activity (and no license yet). For example, the threat of a site being developed in the future may have some impact on property values. This makes sense intuitively if there had been public knowledge that an area of land could be a potential future aggregate site. Future study on proposed pits (that have not been licensed yet), rather than just active or licensed pits, could be explored.

Some of these aggregate sites in the dataset are very close to urban areas. For instance, the city of Guelph has four neighbouring clusters of pits. However, no properties within Guelph's city limits are included in this analysis, because these sales were not classified as rural residential. Including properties that are considered residential properties may add another layer to this analysis.

In addition to the property types, the time period included in the data may have played a role in the outcome of the results. This included twelve years of property sales between the years 2002-2013, which includes periods of time where pits became active and inactive. Further analysis into the pre- and post- extraction may be explored. Additionally, the dataset only includes properties that have been sold within that time period – if a property was not sold, any loss in value cannot be accounted for. Further, the date listed as the sale date for each property is not necessarily the date that the property sold, but is the closing date. This could have an effect on the models, as some properties are actually sold months before closing. This is impossible to ameliorate with the current data set, as it is the only date that is provided by MPAC, and is the best available predictor of when the property was actually sold. Perhaps gaining insight into the dates the properties actually sold may help this analysis.

Geographical information systems (GIS) was used to create all of the distance variables: distance to the nearest aggregate site, distance to Toronto, distance to nearest urban centre, and distance to the 401 highway. For the distance to the nearest aggregate site measure, the straight-line distance was calculated from the middle of the property to the edge of the nearest aggregate site. For large pits, this may be far away from any actual disamenity, and may just be close to a licensed area that could have zero activity. The geographical clusters added in the models are an attempt to improve this calculation. All of these possible shortcomings addressed above could be first points of exploration in future research. In the future, the methods outlined in this thesis can also be applied to other counties or geographical areas.

This analysis has taken on the substantive task of estimating the impact of aggregate sites on nearby rural residential property values, which attempts to address the gap in the current academic literature. As there are current Ontario Municipal Board hearings in Wellington County and beyond regarding the proposals of future aggregate sites, this is an important contemporary issue. As aggregate material is essential to our daily life (the average person makes use of 14 tonnes of aggregate material each year), this will continue to be a subject of importance into the future.

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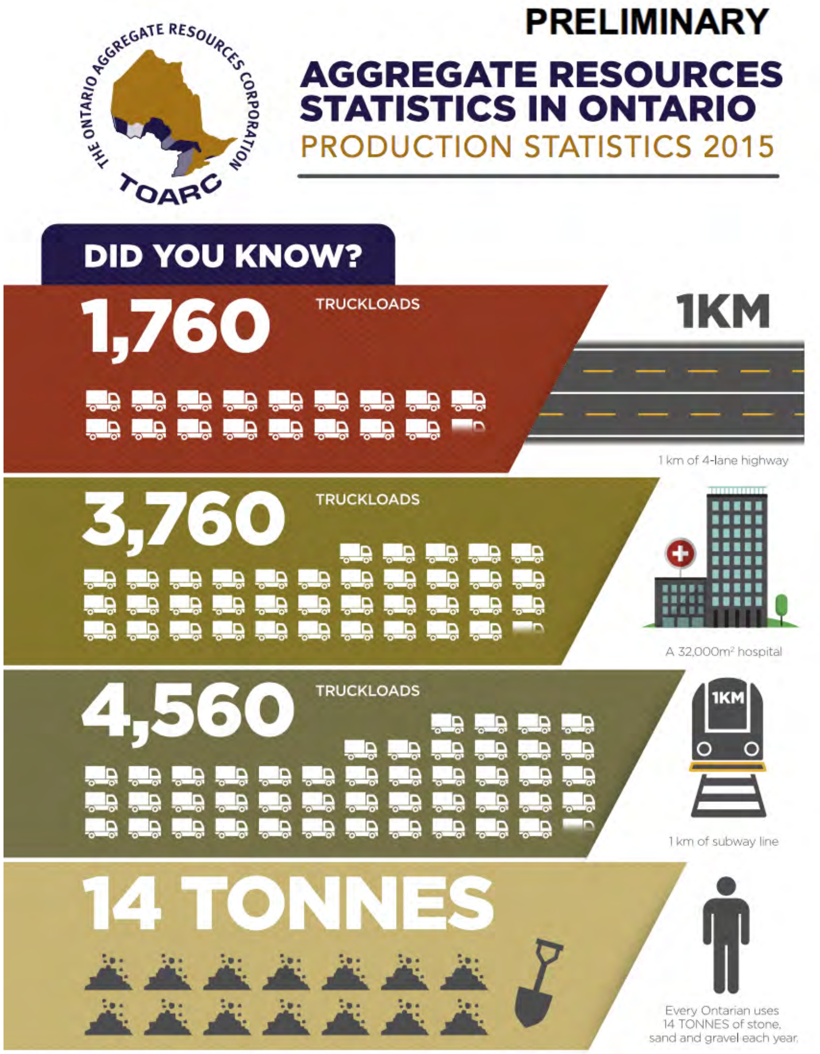
APPENDIX

Figure A1: Uses of Aggregate Resources in Ontario



Source: The Ontario Aggregate Resources Corporation (TOARC, 2015)
Notes: A truckload is about 13 metric tons in this 2015 report.

Table A1: Pit and Quarry Inventory in Wellington County

#	Pit Identifier Number (with Geographic Cluster)	PIT (P) QUARRY (Q) BOTH (B)	LOCATION	LICENSE AND MAX ANNUAL TONNAGE	LICENSED AREA
1	3595 (neighbouring 10606, 80956, 624233, 3634, 3685, 3686)	P	Marsville	Class A 53400	9.2 ha
2	3685 (neighbouring 10606, 80956, 624233, 3634, 3686, 3595)	P	Marsville	Class A 90700	33.08 ha
3	3686 (neighbouring 10606, 80956, 624233, 3634, 3595, 3685)	P	Marsville	Class A 900000	162.33 ha
4	4469	P	Mt Forest	Class A 120000	38 ha
5	4491 (neighbouring 15477, 102306, 4719, 4522, 625192)	P	Mt. Forest	Class A 800000	40.5 ha
6	4495 (neighbouring 4514, 4765)	P	Minto	Class A 100000	39.9 ha
7	4508	P	Mt. Forest	Class B 20000	1.3 ha
8	4511	P	Minto	Class B 20000	5.3 ha
9	4513	P	Minto	Class A 40000	9.85 ha
10	4514 (neighbouring 4495, 4765)	P	Minto	Class A 20000	12.7 ha
11	4519	P	Teviotdale	Class A 100000	27 ha
12	4522 (neighbouring 15477, 102306, 4719, 4491, 625192)	P	Mt Forest	Class A 500000	47 ha
13	4622	P	Clifford	Class A 40000	25 ha
14	4638	P	Lakelet	Class A 50000	12.3 ha
15	4682	P	Palmerston	Class A 50000	10.82 ha
16	4765 (neighbouring 4495)	P	Minto	Class A 100000	80.97 ha
17	4875	P	Keldon	Class A 100000	7.8 ha
18	4878	P	Mt Forest	Class A 30000	10 ha
19	4958 (neighbouring 4961)	P	Mt Forest	Class A 100000	24.5 ha
20	4960	P	Mt Forest	Class A 125000	18.2 ha
21	4961 (neighbouring 4958)	P	Mt Forest	Class A 100000	10.5 ha
22	5015	P	Mt Forest	Class A 30000	12.9 ha
23	5054	P	Mt Forest	Class A 100000	10.8 ha
24	5110	P	Mt Forest	Class A 90000	18.26 ha
25	5462	P	Georgetown	Class A unlimited	6.28 ha
26	5465 (neighbouring 5563, 5520, 5483, 5734, 5631, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5737, 10671)	P	Aberfoyle	Class A unlimited	34.01 ha

27	5472 (neighbouring 15473)	P	Brucedale	Class A unlimited	22.28 ha
28	5482 (neighbouring 5610, 5654, 625189)	B	Guelph	Class A 1,000,000	89.8 ha
29	5483 (neighbouring 5563, 5520, 5465, 5734, 5631, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5737, 10671)	P	Aberfoyle	Class A 500000	33.6 ha
30	5490	P	Guelph	Class A 400000	32.21 ha
31	5514	B	Guelph	Class A 2,000,000	142.34 ha
32	5520 (neighbouring 5563, 5483, 5465, 5734, 5631, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5737, 10671)	P	Aberfoyle	Class A unlimited	115.7 ha
33	5531	P	Erin	Class A 500000	44.96 ha
34	5537 (neighbouring 46162)	P	Hespeler	Class A 300000	48.43 ha
35	5549 (neighbouring 6747, 5570)	P	Hawkesville	Class A 1,300,000	93.15 ha
36	5551	P	Rockwood	Class A 20000	11.75 ha
37	5552	P	Rockwood	Class A 20000	4.94 ha
38	5563 (neighbouring 5520, 5483, 5465, 5734, 5631, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5737, 10671)	P	Aberfoyle	Class A 454000	32.4 ha
39	5569 (neighbouring 124155, 5696, 625138, 19333, 27777, 625212)	P	Elora	Class A 300000	27.14 ha
40	5578 (neighbouring 39158)	P	Fergus	Class B 20000	19.12 ha
41	5579	P	Fergus	Class A 25000	20.25 ha
42	5581 (neighbouring 92916, 5660, 5595, 5678)	P	Elora	Class A 500000	27.14 ha
43	5587	P	Cedar Valley	Class B 20000	9.64 ha
44	5588	P	Elmira	Class A 75000	4.45 ha
45	5592	P	West Montrose	Class A 100000	22.9 ha
46	5598	P	Erin	Class A 725600	102.06 ha
47	5602	P	Erin	Class A 925000	136.4 ha
48	5609	P	Aberfoyle	Class A 1,000,000	78.1 ha
49	5610 (neighbouring 5482, 5654)	P	Guelph	Class A 273000	17.3 ha
50	5611	P	Erin	Class B 20000	8.1 ha
51	5616 (neighbouring 5546, 5480, 5492)	P	Acton	Class A 750000	58.6 ha
52	5618	P	Riverstown	Class A 75000	5.25 ha
53	5631 (neighbouring 5520, 5483, 5465, 5734, 5563, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5737, 10671)	P	Aberfoyle	Class A 1,000,000	8.1 ha
54	5635	P	Mt Forest	Class B 20000	6.31 ha

55	5640 (neighbouring 5686)	P	Arthur	Class B 20000	26.73 ha
56	5645	P	Riverstown	Class A 40000	9.49 ha
57	5646	P	Belwood	Class A 50000	10.13 ha
58	5653	P	Puslinch	Class A 300000	6.37 ha
59	5654 (neighbouring 5482, 5610, 625189)	P	Guelph	Class A 350000	35.64 ha
60	5664	P	Goldstone	Class B 20000	5.15 ha
61	5677	P	Moorefield	Class A 100000	32.7 ha
62	5684 (neighbouring 624375)	P	Floradale	Class B 20000	4.5 ha
63	5685	P	Erin	Class A 454000	41.51 ha
64	5686 (neighbouring 5640)	P	Arthur	Class A 100000	16.61 ha
65	5702	P	Brucedale	Class A 250000	56.6 ha
66	5703	P	Rockwood	Class A 30000	33.5 ha
67	5708	P	Riverstown	Class A 100000	7.49 ha
68	5709 (neighbouring 15338)	P	Guelph	Class A 45000	14.57 ha
69	5710 (neighbouring 20212, 20749, 624889, 625710, 129817)	P	Guelph	Class A 341000	141.45 ha
70	5715	P	Ponsonby	Class A 100000	16.4 ha
71	5726 (neighbouring 625260)	P	Shiloh	Class A 175000	19.36 ha
72	5732	P	Kenilworth	Class B 20000	9.92 ha
73	5733	P	Mimosa	Class A 75000	13 ha
74	5734 (neighbouring 5520, 5483, 5465, 5631, 5563, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5737, 10671)	P	Aberfoyle	Class A 600000	7.03 ha
75	5737 (neighbouring 5520, 5483, 5465, 5631, 5563, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5738, 5734, 10671)	P	Aberfoyle	Class A 1,000,000	5.6 ha
76	5738 (neighbouring 5520, 5483, 5465, 5631, 5563, and south of 401 - 5497, 624864, 625284, 17600, 624952, 5737, 5734, 10671)	P	Aberfoyle	Class A 2,000,000	188.6 ha
77	6524 (neighbouring 21666, 6525)	P	Belfountain	Class A unlimited	36.6 ha
78	9491	P	Mt Forest	Class B 20000	1.9 ha
79	15338 (neighbouring 5709)	P	Guelph	Class A 100000	11.71 ha
80	15343	P	Erin	Class A 750000	49.5 ha
81	15473 (neighbouring 5472)	P	Brucedale	Class A 300000	44.49 ha
82	15477 (neighbouring 4491, 102306, 4719, 4522, 625192)	P	Mt Forest	Class A 300000	18.06 ha

83	17600 (neighbouring 5520, 5483, 5465, 5631, 5563, and south of 401 - 5497, 624864, 625284, 5738, 624952, 5737, 5734, 10671)	P	Aberfoyle	Class A 500000	37.1 ha
84	19333 (neighbouring 124155, 5696, 625138, 5569, 27777, 625212)	P	Elora	Class A 150000	10.3 ha
85	19862 (neighbouring 624934)	P	West Montrose	Class A 150000	5.36 ha
86	20085	P	Aikensville	Class A 1,000,000	96.32 ha
87	20212 (neighbouring 5710, 20749, 624889, 625710, 129817)	P	Guelph	Class A 500000	101.6 ha
88	20214	P	Lake Belwood	Class A 100000	41.5 ha
89	20733	P	Elora	Class A 100000	19.7 ha
90	20749 (neighbouring 5710, 20212, 624889, 625710, 129817)	P	Guelph	Class A 500000	23.03 ha
91	22021 (neighbouring 19352, 20207)	P	West Montrose	Class A 150000	2.9 ha
92	27777 (neighbouring 124155, 5696, 625138, 5569, 19333, 625212)	P	Elora	Class A 250000	17.3 ha
93	39158 (neighbouring 5578)	P	Oustic	Class A 100000	10.21 ha
94	46162 (neighbouring 5537)	P	Hespeler	Class A 100000	31.92 ha
95	55317	P	Maryhill	Class A 200000	37.87
96	69856	P	Mt Forest	Class B 20000	3.1 ha
97	80956 (neighbouring 10606, 3595, 624233, 3634, 3685, 3686)	P	Marsville - close to Orangeville	Class A 500000	60.8 ha
98	92916 (neighbouring 5581, 5660, 5595, 5678)	P	Elora	Class A 200000	31.6 ha
99	124155 (neighbouring 5569, 5696, 625138, 19333, 27777, 625212, 601761)	P	Elora	Class A 350000	17.4 ha
100	126455	P	Mt Forest	Class A 300000	12.9 ha
101	129817 (neighbouring 20212, 20749, 624889, 625710, 5710)	P	Guelph	Class A 750000	74.64 ha
102	603781 (neighbouring 624994)	P	Elora	Class A 350000	33.79 ha
103	624864 (neighbouring 5520, 5483, 5465, 5631, 5563, and south of 401 - 5497, 17600, 625284, 5738, 624952, 5737, 5734, 10671)	P	Aberfoyle	Class A 1,000,000	16.26 ha
104	624994 (neighbouring 603781)	P	Elora	Class A 370000	34.14 ha
105	625006	P	Palmerston	Class A 100000	8.4 ha
106	625108	P	Palmerston	Class A 150000	12.24 ha
107	625189 (neighbouring 5654, 5482)	P	Guelph	Class A 750000	59.1 ha

Table A2: Geographic Clusters of Aggregate Sites in Wellington County

ALPS ID(s)	AREA OF CLUSTER (M^2)	RANK (large to small)
5465, 5563, 5520, 5483, 5734, 5631, 5497, 624864, 17600, 5738, 5737, 10671	**2708606**	**1**
5710, 20212, 20749, 129817	**676969**	**2**
4491, 15477, 102306, 4719, 4522	**593719**	**3**
5609	**502875**	**4**
5569, 124155, 5696, 19333, 27777	**376200**	**5**
5581, 92916, 5595, 5678	**368213**	**6**
5514	**316800**	**7**
5602	**304200**	**8**
15343	286819	9
5598	286031	10
5531	249863	11
20085	223875	12
5472, 15473	156038	13
20691	143438	14
5685	138713	15
5482, 5610, 5654, 625189	137081	16
5677	120150	17
5709, 15338	119813	18
5726	114413	19
5702	91744	20
4495, 4514, 4765	82688	21
5640, 5686	80606	22
5652	74363	23
625108	60582	24
4469	60581	25
4513	54225	26
5645	39994	27
20733	36394	28
5715	35888	29
126455	30431	30
603781, 624994	29475	31
5637	27281	32
5611	21656	33
5646	21544	34
5490	19406	35
5731	17944	36
5661	14794	37

5578, 39158	13838	38
5618	12938	39
4511	12488	40
5708	12431	41
4519	12150	42
5703	10125	43
69856	9900	44
4504	8944	45
5579	7706	46
5664	6525	47
4508	5850	48
5587	5738	49
5635	5456	50
48576	4950	51
9491	3825	52
5551	0	53
5552	0	53
5732	0	53
5733	0	53
20214	0	53
55317	0	53

2016 KRUMENACHER & ORR REPORT

Policy Study The Heartland Institute

No. 140 – February 2016

Social Impacts of Industrial Silica Sand (Frac Sand) Mining: Land Use and Value

By Mark Krumenacher and Isaac Orr*

Fourth in a series

#137 (May 2015): Environmental Impacts of Industrial Silica Sand (Frac Sand) Mining
#138 (June 2015): Economic Impacts of Industrial Silica Sand (Frac Sand) Mining
#139 (September 2015): Roadway Impacts of Industrial Silica Sand (Frac Sand) Mining
#140 (February 2016): Social Impacts of Industrial Silica Sand (Frac Sand) Mining: Land Use and Value

Introduction

As many as 9,000 non-metallic mines operate in Illinois, Iowa, Minnesota, and Wisconsin, approximately one mine per 3,000 residents. They include limestone and granite quarries in addition to sand and gravel mines, providing aggregate for construction, stones for monuments, and sand for glassmaking, foundries, livestock bedding, and oil and natural gas development. These mines represent an enormous amount of economic activity operating without widespread regional impacts on human health or the environment. Industrial silica sand has been mined in the upper Midwest for more than one hundred years.

> Nonmetallic mines in the Midwest represent an enormous amount of economic activity operating without widespread regional impacts on human health or the environment.

Until recently these mines operated without widespread public recognition or opposition. But the rapid growth in the number of industrial sand facilities and the sand's end use for oil and natural gas development have generated new public awareness about this old industry, making this once below-the-radar industry a subject of controversy in certain areas.

* Mark Krumenacher is a senior principal and senior vice president of GZA GeoEnvironmental, Inc. Isaac Orr is a research fellow at The Heartland Institute. More complete bios appear on page 36.

Among the primary concerns voiced by residents in areas where industrial sand mining has expanded are worries about the potential impacts of sand mining on the environment, including the potential impact on air and water quality; the economy, and whether sand mining will be a net benefit to the communities and states in which it occurs; on local roads and highways; and on the quality of life in host communities.[1]

Previous installments in this series of studies presented policymakers and the general public with the latest scientific data on the general environmental[2] and economic[3] aspects of industrial sand mining. The third study in the series focused specifically on roadway impacts of mining.[4]

This *Policy Study* is intended to help local policymakers and the general public better understand the potential impacts of industrial sand operations on property values in the vicinity of sand-mining operations.

This *Policy Study*, "Social Impacts of Industrial Sand (Frac Sand) Mining: Land Use and Values," is intended to help local policymakers and the general public better understand the potential impacts of industrial sand operations on property values in the vicinity of sand-mining operations. We hope it will join the other *Policy Studies* in this series as a resource for understanding the concerns, potential impacts, and benefits associated with industrial sand mining.

The "social" impact of sand-mining operations, including their impact on land use and property values, can be a sensitive topic. Personal preference and opinion tend to dominate the discussion, in contrast to the technical facts and scientific data used to describe mining's impacts on the environment, economy, and roads. We take the sensitive nature of this topic seriously and, we believe, address it thoughtfully in this *Policy Study*. We welcome comments on this work and previous installments in this series.

Part One of this *Policy Study* briefly discusses the importance of mining and raw materials in our lives. Part Two explores concerns commonly expressed about mining as an industry and examines the similarities between farming and mining. Part Three addresses the potential impact of industrial sand-mining operations on the general quality of life, tourism, and scenic beauty in communities that host those operations. Part Four addresses property rights and the potential

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[1] Wisconsin Department of Natural Resources, "Mines, pits, and quarries," updated April 15, 2015, http://dnr.wi.gov/topic/mines/.

[2] Isaac Orr and Mark Krumenacher, "Environmental Impacts of Industrial Silica Sand (Frac Sand) Mining," *Heartland Policy Study* No. 137, The Heartland Institute, May 2015, www.heartland.org/sites/default/files/05-04-15_orr_and_krumenacher_on_frac_sand_enviro_impacts.pdf.

[3] Isaac Orr and Mark Krumenacher, "Economic Impacts of Industrial Silica Sand (Frac Sand) Mining," *Heartland Policy Study* No. 138, The Heartland Institute, June 2015, www.heartland.org/sites/default/files/05-29-15_orr_and_krumenacher_on_frac_sand_economics.pdf.

[4] Isaac Orr and Mark Krumenacher, "#139 (September 2015): Roadway Impacts of Industrial Silica Sand (Frac Sand) Mining," *Heartland Policy Study* No. 139, The Heartland Institute, September 2015, https://www.heartland.org/policy-documents/roadway-impacts-industrial-silica-sand-frac-sand-mining.

impact of industrial sand-mining operations on local and regional property. Part Five offers concluding remarks.

Although opponents of mining often cite the potential impacts of sand mining on property values as a reason to restrict or ban mining operations, this *Policy Study* concludes many mining companies are already addressing these concerns with local officials, who have adequate tools at their disposal to manage the impact of sand mining on their communities.

Part One

The Importance of Mining

The Necessity of Raw Materials

Modern life has resulted in an ever-increasing need for raw materials. Even in the rural Midwest, where agriculture is king and industrial sand mines operate, families tend to live consumer lifestyles, in single-generation, wi-fi-enabled, electrically powered, petroleum-heated homes on mono-cultured chemical-controlled lawns. They drive petroleum-powered vehicles on quality, ice-free roads. And they purchase inexpensive toilet paper at the local discount outlet.

We have a tendency to overlook the fact that most of our residential properties were previously forest or agricultural land. Our roadways, also former agricultural land, were constructed in part with petroleum taxes and built from materials extracted from nearby nonmetallic mines. Most importantly, essentially every material thing in our lives that was not grown is a product of mining.

It is easy for the general public to understand and accept that agricultural land must be preserved. It appears to be more difficult to recognize, but it is no less true, that mining land must also be preserved.

Individuals and groups who oppose mining, advocate the preservation of agricultural land, and demand a transition to so-called “greener” technology hold a self-contradictory position: The modern lifestyle they enjoy is predicated on both farming and mining.

It is easy for the general public to understand and accept that agricultural land must be preserved. It appears to be more difficult to recognize, but it is no less true, that mining land must also be preserved. Farming and mining are similar in almost every respect. Their potential for environmental impacts is comparable, and the need to preserve both must be equally understood. Neither enterprise can exist without the other, and our civilization cannot exist without them both.

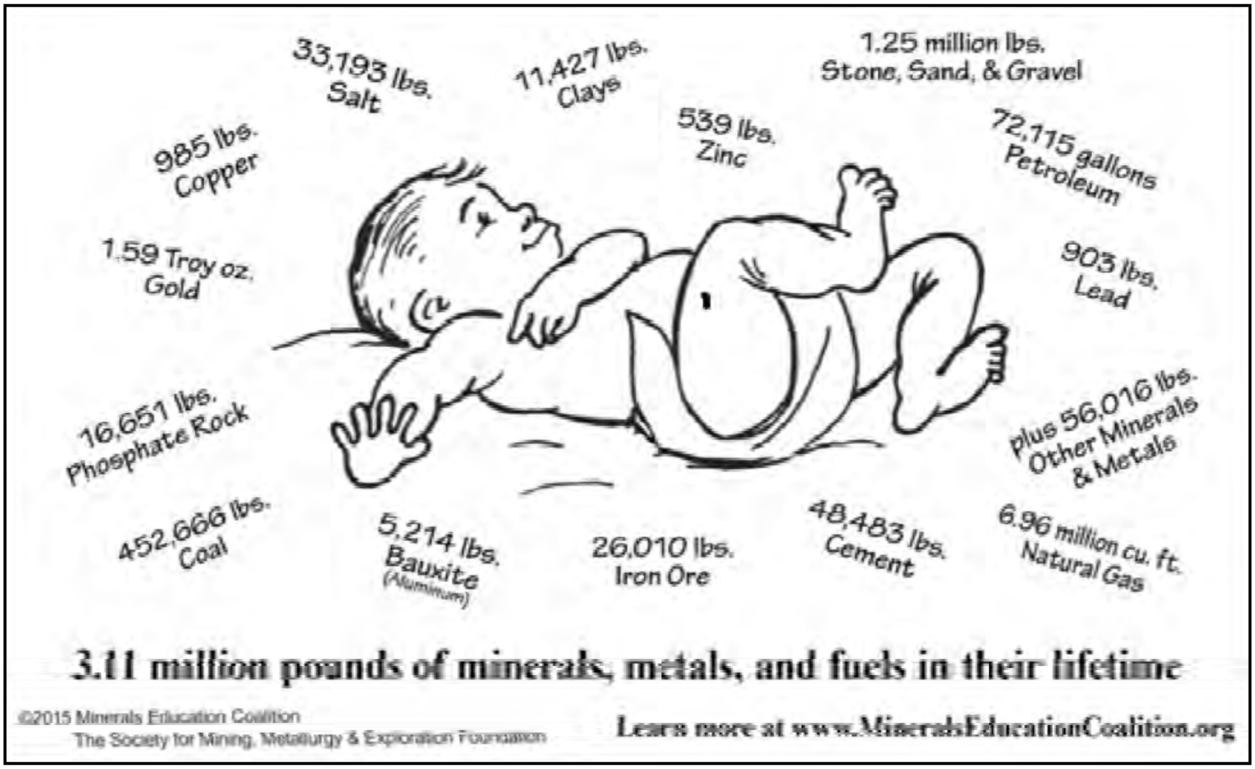
Farming and mining, like all other business pursuits, are done to make money for the business operator. Products are planted or mined in response to demand for a given commodity, and as demand changes, corresponding adjustments to production are made. It is important to note the

> Every material thing in our lives must either be farmed or mined; there are no exceptions.

demand for, and use of, products derived from mining is as high for those who oppose mining as for everyone else.

Every material thing in our lives must either be farmed or mined; there are no exceptions. The Minerals Education Coalition (MEC) reports the average American citizen born in 2015 will require an average of 3.11 million pounds of minerals, metals, and fuels in their lifetime (78.7 years).[5] (See Figure 1.) Our mineral use increases annually, indicating our dependence on mining is growing and there is no indication our need for raw materials will decrease with time.

Figure 1.
The average American will consume ...



Similarly, there would be virtually no employment as we know it without mining. Our ability to travel; tools in every industry, be they pencils, computers, staplers, or welders; our information technology, including our smartphones and streaming media players; our clothing and our shelter – all depend on mining.

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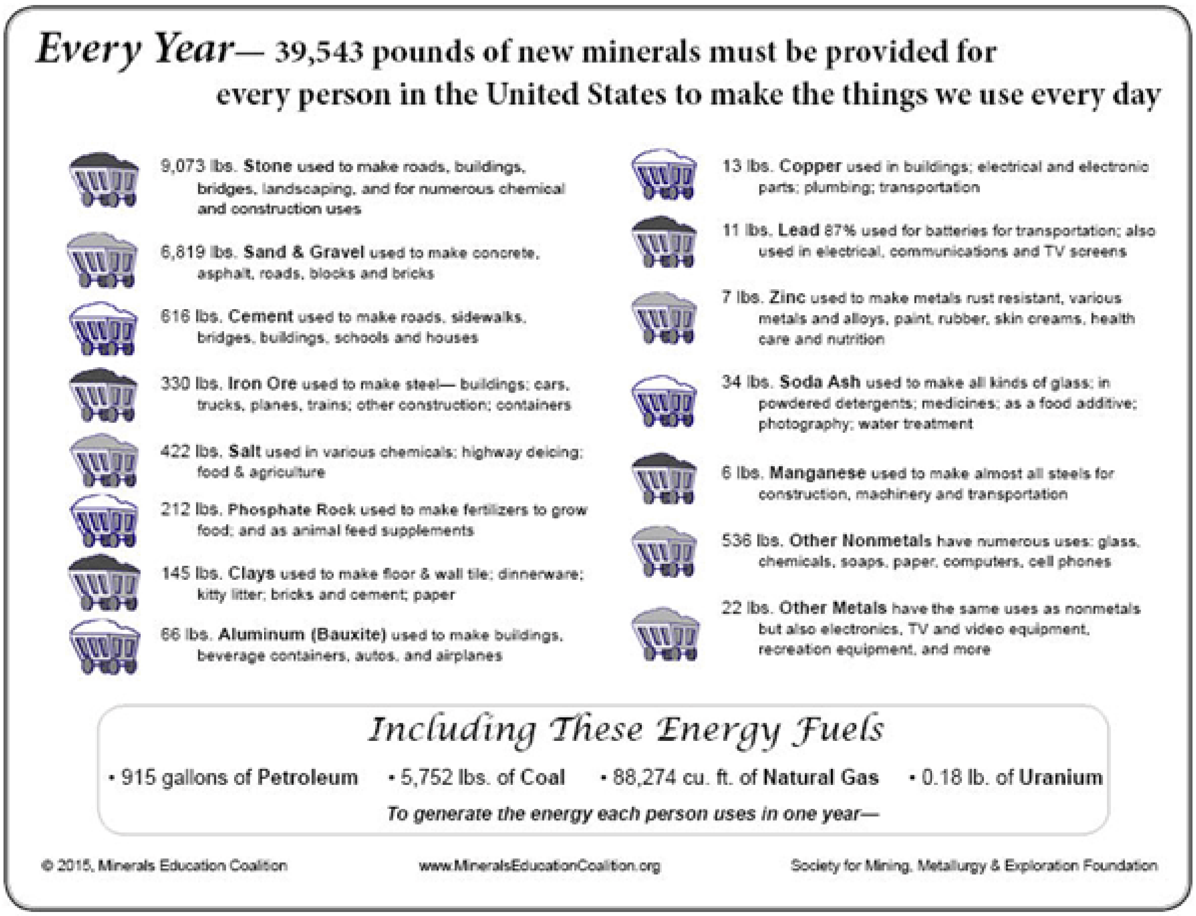
[5] The Minerals Education Coalition (MEC) is a program of the Society for Mining, Metallurgy, and Exploration Foundation. MEC's mission is to develop and deliver accurate and timely K–12 education materials and activities and conduct public awareness outreach about mining and minerals. Mineral use data are from the National Mining Association, U.S. Geological Survey, and Energy Information Administration.

While our earliest ancestors may have used a simple one-pound stone tool in a cave shelter 200,000 years ago, today we use hundreds of pounds of minerals and raw materials per person per year. Figure 2 illustrates the average quantity of minerals used by each person in the United States in 2015. Each person in the United States will require about 616 pounds of cement to make the roads, sidewalks, bridges, schools, and houses he or she will use in 2015. Although it is often not readily apparent, each material object in our lives must be either grown or mined. Even so-called "renewable" energy sources require large quantities of raw materials.

Figure 2.
We Requires Thousands of Pounds of Minerals, Metals, and Fuels Each Year



It is easy to understand why someone might oppose a mining operation near his or her home, as the proximity of these operations to one's backyard may affect one's quality of life. But opposition to mining *as a general principle* makes no sense, because we all rely on materials produced from mining. That a mining operation may open near our home does not change the crucial importance of mining in sustaining our standard of living.

Opposition to mining as a general principle can drive individuals to actions and statements inconsistent with their training, education, and even knowledge for the sake of notoriety, career, or position within a community. The most disturbing examples of this in the Midwestern industrial sand-mining debate include Ph.D. economists and chemists, medical doctors, and other well-educated individuals who use their high esteem in the community as a platform for persuasion on topics unrelated to their expertise.

Mining for a Green Economy

An often unrecognized reality of the transition to a greener economy is increased demand for metals and industrial minerals such as silica sand.

Since at least the early 1990s, "sustainable development" – sometimes called a "green economy" – has attracted the attention of international political organizations[6] and institutions of higher education[7] in the United States and around the world. An often unrecognized reality of the transition to a greener economy is increased demand for metals and industrial minerals such as silica sand.

Demand for strategic minerals is rising, with much of the demand driven by the same individuals and groups who express opposition to local mining operations. So-called green technologies, such as smart glass windows, solar panels, wind turbines, batteries, and energy-efficient consumer electronics, use increasing amounts of rare and strategic resources.[8] The glass for smart windows and solar panels is derived from several mined minerals, most notably the same silica sand deposits used for hydraulic fracturing.[9]

Increased demand for greener energy has driven increased demand for rare earth minerals, which are costly to produce and come with their own environmental impacts. For example, the magnets of wind turbines use neodymium, terbium, and dysprosium,[10] and electric and hybrid cars

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[6] See, for example, "Green Economy," a webpage of the Department of Economic and Social Affairs of the United Nations, no date, https://sustainabledevelopment.un.org/topics/greeneconomy.

[7] Peter Wood and Rachelle Peterson, *Sustainability: Higher Education's New Fundamentalism*, National Association of Scholars, March 25, 2015 https://www.heartland.org/policy-documents/sustainability-higher-educations-new-fundamentalism; and its executive summary, June 8, 2015, https://www.heartland.org/sustainability-education-new-fundamentalism.

[8] Elisa Alonso, Andrew M. Sherman, Timothy J. Wallington, Mark P. Everson, Frank R. Field, Richard Roth, and Randolph E. Kirchain, "Evaluating rare earth element availability: A case with revolutionary demand from clean technologies," *Environmental Science and Technology* **46** (2012): 3406–14, http://pubs.acs.org/doi/pdf/10.1021/es203518d.

[9] Dustin Mulvaney, "Solar Energy Isn't Always as Green as You Think," *IEEE Spectrum*, Institute of Electrical and Electronics Engineers, August 26, 2014, http://spectrum.ieee.org/green-tech/solar/solar-energy-isnt-always-as-green-as-you-think.

[10] "Top 10 Things You Didn't Know about Critical Materials," U.S. Department of Energy, January 18, 2013, http://energy.gov/articles/top-10-things-you-didn-t-know-about-critical-materials.

contain about 10 to 15 pounds more rare earth minerals than a standard car.[11]

China produced 95 percent of the world output of rare earth elements in 2011, largely because lax environmental standards and lower labor costs allowed the nation to produce these materials at costs 66 percent lower than in the United States.[12] It is often better for the global environment for natural resources to be produced in developed nations with more stringent environmental standards, such as the United States, than in developing nations with less-protective regulations.[13]

In addition to rare earth metals, the supply chain for green technologies requires vast quantities of traditional metals, minerals, and fossil fuels that must be mined somewhere. For example, on average a one megawatt industrial wind turbine requires 103 tons of stainless steel, 402 tons of concrete, 6.8 tons of fiberglass, three tons of copper, and 20 tons of cast iron.[14]

On average a one megawatt industrial wind turbine requires 103 tons of stainless steel, 402 tons of concrete, 6.8 tons of fiberglass, three tons of copper, and 20 tons of cast iron.

Obtaining these raw materials requires the use of high-density fuels such as coal, oil, and natural gas. Steel, for example, unless it is recycled, is made by mining iron ore using large mining equipment that is also made of steel and runs on diesel fuel. After it is mined, the iron ore must be transported to a steel mill, typically by water or rail, and ships, barges, and trains are also powered by diesel engines.

Iron must then be converted into steel by grinding the ore with specialty metal grinders, separating the ore using industrial-sized magnets containing rare earth elements, and adding industrial minerals such as limestone and dolomite and metals such as manganese, aluminum, and nickel. The process requires either blast furnaces or direct reduction routes, both of which require large amounts of coal or natural gas. In most steelmaking operations around the world, blast furnaces are the primary means of converting iron ore into steel, and this process requires coke produced from coal. After the iron is converted to steel, the finished product is shipped to manufacturers where it is cut, rolled, pressed, and formed by equipment powered by fossil fuels.

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[11] Kharunya Paramaguru, "Rethinking our Risky Reliance on Rare Earth Metals," *Time*, December 20, 2013, http://science.time.com/2013/12/20/rare-earths-are-too-rare/.

[12] Pui-Kwan Tse, "China's Rare-Earth Industry," United States Geological Survey, February 22, 2011, http://pubs.usgs.gov/of/2011/1042/of2011-1042.pdf; and Cindy Hurst, "China's Rare Earth Elements Industry: What Can the West Learn?" Institute for the Analysis of Global Security, March 2010, http://www.iags.org/rareearth0310hurst.pdf.

[13] *Supra* note 11.

[14] Robert Wilson, "Can You Make a Wind Turbine Without Fossil Fuels?" *The Energy Collective*, February 25, 2014, http://www.theenergycollective.com/robertwilson190/344771/can-you-make-wind-turbine-without-fossil-fuels.

Simple physical realities mean shipping requires high-energy, dense fuels – almost universally, diesel fuel. Because of the intrinsic low power density of wind and solar, putting solar panels or a sail on a large ship will not come close to providing the energy needed to transport these materials, and diesel engines will likely remain important for transportation for generations to come.[15]

> Our lives and lifestyles, and our desires for a better planet, are intimately intertwined with mining as much as with agriculture.

It is impossible to make steel without fossil fuels, and it is impossible to make concrete without mined aggregate. Fiberglass used to insulate our homes to conserve energy is made from silica sand, limestone, soda ash, epoxy resins, and a variety of other mined minerals. Copper, rare earth elements, and other metals used in wind turbine production also depend on fossil fuels to mine, process, and transport raw materials. All of these materials are indispensable to "renewable" energy sources and products for conserving energy.

The point of this discussion is to demonstrate that our lives and lifestyles, and our desires for a better planet, are intimately intertwined with mining as much as with agriculture. Environmental and human health protections are stronger in the United States than in the developing world. If our conversations about environmental policy are to be serious and intellectually honest, those who wish to increase the amount of energy generated from renewable energy sources must recognize the necessity of mining.

Part Two

Why Development – That Is, *Change* – Raises Concerns

Once a routine aspect of life in the Midwest, industrial sand mining has become a controversial topic, not only in communities where mining operations have been recently proposed, but also in communities where industrial sand facilities have operated for decades.

Not only mining, but nearly every proposed development or land use change in a community, whether residential, commercial, institutional, governmental, or industrial, generates local opposition. While each proposal generates specific concerns, those concerns are most often simply a variation on "not in my backyard" – a response to a proposed use in the immediate vicinity that changes the existing land use in any way.[16]

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[15] *Ibid.*

[16] For example, see "Property values, traffic, water supply among concerns raised by Merton neighbors of proposed subdivision," *Lake Country Reporter*, February 2015 print, http://www.lakecountrynow.com/news/lakecountryreporter/property-values-traffic-water-supply-among-issues-for-hartland-merton-neighbors-of-proposed-four--b9-293858351.html.

The proposed change often first becomes the focus of just one or a few outspoken opponents, but organized opposition can form and spread quickly. Their message is that the proposed change is a burden, rather than a benefit, to the local community. That overall "burden, not benefit" message is the same for a mine as it may be for something more socially acceptable, say a new church, cell phone tower, waste treatment plant, or affordable housing project.[17] Ironically, and perhaps out of convenience, the reasons cited for opposition are generally the same regardless of the proposed development.

Most residents do not become engaged in the debate at all. The issue takes on the appearance of a major controversy because the vocal minority is generally the only side in the debate that attracts the attention of the press ("the squeaky wheel gets the grease"), takes advantage of social media, writes letters and emails to local government officials, holds rallies, and fills the rooms at local public hearings, monopolizing the public discussion.

A township supervisor in west central Wisconsin noted at a public hearing that the most vocal opposition to any development in the town generally comes from residents who have recently relocated and built new houses in the area. Those residents want to close the door on further migration and development that might "change" the community ... after they've moved in.

> Local government officials will be most effective in communicating with a concerned community if they take the time to understand the nature of those concerns.

Four Ways to Understand a Community's Concerns

Local government officials and supporters of development are most effective in communicating with a concerned community if they understand the nature of those concerns. While some concerns can be addressed with facts and technical information, other concerns are more emotional, sometimes expressed as accusations, sometimes based on rumors. Such concerns *can* be addressed, but first they must be understood.

Experts in risk communication identify four ways to understand the more emotional concerns a community might raise about development.[18] They are:

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[17] Rick Barrett, "Proposed Cellphone Tower Opposed," *Milwaukee Journal Sentinel*, July 28, 2015, http://www.jsonline.com/business/cellphone-tower-plan-stirs-concern-among-mequon-property-residents-b99545492z1-318724291.html; William Rabb, "Environmentalists Oppose Beach Treatment Plant," Studer Community Institute, February 13, 2015, http://studeri.org/2015/02/environmentalists-rail-beach-treatment-plant/; and Jamie Ross, "NIMBYism: Overcoming Community Opposition to Affordable Housing," Florida Housing Coalition, accessed December 22, 2015, http://www.flhousing.org/wp-content/uploads/2012/07/NIMBYism-Overcoming-Community-Opposition-to-Affordable-Housing.pdf.

[18] Dr. Vincent T. Covello and Patricia A. Milligan, "RIC 2010: Risk Communication Principles, Tools, & Techniques," United States Nuclear Regulatory Agency, March 11, 2010, http://www.nrc.gov/public-involve/conference-symposia/ric/past/2010/slides/th39covellovpv.pdf.

Four Ways to Understand Emotional Concerns

- Mental Noise
- Perceptions of Threats
- Elements of Trust
- Dominance of Negatives

Mental noise is experienced when people become highly concerned or stressed about something they value. Mental noise makes it difficult, and sometimes impossible, to receive, process, and retain information. The New Jersey Department of Health reports 80 percent of the information communicated to people is lost when they are experiencing stress and mental noise.[19]

Mental noise is difficult to address at emotionally charged meetings. By contrast, providing concerned individuals with information in writing frees them from the intensity of a public meeting, gives them the benefit of time to process information, and allows them to re-read material as often as they need. People are more likely to understand and retain information when it is presented in writing.

Perceptions of potential threats are amplified when people are worried. Under these circumstances, the gap between the perceived threat and the actual risk of harm widens, and it is these perceptions, not the actual risk of harm, that people act on.

Four factors influence how individuals perceive threats: whether the individual *trusts* the person or organization presenting the potential threat; how much *control* the individual has over the perceived threat; whether the individual stands to *benefit* from the potential threat; and whether the benefits (or risks) are perceived to be *fairly distributed*.

These factors are readily apparent in the concerns cited by opponents of industrial sand mining. Some critics have no trust in the regulatory authorities who issue environmental permits and approvals. Others seek to control development themselves; they express concern over increasing volumes of traffic related to mining but claim to desire increased tourism. Others take issue with mining company profits while promoting their own right to profit from a business or employment in the community.

Elements of trust are undermined when people feel threatened. High levels of concern cause people to have low levels of trust. This phenomenon is frequently on display in discussions of industrial sand mining. Many comments pertaining to the potential environmental impact of a proposed mine, for example, suggest the need for an independent, third-party analysis versus the "mine's employed experts." The assumption is that everyone is "on the take," inherently corrupt if employed or retained by a mining company, or cannot be trusted and is part of a conspiracy. Since mining affects everyone, this mindset implies no one in any profession can be trusted, regardless of their profession, education, and personal ethical standards.

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[19] New Jersey Department of Health, "Risk Communication Primer," http://www.state.nj.us/health/er/documents/risk_comm_primer.pdf.

Dominance of negatives describes the tendency of people to view situations from the most-negative perspective possible, regardless of whether the worst is likely to happen. Negative perceptions are powerful; they trigger strong emotions and are difficult to overcome or balance with positive information.

Concerns Can Be Genuine ... or Not

Like any development or proposed land-use change, industrial sand-mining operations attract concerns that are both genuine and disingenuous. It is important for local elected officials, industry leaders, and the general public to understand the distinction.

Genuine concerns are sincere. They are based on common, justified, and fact-based problems that can be resolved. We discussed several such concerns in the previous installments in this *Policy Study* series.[20] Genuine concerns tend to be specific in nature – what impact will the proposal have on the community's roadways, for example – and they can be addressed with careful explanations of the mining process, technological safeguards, and mitigation efforts.

Disingenuous concerns are insincere, commonly used as smokescreens, generally broad-brush, and raised with the understanding that *no response*, no matter how sound, will satisfy the accuser.

Disingenuous concerns are insincere, commonly used as smokescreens, generally broad-brush, and raised with the understanding that *no response*, no matter how sound, will satisfy the accuser. Individuals or groups who know safeguards are in place to address genuine concerns may raise disingenuous ones in the hope others will believe they are legitimate. Disingenuous concerns are raised merely to stir up fears and build opposition to a proposal. When presented with facts that address that particular concern, the accuser responds with a "yeah but" and shifts to another concern.

Examples of disingenuous concerns can be found in Iowa, Minnesota, and Wisconsin along the Mississippi River, where mining opponents have lined up to speak and experts have written reports against proposed and existing industrial sand-mining operations. They warn of impending damage to tourism and other businesses – failing to acknowledge tourism and mining have coexisted and indeed flourished along this Mississippi River corridor for almost 100 years.

For example, the 25-mile segment of the Great River Road along the Mississippi River from Diamond Bluff to Stockholm, Wisconsin includes decades-old sand and gravel mining operations, an asphalt plant, three industrial sand operations (two of which have operated for decades), and other industrial facilities. As industrial sand-mining operations expanded in the area, each of the communities[21] along that stretch of highway experienced an increase in the

[20] *Supra* notes 2, 3, and 4.

[21] Hager City, Bay City, Maiden Rock, and Stockholm, Wisconsin.

development of tourist-based businesses such as campgrounds, bars, restaurants, bed and breakfast operations, rental halls/suites, and art shops. Many of those tourist businesses were developed in the past 10 years.

> One way to recognize a disingenuous concern is to notice it is applied not just to mining but to all kinds of proposed development – even tourist businesses.

One way to recognize a disingenuous concern is to notice it is applied not just to mining but to all kinds of proposed development – even tourist businesses. For example, the same individuals who complain about mining's negative impact on tourism also testified against the development of a tourist business – a local winery – in the same area.[22] The complaints used to impede development of tourist businesses are the same as those raised in opposition to mining: increased traffic, falling property values, noise, putting a commercial business in a rural setting, groundwater and wastewater concerns, hours of operation, and the safety of pedestrians. In 2014, nearly 100 people signed a petition and retained an attorney to represent them in an ultimately unsuccessful effort to stop development of a small winery in the town of Clifton in Pierce County, Wisconsin.[23]

Professional activist groups also raise disingenuous concerns to generate financial support for their cause. These groups often use dramatic, emotionally charged but false and unscientific comments to stir fear and draw attention to themselves. A typical example is from the Sierra Club–John Muir Chapter, which solicits financial support for its anti-mining position by falsely claiming "mining companies are using open pit, hilltop removal mining in Wisconsin that is destroying landscapes, quality of life, and poisoning our air and water."[24]

Accusing industrial sand mining of poisoning air and water is a serious allegation, and claims of this nature provoke emotional responses that can lead to high levels of stress, anxiety, and distrust among residents. The Sierra Club offers no technical research to support its claims, instead citing controversial and widely discredited documentaries, posts on social media platforms such as anti-mining Facebook pages, and materials from nonscientific activists groups such as the Minnesota-based Land Stewardship Project.[25]

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[22] "Area frac-sand mining is hot topic of concern," *Pierce County Herald*, August 13, 2012, http://www.piercecountyherald.com/content/area-frac-sand-mining-hot-topic-concern; "Clifton residents rally to stop winery/restaurant," May 8, 2013, *Rivertowns.net*, http://www.rivertowns.net/content/clifton-residents-rally-stop-wineryrestaurant; and "Conflict returns: Clifton residents rally against neighborhood winery," *Pierce County Herald*, June 20, 2014, http://www.piercecountyherald.com/content/conflict-returns-clifton-residents-rally-against-neighborhood-winery.

[23] "Proposed winery, minus restaurant, gets town support," *Pierce Count Herald*, July 11, 2013, http://staging.piercecountyherald.com/content/proposed-winery-minus-restaurant-gets-town-support.

[24] "Blocking Destructive Mining," Sierra Club – John Muir Chapter, no date, http://www.sierraclub.org/wisconsin/issues/mining.

[25] Save The Hills Alliance: wisair.wordpress.com; Save Our Knapp Hills Alliance; Fracsandfrisbee.com; Dunn County Sand, http://dunncountysand.org/; Township Rights: landstewardshipproject.org; Mississippivalleyconservancy.org; Wisconsin Network for Peace and Justice Informational Pamphlet,

Similarly, a Chippewa Falls, Wisconsin-based website claims local industrial sand mining will result in the "destruction of productive agricultural land, risks of water contamination and depletion, degraded property values, loss of traditional rural communities, noise and traffic increases, and threats to health and safety," and "many thousands of acres of Wisconsin hills, farmland and woods will be converted to open pit mines."[26] Raising human health worries, the website also claims, "Large scale mining operations will increase the amounts of both Particulate Matter (PM) and Respirable Crystalline Silica in the air. These pollutants at certain levels can cause respiratory illnesses, including silicosis, and do pose a public health threat."

These activist groups make no attempt to cite scientific evidence to support their claims that sand mining poses a threat to public health. Their websites make only unsupported statements intended to stoke fear about concerns scientific studies have already proven to be unjustified.

> Because farming and mining are so intertwined, these industries should be defended together, not pitted against each other.

The Land Stewardship Project (LSP) was founded to foster an ethic of stewardship for farmland, promote sustainable agriculture, and develop sustainable communities.[27] Translating that mission statement into an attack on the sand mining industry is unfortunate and counterintuitive. Because farming and mining are so intertwined, these industries should be defended together, not pitted against each other. It is unfortunate that a misguided, tiny but vocal faction of LSP would make a claim such as, "The corporate-driven frac sand industry exploits rural communities and threatens the health and well-being of people and the land. Oil and gas corporations and their allies want to strip mine the land for frac sand, destroying bluffs and hills." Such statements seem calculated only to scare LSP members who do not reside or travel in areas where industrial sand mines operate and thus do not know the truth of the situation.

LSP cites this as its reference: "We know from direct experience that the frac sand industry puts corporate profit above the stewardship of our land, air, water, health, safety, quality of life and local economy." The only proof LSP offers is, "We know." LSP also claims "the frac sand mining industry is 'inherently destructive and exploitative.'" Here, too, its evidence is simply, "we know."

With 3,400 members as of 2014,[28] LSP represents a tiny minority (less than 0.06 percent) of the population of Minnesota (population 5.3 million in 2010). It is likely even many of its members

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http://www.wnpj.org/fracsand. Films include Gasland, The Price of Sand, and The Last Mountain: Coal Mining Mountaintop Removal.

[26] The Concerned Chippewa Citizen, accessed November 16, 2015, https://wisair.wordpress.com/about-ccc/.

[27] Land Stewardship Project, "25 Years of Keeping the Land & People Together," accessed November 16, 2015, http://landstewardshipproject.org/about/history.

[28] Land Stewardship Project, "Long-Range Plan: 2014–2019," no date, page 2, http://landstewardshipproject.org/repository/1/1222/long_range_2014_2019.pdf.

don't support such fear-mongering statements. LSP certainly does not represent the majority, but the fear it creates is real and can cause governments to take counterproductive regulatory actions.

> In Parts Three and Four of this study, we address legitimate concerns including quality of life and tourism, property rights and land use, property values, and public health.

Activists in Wisconsin make similar claims. The Wisconsin League of Conservation Voters (WLCV) claims industrial sand mining is "wreaking havoc on air and water quality and public health" and alleges the industrial sand mining industry in Wisconsin, which is more than a century old, is "operating with very little oversight in Wisconsin and is significantly degrading our environment, public health, and quality of life."[29] WLCV says Wisconsin laws are inadequate or insufficiently enforced, claiming, "the few Wisconsin state laws that are applicable to frac sand mining are rarely enforced." These claims are never – and cannot ever be – supported by credible sources, because they are false.[30]

How to Address Genuine Concerns

Any residential, commercial, or industrial development will affect the communities that host or are near the development. Newton's third law of physics, "for every action, there is an equal and opposite reaction," is applicable and relevant. However, most if not all impacts of industrial sand mining can be managed, contained, and minimized with safeguards developed to prevent unnecessary hardship and protect the public health, safety, and welfare. The current operation of about 10,000 nonmetallic mines in a four-state area is testament to this fact.

In Parts Three and Four of this study, we recognize and address some genuine social concerns regarding industrial sand mining, including quality of life and tourism, property rights and land use, property values, and public health. We describe the concern, present an analysis of the risks, and evaluate the adequacy of protections in place or explain what additional safeguards are needed.

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[29] Wisconsin League of Conservation Voters, "Frac Sand," accessed November 16, 2015, http://conservationvoters.org/?s=frac+sand+&submit=GO.

[30] The fifth *Policy Study* in this series will address this issue.

Part Three

Quality of Life: Tourism and Scenic Beauty

A commonly cited concern is that a new mine or mine expansion will reduce the quality of life of local and regional residents. The claim seems plausible, especially to those without the benefit of experience from living near a mine. The concern may be driven by a fear of the unknown, fueled by the predominance of negative information spread by websites and social media platforms.

Groups opposed to mining often portray the activity as incompatible with tourism and recreation. Among the primary concerns cited are traffic congestion and noise from increasing numbers of trucks hauling sand, the potential loss of scenic beauty from hills and farm fields being converted to mining, and the potential degradation of local air and water quality.

Prior to the release in 2015 of our *Heartland Policy Studies* No. 137, 138, and 139[31], an Internet search for "impacts of industrial sand mining" yielded page after page of anti-mining misinformation and negative Facebook pages. Until recently that was almost the only publicly available source of information cited on issues associated with industrial sand mining. A search today provides a much different result.

Tourism

> Industrial sand is mined in 20 Wisconsin counties, each of which relies on tourism to some extent for its economic activity.

Industrial sand is mined in 20 Wisconsin counties, representing nearly a third of the 72 counties in the state. Each of these sand-producing counties relies on tourism to some extent for its economic activity, and whether industrial sand operations harm the tourism industry is a question meriting a serious, data-driven discussion. Tourism is discussed extensively in *Heartland Policy Study* No. 138, "Economic Impacts of Industrial Sand (Frac Sand) Mining."[32] A brief recap of that study is presented below.

To evaluate the impact of industrial silica sand mining on tourism in sand-mining counties, we obtained tourism data from the Wisconsin Department of Tourism for the years 2010 through 2014 to analyze trends in Wisconsin's 20 silica sand-producing counties, the period of expansion of industrial sand activity. These data show a majority of sand-producing counties experienced growth in all tourism metrics between 2010 and 2014. The analysis below "unpacks" each of the six metrics reported by the Wisconsin Department of Tourism, as shown in Figure 3.

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[31] *Supra* notes 2, 3, and 4.

[32] *Supra* note 3.

Figure 3

Tourism Impacts

Wisconsin and Silica Sand Producing Counties - Alphabetical

	Direct Visitor Spending			Total Employment-Direct, Indirect, Induced			Total Labor Income*			State and Local Taxes			Per Capita Income*			Tourism Jobs		
	Millions		%	Total		%	Millions		%	Millions		%	Dollars		%	Jobs		%
County	2010	2014	Change	2010	2014	Change	2011	2014	Change	2010	2014	Change	2011	2014	Change	County*	Tourism 2014	% of Total Jobs
Wisconsin	$9,197.3	$11,419.1	19.46%	180,608	187,643	3.7%	4,292.2	$4,829.9	11.13%	$1,202.1	$1,412.3	14.89%	$23,765.54	$25,739.51	8.31%	2,752,732	187,643	6.82%
Barron County	$76.9	$94.7	18.82%	1,377	1,407	2.2%	$26.6	$30.4	12.34%	$9.2	$10.7	14.00%	$19,343.01	$21,590.90	11.62%	28,781	1,407	4.89%
Buffalo County	$8.5	$10.8	21.19%	173	189	8.5%	$3.3	$3.7	11.33%	$1.1	$1.3	16.89%	$19,179.61	$19,781.87	3.14%	8,435	189	2.24%
Burnett County	$21.9	$22.4	2.42%	422	366	-15.4%	$6.6	$6.6	0.25%	$2.9	$2.9	-0.09%	$15,568.11	$18,017.74	15.73%	6,820	366	5.37%
Chippewa County	$66.2	$77.6	14.72%	1,296	1,313	1.4%	$26.2	$29.3	10.70%	$8.2	$8.9	8.16%	$20,217.79	$22,331.60	10.46%	31,660	1,313	4.15%
Clark County	$22.1	$27.1	18.68%	354	356	0.7%	$6.1	$6.5	6.37%	$2.5	$2.9	13.57%	$17,296.99	$18,343.88	6.05%	16,905	356	2.11%
Columbia County	$88.3	$115.4	23.50%	1,585	1,700	6.7%	$29.8	$33.9	11.85%	$11.9	$13.6	12.43%	$18,821.38	$19,909.92	5.78%	29,006	1,700	5.86%
Crawford County	$33.0	$41.2	19.91%	681	714	4.6%	$11.7	$11.7	0.11%	$4.9	$5.5	10.71%	$17,160.71	$16,395.20	-4.46%	10,460	714	6.82%
Dunn County	$36.5	$46.4	21.21%	809	864	6.4%	$14.9	$17.2	13.51%	$5.0	$6.0	16.26%	$18,382.81	$19,891.35	8.21%	21,245	864	4.07%
Eau Claire County	$166.8	$214.8	22.34%	3,879	4,055	4.3%	$81.2	$90.9	10.60%	$23.2	$27.1	14.41%	$20,938.39	$22,404.07	7.00%	70,107	4,055	5.78%
Green Lake County	$28.9	$35.3	18.13%	687	763	9.9%	$12.0	$15.3	21.38%	$4.6	$5.4	15.94%	$17,500.73	$20,047.03	14.55%	9,769	763	7.81%
Jackson County*	$30.7	$36.1	14.74%	556	545	-2.1%	$8.9	$9.2	3.13%	$4.2	$4.5	5.77%	$15,951.99	$16,819.35	5.44%	11,513	545	4.73%
Monroe County	$58.7	$79.6	26.28%	1,055	1,203	12.3%	$19.7	$24.6	19.92%	$8.1	$9.8	17.68%	$18,704.63	$20,492.62	9.56%	24,727	1,203	4.86%
Outagamie County	$260.1	$315.8	17.62%	6,217	6,287	1.1%	$137.3	$154.0	10.84%	$36.5	$40.7	10.45%	$22,080.56	$24,486.69	10.90%	124,258	6,287	5.06%
Pepin County	$4.5	$5.7	20.54%	97	101	4.5%	$1.7	$1.8	6.64%	$0.6	$0.7	14.72%	$17,755.83	$18,167.35	2.32%	3,266	101	3.10%
Pierce County	$21.8	$25.0	12.96%	406	416	2.2%	$7.6	$8.2	7.10%	$2.7	$3.0	10.10%	$18,730.88	$19,715.38	5.26%	14,369	416	2.89%
Polk County	$70.1	$79.5	11.76%	1,070	1,061	-0.9%	$19.7	$20.3	3.24%	$7.5	$8.5	11.95%	$18,380.44	$19,160.86	4.25%	20,122	1,061	5.27%
Portage County	$92.5	$111.6	17.12%	2,074	2,073	-0.1%	$40.5	$42.4	4.36%	$13.2	$14.7	10.16%	$19,551.21	$20,453.51	4.62%	43,167	2,073	4.80%
Trempealeau County	$20.8	$24.2	14.12%	389	371	-5.0%	$7.0	$7.3	3.63%	$2.5	$2.8	9.12%	$17,981.79	$19,587.40	8.93%	16,829	371	2.20%
Waupaca County	$71.2	$87.4	18.47%	1,274	1,303	2.2%	$21.4	$23.9	10.23%	$9.2	$10.5	12.34%	$16,810.33	$18,305.76	8.90%	25,734	1,303	5.06%
Wood County	$75.2	$86.6	13.21%	2,158	2,166	0.4%	$50.3	$57.3	12.22%	$10.2	$11.1	7.56%	$23,320.85	$26,463.90	13.48%	50,781	2,166	4.27%

Data from the Wisconsin Department of Tourism show the majority of sand-producing counties experienced growth in all major tourism metrics between 2010 and 2014.

Notes

*Jackson County data were not available for 2010, so 2011 data were used.

* Total labor income data were not available for 2010, so 2011 data were used.

* County job estimates derived from University of Wisconsin Extension, *County Impact Reports*, http://www.uwex.edu/ces/ag/wisag/. Statewide job data from Bureau of Labor Statistics, "County Employment and Wages in Wisconsin–Third Quarter 2013," April 16, 2014, http://www.bls.gov/regions/midwest/news-release/countyemploymentandwages_wisconsin.htm.

* Per-capita income was calculated from 2011 total employment data because total labor income data were not available for the year 2010.

Direct visitor spending increased in all of the state's 20 silica-sand producing counties between 2010 and 2014, with 95 percent (19 of 20 counties) registering double-digit growth as a percentage of total visitor spending. These data suggest industrial sand mining and related activities have not been a deterrent to travelers visiting sand-producing counties and generating income for tourism-related industries. Total tourism-related employment increased in 75 percent of the sand-producing counties. The Wisconsin Department of Tourism data include direct, indirect, and induced jobs.

Figure 3 shows total labor income increased in all sand-producing counties between 2011 and 2014. Figures from 2011 are used in this metric because the Wisconsin Department of Tourism did not report total labor income in 2010. Tourism-related employment increased in only 75 percent of the sand-producing counties, but all sand-producing counties experienced gains in per-capita income earned by the people holding tourism-related jobs.

State and local tax revenues generated by tourism-supported industries increased in 95 percent of industrial sand-producing counties, with a very modest decline of 0.09 percent in Burnett County. Monroe County experienced the largest increase in tourism-related revenue, as state and local taxes increased by more than 17 percent, from $8.1 million in 2010 to $9.8 million in 2014.

Wisconsin Department of Tourism data indicate Wisconsin's tourism industry appears to have little to fear from the expanding industrial sand business.

Per-capita income for tourism-supported jobs increased in 95 percent of sand-producing counties, with Crawford County the only one experiencing a decline. The per-capita income data begin in 2011 because that is the first year for which total labor income data were available.

Service-oriented businesses experienced an increase in revenues because the presence of nearby mining operations can support these local business where there would otherwise be fewer customers to serve. The *Federal Gazette* reported on one such small business, Park Service & Convenience, the only gasoline, convenience, and grocery store in Maiden Rock, Wisconsin, population approximately 120.[33] The store provides the only fuel stop and convenience store for nearby residents and travelers on a 20-mile stretch of the Great River Road between Bay City and Pepin. The story noted the store derives more than 40 percent of its annual revenue from the nearby mine.

Wisconsin Department of Tourism data indicate Wisconsin's tourism industry appears to have little to fear from the expanding industrial sand business. Tourism-related revenues in these counties may actually increase as a result of industrial sand operations because of the

[33] "Sand Surge: In Minnesota and Wisconsin, frac sand mining has lifted local economies—and stirred opposition," Federal Reserve Bank of Minneapolis, July 16, 2012, https://www.minneapolisfed.org/publications/fedgazette/sand-surge.

living-wage jobs mining creates in these communities,[34] along with activities such as trout stream habitat restoration projects in which mining companies have participated.[35]

Scenic Beauty

Opponents of industrial sand mining say mining activities will alter the landscape in rural areas, resulting in a loss of scenery, including bluffs, hills, and wildlife habitat.[36] Of course, almost every use of land will alter the landscape; that concern is not unique to mining.

Nevertheless, changes that appear to be permanent generate more resistance than those considered to be temporary or reversible. While some anti-mining groups claim industrial sand mining will permanently alter or detract from the landscape, that concern is largely exaggerated.

> Although most mines are reclaimed for recreational or wildlife habitat, studies measuring agricultural productivity from reclaimed sand mines show productivity returns in two to five years.

States and municipalities in Illinois, Minnesota, and Wisconsin, for example, require mining sites to be remediated, or reclaimed. Moreover, although industrial sand mine operators may be permitted to develop hundreds or even thousands of acres of silica sand deposits, the entire permitted area is not mined simultaneously. Typically, these deposits are mined in smaller, 10- to 40-acre parcels, with reclamation of the land performed as soon as possible after mining. Topsoil removed during the initial excavation is replaced, and vegetation and plant cover are generally restored within a few years.[37]

Much of the discussion of reclamation in sand mining communities centers on whether reclaimed sand mines will be suitable for agricultural uses after mining is completed. Although most mines are reclaimed for recreational or wildlife habitat, studies measuring agricultural productivity from reclaimed sand mines show productivity returns in two to five years. (This topic is discussed in greater detail in *Heartland Policy Study* No. 137, "Environmental Impacts of Industrial Sand (Frac Sand) Mining."[38])

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[34] "Fairmount Santrol: Wisconsin Industrial Sand Company," webpage, Wisconsin Department of Natural Resources, last revised January 7, 2016, http://dnr.wi.gov/topic/GreenTier/Participants/WIIndustrialSandCo.html.

[35] Regan Carstensen, "Trout Unlimited, mining company team up for river restoration," *Pierce County Herald*, http://www.charity-charities.org/news.php?artid=1780583.

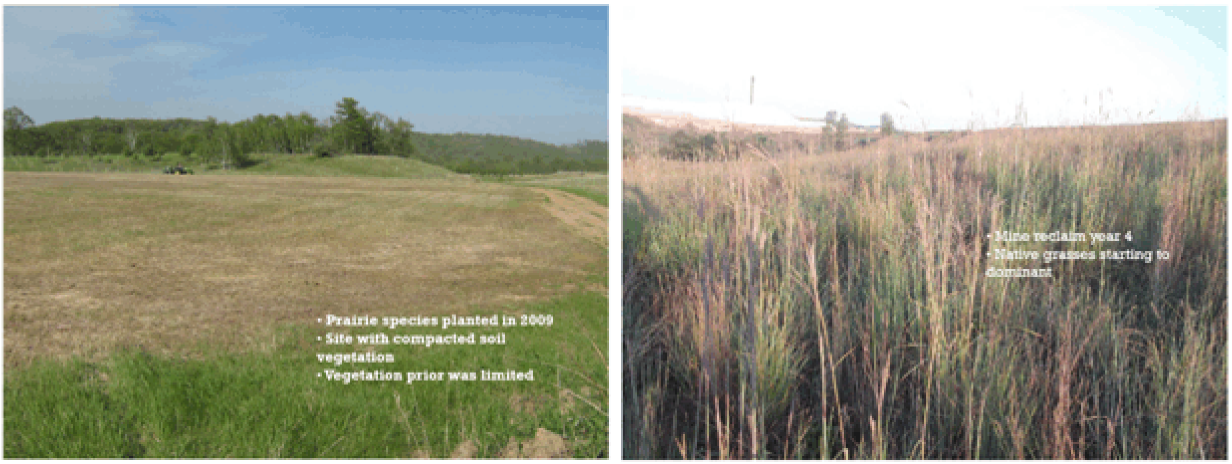
[36] Save Our Hills Alliance, "Open Letter," accessed October 30, 2015, https://saveourknapphillsalliance.wordpress.com/open-letter/.

[37] Evan Mudd, Andy Chikowski, "Reclamation at Badger Mining's Taylor Plant," SME Fall Meeting, October 7, 2014, https://www.heartland.org/policy-documents/reclamation-badger-minings-taylor-plant.

[38] *Supra* note 2.

In addition to agriculture, reclamation scientists can engineer industrial sand mines to serve as native prairie grasslands, providing excellent habitat for wildlife. (See Figure 4.) Native prairie is often the preferred post-reclamation use of industrial sand mines because these ecosystems provide benefits to the soil and water, including soil stabilization, improving soil fertility, reducing soil compaction, increasing water infiltration rates, and reducing soil runoff during stormwater events.[39]

Figure 4
Industrial Sand Mine Reclaimed to Prairie



Native prairie plant species are often desired by ecologists and soil scientists for the favorable ecosystem they create and because the long taproot of many of these plants helps to prevent or reverse soil compaction.[40] This reclaimed industrial sand mine in Wisconsin has become a biologically diverse ecosystem supporting a wide variety of plants and animals.

Expressions of concern about the potential impact of industrial sand mining on the bluffs of northeastern Iowa, southeastern Minnesota, and western Wisconsin are common at local government meetings and in online forums. In fact, industrial sand mining has not historically affected these bluffs and it is unlikely to do so in the future, because the bluffs are capped with 200 or more feet of limestone, removal of which is impractical to access the underlying sandstone. In most areas where limestone is present on top of these sandstone deposits, it would be far too costly to remove the limestone to access the deposits of silica sand.

Figure 5 shows a stratigraphic section of western Wisconsin and southeastern Minnesota. The primary sandstone deposits mined for industrial sand are, from youngest to oldest, the Jordan (J), Wonewoc (W), and Mount Simon (MS) Formations. These sandstone formations are the primary sources of industrial sand because of the physical properties of the sand and their ability to easily

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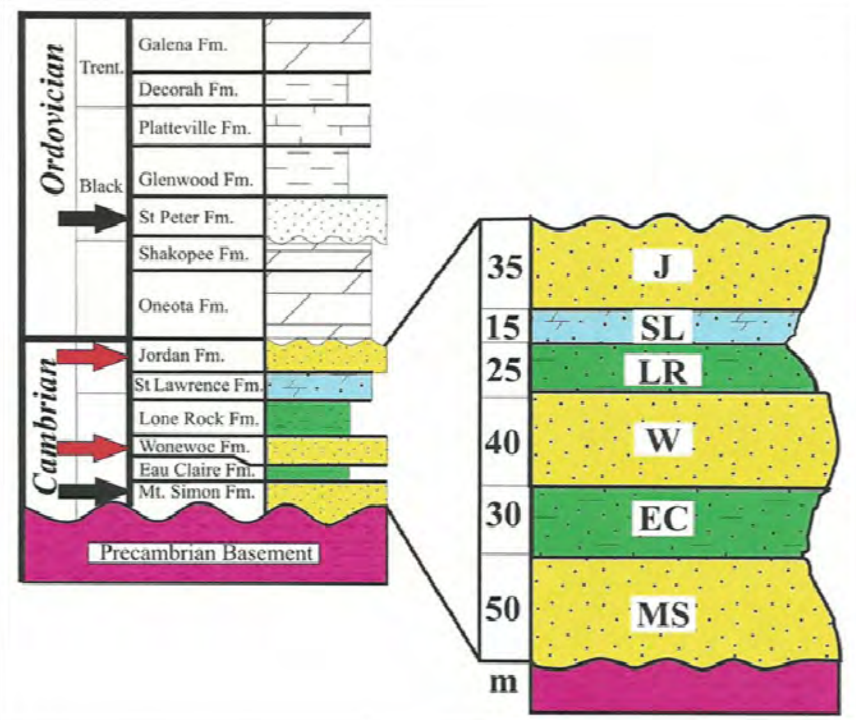
[39] Susan T. Rouse, "Roots," *Biology Reference*, accessed December 22, 2015, http://www.biologyreference.com/Re-Se/Roots.html.

[40] *Ibid.*

disaggregate, or break apart. In many areas, these sandstone formations lie deep beneath the Oneota limestone formation and thus are not easily accessed. In some counties, the Wonewoc Formation is accessible in areas where much of the limestone bedrock has been eroded away, leaving behind sandstone hills.

Figure 5
Deep Sandstone Deposits Are Not Targeted for Frac Sand Mining



Red arrows indicate the Jordan and Wonewoc Sandstone formations, the primary source of industrial silica sand that is mined in Minnesota and Wisconsin and used for hydraulic fracturing. These sandstone units are near the surface in many parts of Wisconsin, but they are present deep beneath the Oneota Formation, a thick layer of dolomite, in much of Iowa, Minnesota, and Wisconsin, making the sandstone less accessible for surface mining. Modified from Mahoney *et al.* 1997.[41]

Thick, unconsolidated soil and dolomite deposits are the primary reason industrial sand mining opportunities are limited in Minnesota. These thick deposits limit industrial sand mining primarily to the Minnesota River Valley of southeastern Minnesota, where a prehistoric flood removed most of the soil and limestone, leaving only about 40 feet of limestone near the ground surface. Industrial sand mining is conducted primarily in existing and former limestone quarries where the Jordan Formation sandstone is accessible. Such sites are not “scenic landscapes” hurt by industrial sand mining.

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[41] J.B. Mahoney, *et al.*, “Late Cambrian shelf sedimentation, Upper Mississippi Valley, Wisconsin and Minnesota (abbreviated version),” in M.G. Mudrey, ed., *Guide to field trips in Wisconsin and adjacent areas of Minnesota* (Madison, Wisconsin: Geological and Natural History Survey, 1997), pp. 51–65.

Underground mines are also used to extract silica sand beneath the limestone bluffs of the Mississippi River Valley. Such mining has occurred for about 100 years. These operations enter the sandstone through horizontal tunnels and do not alter the overlying limestone formations, leaving them, and the bluffs they form, intact.

In addition to concerns about mining on scenic limestone bluffs, some citizen groups oppose the mining of sandstone hills. There is little cause for concern. The Driftless Area, where most of the industrial sand mines in Iowa, Minnesota, and Wisconsin are located, spans an area covering more than 10 million acres – an area twice the size of the state of Massachusetts.[42] Because this area is so large, it is able to provide industrial sand to meet demand while leaving the vast majority of the Driftless Area unmined.

> The Driftless Area, where most of the industrial sand mines in Iowa, Minnesota, and Wisconsin are located, spans an area covering more than 10 million acres – an area twice the size of the state of Massachusetts.

Although industrial sand mining requires the removal of trees, topsoil, and other overburden to gain access to silica sand deposits, these operations do not leave the mines as permanent eyesores or barren wastelands. Reclamation begins when mining in one section of the mine has concluded, and substantial diversity in plant and animal species can be observed within a few years. This type of mining is far less long-lasting than many other forms of development, such as closed industrial or commercial developments that can remain vacant for years.

Somewhat remarkably, another subject of debate and often unnecessary regulation is the visual appearance of industrial sand mines. Exposed bedrock is common along the major river valleys in silica sand mining regions such as the Illinois, Mississippi, Minnesota, and Wisconsin Rivers and along bluffs and local roads cut throughout the upper Midwest. These bluffs and views are themselves tourist attractions, yet a charge commonly leveled against many proposed industrial sand mines is the visual appearance of exposed bedrock walls and the need to block that view forever. Such a concern is clearly not genuine and is obviously raised for other reasons.

[42] Rodney Jacobs and Robert Wray, "Managing Oak in the Driftless Area," University of Minnesota Extension, 2013, http://www.extension.umn.edu/environment/trees-woodlands/managing-oak-in-the-driftless-area/.

Part Four

Property Rights, Land Use, and Property Values

The Right to Operate a Business and the Right to Mine

In most countries of the world, all mineral resources belong to the government. This includes all valuable rocks, minerals, oil, or gas found on or within the Earth. Individuals or organizations in those countries cannot legally extract and sell any mineral commodity without first obtaining authorization from the government.[43] The United States is one of the few nations in the world where individuals or organizations can own mineral rights. Mineral rights holders can explore, develop, extract, and market various resources under the surface of the applicable parcel of land. They also have the legal right to transfer or lease their mineral rights to another party.[44]

> The zoning process should not become a forum in which the industry must defend the importance of jobs, capitalism, the need for raw materials, U.S. industrial activity in a global marketplace, or local tax law.

Individuals and companies have the legal right to purchase property and mineral rights, make financial investments in capital and labor, operate businesses, and make a profit. This is especially true if the current or proposed use of the land is consistent with the goals, objectives, and policies of any local comprehensive land use plan, county smart growth plan, or other comprehensive plan adopted by the host community. Local zoning became common in the early years of the twentieth century, and it is the foundation of the modern local system of land-use control. Generally, local zoning regulates land use to ensure a use is not offensive and does not harm neighbors, the general public, public infrastructure, or the environment. Most of these standards are measurable, but some are subjective and all can be hotly debated.

Local governments play an important role in regulating nonmetallic mining and have a variety of tools at their disposal, including comprehensive plans, zoning ordinances, nonmetallic mining ordinances, moratoria, development agreements, and local road use agreements.[45] The purpose of land use and zoning processes, as it pertains to industrial sand mining, is to address specific concerns such as road access, traffic routes, hours of operation, visual barriers, lighting, noise, and other potential land use conflicts that can be reasonably resolved through ordinances.

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[43] Hobart King, "Mineral Rights," Geology.com, accessed October 22, 2015, http://geology.com/articles/mineral-rights.shtml.

[44] Courthousedirect.com, "Mineral Rights vs. Property Rights: Are You Sitting on a Gold Mine?" May 3, 2013, http://info.courthousedirect.com/blog/bid/273602/Mineral-Rights-vs-Property-Rights-Are-you-Sitting-on-a-Gold-Mine.

[45] Anna Haines, *Planning and Zoning for "Frac Sand" Mining*, Center for Land Use Education, April 2012, https://www.uwsp.edu/cnr-ap/clue/Documents/Mining/FracSand1.pdf; see also Orr and Krumenacher, *supra* note 4.

The zoning process, while important for its specific purpose, should not become a forum in which the industry must defend the importance of jobs, capitalism, the need for raw materials, U.S. industrial activity in a global marketplace, or local tax law. Examples of industries that strive to keep a business viable for only a limited period of time are rare. Every industry has a right to plan for the benefit of current and future employees and stakeholders, including local residents.

Mining is a legal and responsible land use. Although individuals have the right to control their property, use must sometimes be regulated for the common good; property rights are not absolute. Local land use controls are normally the primary mechanism for regulating the siting and operation of industrial sand and other nonmetallic mines in the United States.

> The potential negative impact of industrial sand operations on property value is one of the top concerns raised in response to almost every proposed new mine or mine expansion.

Recently, pressures have been mounting for more state-level control of land-use policy in Wisconsin. Although recently driven by the increase in silica sand mining, this is not a new issue in Wisconsin, and it is applicable to all industries that propose changes in land use. Whether Wisconsin opts for a greater state role in land-use policy will depend on whether the existing laws, which emphasize local control, can meet the challenges facing local property owners, municipal governments, and the state.[46]

Effects on Property Values and Land Use

Concerns about the potential impact on property value are present for almost every land-use change proposed in a neighborhood or near residential property. There are few if any exceptions. Equally strong local opposition will occur if the proposed development is a residential subdivision, church, or playground if that development is planned for an area where individuals have a different perspective on the best use of the property proposed for development.[47] The same is true even of wind farms, supposedly prized for their eco-friendly nature.[48]

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[46] Michael J. Keane, "The Regulation of Land Use," *Informational Bulletin 98–3*, State of Wisconsin Legislative Reference Bureau, September 1998, http://lrbdigital.legis.wisconsin.gov/cdm/singleitem/collection/p16831coll2/id/1299/rec/2.

[47] Rhonda Goodman, "Proposed Playground a Subject of Controversy. A Group Is Raising Money for a Tot Lot In Hillcrest Park. Some Nearby Residents Oppose It," Philly.com, April 16, 1995, http://articles.philly.com/1995-04-16/news/25686544_1_tot-lot-playground-hillcrest-park.

[48] Amanda Brodhagen, "Ontario Court Says Wind Turbines Reduce Property Values," April 24, 2013, Farm.com, http://www.farms.com/ag-industry-news/ontario-court-says-wind-turbines-reduce-property-values-882.aspx. See also John Rodgers, "The Effect of Wind Turbines on Property Values: A New Study in Massachusetts Provides Some Answers," Union of Concerned Scientists, January 22, 2014, http://blog.ucsusa.org/effect-of-wind-turbines-on-property-values-384.

The potential negative impact of industrial sand operations on property value is one of the top concerns raised in response to almost every proposed new mine or mine expansion. Opponents to mining often claim the construction or expansion of a mine will reduce property values in the surrounding community. Although individuals and organizations issue statements and use social media networks in an attempt to validate these concerns, they simply make claims without citing research. It is a common tactic of anti-mining activists, but repeating an unsupported statement often and loudly does not make it true.[49]

There are no credible studies supporting claims of widespread and predictable property value declines associated with industrial sand mining or any other similar nonmetallic mining activity. This lack of credible evidence assurance the concern is unfounded.

> Every sand mine is unique, and circumstances where the value of adjacent properties may be affected can be addressed only on an individual basis.

Every sand mine is unique, and as is true of any development, there are circumstances where the value of adjacent properties may be affected. These are finite and unique circumstances at some, not all, mines, and they can be addressed only on an individual basis. There are no documented circumstances of industrial sand mining causing a community-wide reduction of property values.

Between 1981 and 2011, several studies, using technically sound methods, examined the relationship between nonmetallic mining and property values. Each of the studies concluded there was no consistent relationship between mines and property values. Although there were specific instances where mines or quarries may have reduced nearby property values, other homeowners realized an increase in property value because of the setbacks, open space, and wooded areas used to buffer mining operations. While it can be difficult to explain this seemingly counterintuitive finding during an emotionally charged public meeting, it is a demonstrable fact and logical when calmly considered or, better yet, witnessed.

Some studies report property values near quarries were higher than similar properties farther from the quarry. This does not necessarily imply the mine itself increased the property value, but it does demonstrate a mine does not necessarily reduce the value of nearby properties. Many mines actually suffer from so much post-development encroachment by residential development they end up operating in a residential rather than rural environment, without complaint from, and more importantly without harm to, the neighbors or their properties.

Residential encroachment on existing nonmetallic mining operations has become a serious land-use issue that is gaining recognition from local officials who see a growing need for future

[49] For more on this propaganda tactic, see Dr. L. Kip Wheeler, "Logical Fallacies Handlist," Carson-Newman University, no date, https://web.cn.edu/kwheeler/fallacies_list.html.

planning.[50] This planning is needed not specifically or only to protect residential land uses, but to protect the future availability of nonmetallic minerals as well. Without proper planning, for example, the most ideally situated local nonmetallic mineral resources may be buried by a subdivision, with the next-available source of minerals needed to build the local development and infrastructure significantly farther away. This unnecessarily increases costs to consumers and municipalities.

Historical Property Value Studies

The earliest study we have identified that addressed property values was completed in 1981 by the U.S. Bureau of Mines, which evaluated bedrock quarries in Illinois, Kentucky, Missouri, and Pennsylvania.[51] The analysis found no consistent relationship between quarries and property values.

The earliest study we have identified that addressed property values, completed in 1981 by the U.S. Bureau of Mines, found no consistent relationship between quarries and property values.

In 1987, the Department of Real Estate at Georgia State University conducted a study to measure adverse impacts on the value of existing homes or homes to be built near a proposed quarry in Bolingbroke, Georgia. The analysis considered quarries in DeKalb, Newton, and Monroe Counties in Georgia, utilizing two comparative analyses.[52] The study concluded the following:

1. Properly developed quarries had no effects on the value of housing adjacent to the operation.

2. In one of three counties, property values in the non-quarry area increased more slowly than values in the quarry-influenced area.

3. Some homeowners said they benefited from being near a quarry because of the open space and wooded areas used to buffer operations.

4. The overall study of changes in the value of homes located both nearby and away from properly operated rock quarries indicates quarries have no significant adverse impact on the value of homes.

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[50] John Henriksen, Mark Krumenacher, Zak Lesemi, and Mathew Hensel, "Planning for Sustainable Aggregate Production," presentation to the National Planning Conference of the American Planning Association, Chicago, Illinois, April 16, 2013.

[51] M. Radnor, D. Hofler, C. Aimone, *et al.*, *Social, Economic and Legal Consequences of Blasting in Strip Mines and Quarries*, U.S. Bureau of Mines, May 1981, http://www.cdc.gov/niosh/nioshtic-2/10006499.html.

[52] Joseph Rabianski and Neil Carn, "Impact of Rock Quarry Operations on Value of Nearby Housing," Department of Real Estate, Georgia State University, August 1987.

A 1995 analysis of a proposed sand and gravel quarry in Granite Falls, Washington conducted by Schueler, McKown & Keenan, Inc., a real estate appraisal firm, considered four case studies in Washington.[53] The analysis concluded properties adjacent to quarry operations buffered by 100 or more feet showed no difference in value compared to properties removed from the operation, and in some instances the values near a quarry were found to be higher.

A study by the Department of Economics at Ohio Wesleyan University in 1996 evaluated previous studies by the U.S. Bureau of Mines (1981) and Rabianski and Carn (1987), who focused on residential appreciation rates near a Delaware County, Ohio quarry and a quarry located in Franklin County, Ohio.[54] The Ohio Wesleyan researchers also used the repeat sales method to study values near the Marble Cliff Quarry and Shawnee Quarry. They found values of properties located adjacent to an existing quarry were not reduced. The researchers concluded an expansion of the Shawnee Quarry would not reduce the values of adjacent and nearby residential properties.

> Studies by university researchers, land-use consulting firms, real estate appraisal firms, individual certified appraisers, and government agencies have found no evidence mining operations hurt the values of adjacent and nearby residential properties.

The land-use consulting company Banks and Gesso, LLC, conducted a study in 1998 examining property values near three quarries in Jefferson County, Colorado that sold before and after quarry development. The analysts found no basis for suggesting quarries devalue residential properties.[55]

In 2002, Banks and Gesso evaluated 10 subdivisions in the vicinity of three sand and gravel operations in the Fort Collins, Colorado area.[56] The analysts found no significant statistical difference in the data suggesting locations near sand and gravel mines suffered lower property values. For two of the mines, the subdivisions nearest the operations had higher rates of appreciation for home values than subdivisions farther away.

Two studies addressed expansion of existing industrial sand mines. A 2005 study by William A. McCann & Associates, Inc., a real estate appraisal company, evaluated real estate values near two quarries in Naperville and Bolingbrook, Illinois and compared them to properties near a

[53] Richard McKown, “Analysis of Proposed Sand & Gravel Quarry, Granite Falls, Washington,” Schueler, McKown & Keenan Inc., September 1995.

[54] Anne Dorrian and Clifford Cook, “Do Rock Quarry Operations Affect Appreciation Rates of Residential Real Estate,” Department of Economics, Ohio Wesleyan University, April 1996.

[55] “Impacts of Rock Quarries on Residential Property Values, Jefferson County, Colorado,” Banks and Gesso LLC, May 1998.

[56] “A Property Valuation Report: Affect of Sand and Gravel Mines on Property Values,” Banks and Gesso LLC, October 2002.

proposed industrial sand mine expansion in Ottawa, Illinois.[57] The empirical data indicated the proposed mining expansion would not have any measurable adverse effect on nearby property values. In 2011, two Wisconsin certified appraisers, William Richardson and Brian Ducklow, analyzed sales in the Town and Village of Maiden Rock and comparable markets along the Great River Road in Pierce County, Wisconsin to determine the effect on the local real estate market of an underground industrial sand mine.[58] They found no historical data to suggest the mine had affected the real estate market in Maiden Rock and the area.

Also in 2011, the Winona County, Minnesota, Planning Department prepared a memo to address questions submitted by the county board, planning commission, and the public regarding three proposed silica sand mines in Saratoga Township.[59] The Planning Department concluded property values around existing quarries and sand pits in the county (54 mine sites identified) were not noticeably reduced due to proximity to existing mining operations.

Misinformation on Property Values

Property values depend upon a variety of local factors, with each property having specific characteristics, making it difficult to draw broad generalizations about how a particular property will be affected by development of any form. Because property values are affected by such specific factors, modeling exercises that try to isolate the influence of a specific factor, such as proximity to an industrial sand facility, rarely succeed in accurately assessing property values.

> Modeling exercises that try to isolate the influence of a specific factor, such as proximity to an industrial sand facility, rarely succeed in accurately assessing property values.

Below, we discuss the strengths and limitations of several studies commonly cited by opponents of industrial sand mining as allegedly demonstrating nonmetallic mines decrease nearby property values.

Erickcek and Hite

The most widely cited information claiming nonmetallic mining operations have a consistent, negative effect on property values is based on a report by George Erickcek of the W.E. Upjohn

57 "Property Value Impact Study, Proposed Mining Expansion, Ottawa, Illinois," William A. McCann & Associates, Inc., April 2005.

58 William Richardson and Brian Ducklow, "Comparative Study of the Maiden Rock Real Estate Markets to Surrounding Markets," 2011.

59 Winona County (Minnesota) Planning & Environmental Services, "Memo to Winona County Board Planning Commission RE: Frac Sand Questions," November 10, 2011, http://www.red-wing.org/media/files/planning/silicansand/winonacountyregulatoryframework.pdf.

Institute for Economic Research, "An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township."[60] Commonly but erroneously referred to as the "Erickcek study" or "Hite study," this information is in fact not a study but a theoretical model based on an unpublished, non-peer-reviewed working paper by Diane Hite, an associate professor at Auburn University.

Although Erickcek presented Hite's model as credible evidence for decreased property values, and he calls Hite's analysis "the only rigorous study to date of gravel mine impacts on property values," research by GZA GeoEnvironmental, Inc.,[61] which included a personal conversation with Hite and others, concluded Hite's work was never more than a working paper that was neither peer-reviewed nor published and was grossly misrepresented by Erickcek and others.

> The environmental impacts of landfills and industrial sand operations are vastly different, rendering these comparisons invalid and inappropriate.

Others analysts have drawn similar conclusions about Erickcek's work. The Great Lakes Appraisal Company (GLAC) exposed Erickcek's misuse of Hite's information as "unprofessional at best and likely misleading and reckless." GLAC stated, "If the author(s) of the Upjohn report were subject to the same rules and regulations governing our profession, they would be in violation of a number of basic tenets, particularly those regarding unsubstantiated conclusion and the requirement to produce credible results."[62]

The major shortcomings of Erickcek's paper include:

- his use of studies that investigated the impact of trash landfills on property values as a proxy for industrial sand mines;
- his refusal to acknowledge his own findings that appreciation rates for property values near sand and gravel mines are the same as for properties distant from these operations; and
- his demonstrated lack of understanding of the inputs of the conceptual model used by Hite, which severely limit the usefulness of Erickcek's modeling.

Most of the studies presented by Erickcek as evidence that environmental disamenities (environmental features some parties may consider undesirable) can reduce property values actually assessed the potential impact of landfills on property values. The environmental impacts

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[60] George Erickcek, "An Assessment of the Economic Impact of the Proposed Stoneco Gravel Mine Operation on Richland Township," August 15, 2006, https://www.heartland.org/policy-documents/assessment-economic-impact-proposed-stoneco-gravel-mine-operation-richland-township.

[61] Disclosure: Mark Krumenacher, an author of this *Heartland Policy Study*, is senior principal and senior vice president of GZA Environmental, Inc.

[62] Memorandum to Alamo Township Michigan Planning Commission Regarding Aggregate Industries Application and Matters and Information Brought Before the Township, Great Lakes Appraisal Company, February 2007.

of landfills and industrial sand operations are vastly different, rendering these comparisons invalid and inappropriate. For example, among the primary concerns regarding landfills are objectionable odors and fears of an influx of undesirable animals such as rats and seagulls.[63] Industrial sand facilities do not emit objectionable odors or attract vermin.

Erickcek found appreciation rates (the rates at which property increases in value) to be similar for property located next to a mining operation and property located farther away. These findings suggest proximity to sand and gravel mines does not substantially influence the value of a given property.

Without data to support his claim, Erickcek developed an unsubstantiated theory suggesting sand and gravel mines create a one-time, immediate loss of property value that is then priced into the value from that point forward, essentially lowering the value all at once and hitting a "reset button" allowing the property to appreciate at the same rate as other properties. Research conducted by GLAC to assess the validity of this theory found it to be unsupported by the data. Looking back in time to before the mining operations opened, GLAC determined there was no evidence to support the hypothesis of an immediate, one-time decline in property value.

Finally, research conducted by GLAC found the supposed sand and gravel mine that was the basis of Hite's work and the Erickcek report was in fact not a gravel mine at all, but a limestone mine in Ohio. Hite did not collect the data she used in her working paper. Neither Hite nor Erickcek visited the subject site, and they did not collect sufficient information to construct a model capable of accurately predicting the impact of industrial sand mines on property value.

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Despite the documented inaccuracy of Erickcek's representation of Hite's working paper, others have repackaged Erickcek's work as fact in subsequent reports, blogs, and articles relaying his manipulation of Hite's initial working paper. Erickcek's deeply flawed work is still being used to oppose mines in Canada[64] and the United States, with the initial concept getting twisted a little more with every subsequent report. This is especially true of a seemingly simple curve initially created by Erickcek showing a reduction in property value plotted against distance from a mine. This now convenient curve is cited frequently as fact and even "irrefutable" without an understanding of its genesis. Inconceivably, even Diane Hite now cites Erickcek's 2006 report

[63] See, for example, Ariel Barkhurst and Lisa J. Huriash, "Mount Trashmore smell prompts resident complaints," *Sun Sentinel*, July 15, 2013, http://articles.sun-sentinel.com/2013-07-15/news/fl-trashmore-odor-violations-20130711_1_monarch-hill-landfill-operator-waste-management-inc; New York Department of Health, "Important Things to Know About Landfill Gas," New York State, August 2012, https://www.health.ny.gov/environmental/outdoors/air/landfill_gas.htm.

[64] "The Potential Financial Impacts of the Proposed Rockfort Quarry," The Centre for Spatial Economics, February 26, 2009, http://www.wcwrpc.org/FinancialImpacts_RockfortQuarryCanada.pdf.

and his use of "the Hite (2006) study" in a recent report prepared in opposition to an aggregate operation in Colorado.[65]

Hite's model – a hedonic pricing model that assumes the price of property is determined both by its own characteristics and external factors – requires credible inputs into the model. But property value is influenced by a complex mixture of variables that are difficult to control for and separate from one another for analysis. Erickcek's work fails to take the complexity of property value into account and lacks credible inputs, rendering the outputs of the model useless for predicting the impact of industrial sand mines on property values.

Public opinion is too often influenced by unsubstantiated claims or modeling exercises that appear to be sophisticated but produce results that do not match real-world observations.

It is vitally important that local decision makers and residents understand the limitations of such reports alleging to be scientific studies. Public opinion is too often influenced by unsubstantiated claims or modeling exercises that appear to be sophisticated but produce results that do not match real-world observations.

Midwest Environmental Advocates and University of Wisconsin Extension

Several economic reports claim to address the negative impact of mining on property values, yet not one of the reports provides data to support that position. Instead, the approach many of these self-proclaimed researchers take is to incorporate repeated statements as if they were forgone conclusions of fact without doing original research or verifying sources.

That approach was used by Midwest Environmental Advocates (MEA) in its petition to compel the Wisconsin Department of Natural Resources to conduct a strategic analysis of the industrial sand mining industry.[66] The success of MEA's petition is an unfortunate testament to the fact that truth and technical facts often do not matter to activists so long as the end justifies the means.

MEA repeats others' conjectures in statements such as this: "Further, negative impacts of frac sand mining *may hurt neighboring property values* and businesses that benefit from Wisconsin's scenic beauty and natural resources" [emphasis added], providing no appraisal data or facts to support these claims. MEA also reports, "While frac sand mining may temporarily increase

[65] Chuck Wallace, "Property Values Decrease Around a Quarry," *StopTheQuarryCascadeTownship*, November 25, 2014, https://stopthequarrycascadetownship.wordpress.com/2014/11/25/property-values-decrease-around-a-quarry/; Ellen E. Kisker and Diane Hite, "Response to Weld County 34 Value Diminution Study by Michael Smith, Foster Valuation Company LLC," August 5, 2015, http://www.clr-34.org/images/Real%20Estate%20value%20impacts.pdf.

[66] Midwest Environmental Advocates, "Petition for a Strategic Analysis of Frac Sand Mining," September 2014, http://midwestadvocates.org/assets/resources/Frac%20Sand%20Mining/2014-9-12_FINAL_frac_sand_stratgic_analysis_petition_PDF_Color.pdf.

property values of land used for mining, it may also decrease the value of neighboring residential properties that are not sold for industrial uses." This second statement cites a paper from the Department of Agricultural and Applied Economics of the University of Wisconsin, "The Potential Impacts of Frac Sand Transport and Mining on Tourism and Property Values in Lake Pepin Communities."[67] Although providing a convenient reference, the authors of the cited report provide no facts or studies, instead relying solely on speculation that mining "may" or "has the potential" to affect property values. As such, the paper referenced by MEA is not a study but merely another opinion piece similar to a number of Facebook pages. In this case, however, the opinion piece was prepared by University of Wisconsin Ph.D. researchers to provide a few local anti-mining activists with a credible-sounding report, which persuaded Pepin County to pass an ordinance prohibiting industrial sand mining under the guise of concern the activity would reduce property values and tourism.[68]

The most disturbing element of the report prepared for Lake Pepin communities is the authors' complete disregard for the three industrial sand mining operations already located along the east shore of Lake Pepin. These operations are located on the border of Pepin County or seven to 15 miles from Pepin County along the lake, yet the authors neither acknowledged them nor apparently knew them to exist. Even more damning of the authors' credibility, two of the industrial sand mines have been there for nearly 100 years. Nevertheless, the authors claim the current high property values and flourishing tourism along the lake will be forever reduced if an industrial sand operation were to be allowed there.

The most disturbing element of the report prepared for Lake Pepin communities is the authors' complete disregard for the three industrial sand mining operations already located along the east shore of Lake Pepin. The authors neither acknowledged them nor apparently knew them to exist.

It is amazing their report should have garnered any amount of credibility. But the paper served its intended purpose for a small number of individuals in Pepin County set on banning mining for their own personal reasons: another unfortunate testament to the fact that evidence, truth, and technical facts often do not matter so long as the means justifies the end.

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[67] Dominic Parker and Daniel Phaneuf, "The Potential Impacts of Frac Sand Transport and Mining on Tourism and Property Values in Lake Pepin Communities," Department of Agricultural & Applied Economics, University of Wisconsin-Madison, May 14, 2013, http://www.sandpointtimes.com/pdf/Frac-Sand-Impact-Tourism-Property-Values.pdf.

[68] The Associated Press, "Pepin County Bans Frac Sand Mining Along Scenic Stretch," *Winona Daily News*, June 21, 2013, http://www.winonadailynews.com/news/pepin-county-bans-frac-sand-mining-along-scenicstretch/article_cbd8e3c4-da21-11e2-a277-001a4bcf887a.html.

Property Values and Perceptions of Harm

Property values can be affected by the mere *perception* of possible harm from a given source, such as a cell phone tower, water treatment plant, industrial wind turbine, or industrial sand mine. The ways in which people perceive risks can influence how they view themselves, their surroundings, properties, and society at large.[69] As noted earlier, people exposed to new ideas tend to give more weight to negative information, even if their initial fears are not based on a rational view of the available evidence.

> Research shows the irrational perception of harm can be addressed by scientific, evidence-based information.

Unscientific, anecdotal studies that inaccurately quantify potential risks – such as those conducted by Dr. Crispin Pierce of the University of Wisconsin-Eau Claire[70] and those erroneously reported as fact by influential groups such as Midwest Environmental Advocates[71] – feed the irrational perception of harm. Such studies do nothing to quantify the potential environmental impacts of industrial sand mining, instead causing unnecessary consternation among local residents. Such studies may very well have a greater negative impact on property values near industrial sand mines than the mining operations themselves.

Perceptions of harm that have no basis in fact are likely to be temporary, and so too is any property value decrease based on those perceptions. Research shows the irrational perception of harm can be addressed by scientific, evidence-based information. An important example is the concern over air quality and its impact on human health and property values near industrial sand mines.

Air quality monitoring studies conducted at or near industrial sand mining operations find levels of particulate matter and respirable crystalline silica well below concentrations that could cause harm to human health.[72] For example, a study conducted by the University of Iowa found daily mean concentrations of particulate matter at residences near sand facilities were substantially lower than National Ambient Air Quality Standards (NAAQS) established by the U.S.

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69 Alex Geisinger, "Nothing but Fear Itself: A Social-Psychological Model of Stigma Harm and Its Legal Implications," *Nebraska Law Review* **76** (3), http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1513&context=nlr.

70 Crispin Pierce, "PM2.5 Airborne Particulates Near Frac Sand Operations," *Journal of Environmental Health*, November 2015, https://minds.wisconsin.edu/handle/1793/73716.

71 *Supra* note 66.

72 For more information on the health impacts of frac sand mining, see *supra* note 2.

Environmental Protection Agency.[73] Industrial sand operations do not cause airborne particulate matter to reach concentrations that could cause chronic health conditions such as silicosis.[74]

Scientific investigations by universities, state regulators, and other independent third-party air sampling experts have concluded industrial sand mining is a low-risk industry. As the results of these studies become better known, temporary reductions in property values stemming from concerns about the safety of industrial sand facilities are likely to diminish over time ... unless environmental groups and NIMBY activists continue to raise them and gullible or complicit reporters continue to give them undeserved attention.

Property Value Agreements

> Using local ordinances to force mining companies to offer concessions to property owners within arbitrarily determined distances is not justified.

While current homeowners in the neighborhood of a new mine may be convinced that any change in the local environment will inevitably hurt property values, the fact is property values rarely fall. The concerns or perceptions of harm held by current homeowners are not universally shared by future owners. Although some potential buyers may choose not to buy a home near a mine, a sufficient pool of buyers for such properties exist and fair market value generally is obtained, subject to normal market variations.

In some communities, public concern over the potential negative impact of industrial sand operations on property values has led to "property value agreements," whereby local mining ordinances or developers' agreements require mine operators to guarantee the value of property within an arbitrarily specified distance from the mine. Agreements of this nature have been negotiated between industrial sand operators and local property owners in Trempealeau County, Wisconsin.[75] Similar agreements are sought with other developments such as wind farms.

Implementation of a property value agreement is an inherently local effort. Every sand mine is unique, as are its surrounding environment and demographics. Assessing the value of residential real estate, in particular, is subjective and difficult, because the owner almost certainly has a personal relationship with the property and has invested sweat equity in it. He or she is likely to be convinced that *any* change to the property made by someone else or caused by something else will have a negative affect on the property's value.

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[73] Ryan James Grant, "Community based air quality monitoring near proppant sand facilities," Iowa Research Online, University of Iowa, August 2015, http://ir.uiowa.edu/cgi/viewcontent.cgi?article=5903&context=etd.

[74] *Ibid.*

[75] Alison Dirr, "Frac sand mines credited for rising, dropping property values," Wisconsin Center for Investigative Journalism, March 30, 2014, http://wisconsinwatch.org/2014/03/frac-sand-mines-credited-for-rising-dropping-property-values/.

Property value agreements are rarely complex. They tend to be based on a simple determination of fair market value prior to mine development, typically by a mutually agreed upon licensed real estate appraiser or similar professional. If the owner sells the property for less than the determined fair market value, the mine operator must pay the owner the difference between the selling price and the fair market value. Commonly, such agreements also provide the mine operator will purchase properties that do not sell within a set period of time, such as six or 12 months.

It is clearly appropriate in some instances for mine developers to make concessions and appropriate offers to neighbors, and they often have done so. However, using local ordinances to force such concessions to property owners within arbitrarily determined distances is not justified by the evidence or research discussed in this paper.

Part Five

Conclusions

> Mining is an indispensable part of life. It is *not* a threat to tourism, scenic beauty, or property values.

Mining is an indispensable part of life: If an object is not farmed, it must be mined. Every American citizen born in 2015 will require millions of pounds of minerals, metals, and fuels in his or her lifetime, and these materials must be obtained through mining. Even so-called "green technologies" depend on mining because they require vast quantities of traditional metals, minerals, rare earth elements, and fossil fuels.

Mining is *not* a threat to tourism, scenic beauty, or property values.

- Wisconsin Department of Tourism data for the years 2010 through 2014, when industrial sand activity expanded dramatically in the state, show most sand-producing counties experienced growth in all tourism measures. Industrial sand mining may actually help increase tourism-related revenues through the living-wage jobs it creates in these communities, along with activities such as trout stream habitat restoration projects in which mining companies have participated.

- Scenic natural bluffs are unlikely to be affected by industrial sand mining. It is very rarely economically feasible to access sandstone deposits buried deep beneath thick layers of limestone rock. In some situations, underground mining techniques can be used, as they have been for nearly a hundred years along the Mississippi River Corridor – an area still prized for its scenic beauty.

- In the exposed sandstone hills where industrial sand mining is feasible, mining is far less permanent than many other forms of development, such as commercial shopping outlets, where stores can remain vacant for years. Reclamation of mining sites begins when mining in one section of the mine has concluded, and substantial diversity in plant and animal species can be observed within only a few years.

- As is true of any development, concerns about the impact of industrial sand mining on property values may be valid in some situations. It is important to address those concerns with information that applies to the specific local circumstances. In some situations, industrial sand companies have entered into property value agreements guaranteeing residents that the operations will not prevent them selling their property at fair market value.

Too often, concerns about the impact of industrial sand mining operations are driven by irresponsible fear-mongering. Anti-mining activists often feed the public's intense emotional reaction to change by issuing "reports" that do not inform, but cause consternation and whip up fear. Experts in risk communication identify four ways to understand the emotional reactions a community might have to a proposed new development. Mental noise, perception of threats, elements of trust, and dominance of negatives can limit the ability of individuals in a community to examine an issue rationally and can cause them to become unnecessarily concerned.

The way to address emotional reactions is to acknowledge them, understand them, and respond to them with scientific evidence and real-world data.

The way to address emotional reactions is to acknowledge them, understand them, and respond to them with scientific evidence and real-world data to counter irresponsible and anecdotal studies – which is what we have aimed to do in this series of *Heartland Policy Studies*.

# # #

About the Authors

Mark Krumenacher

Mark Krumenacher is a senior principal and senior vice president of GZA GeoEnvironmental, Inc. and works in its Waukesha, Wisconsin office. He has served as principal, project manager, and project hydrogeologist during the past 27 years with GZA on environmental, geologic, hydrogeologic, and engineering projects throughout North America.

Krumenacher is a professional geologist with licensure nationally and in several states and is a certified hazardous materials manager. He has managed and conducted geologic, hydrogeologic, and engineering studies, remedial investigations, environmental assessments, pre-acquisition environmental due diligence, and hazardous waste management at various properties including surface and underground mines; large industrial, commercial, and urban redevelopment projects; federal Superfund sites; and state-lead environmental projects.

He has provided testimony regarding aggregate and industrial mineral mining before municipal, township, and county units of government as well as nongovernment organizations, local environmental groups, and community advisory councils to help address residents' concerns about mining. Krumenacher is actively involved with several mining associations, including the National Stone Sand and Gravel Association, Illinois Association of Aggregate Producers, National Industrial Sand Association, Industrial Minerals Association–North America, Wisconsin Industrial Sand Association, and Society for Mining Metallurgy and Exploration.

Isaac Orr

Isaac Orr is a research fellow at The Heartland Institute. He previously worked as a research analyst and writer in the Wisconsin State Senate, and prior to that interned with the Rancher's Cattleman Action Legal Fund. He graduated in 2010 with honors from the University of Wisconsin-Eau Claire, with a B.A. in political science and a minor in geology.

Orr is the author of *Heartland Policy Study* No. 132, "Hydraulic Fracturing: A Game-Changer for Energy and Economies" (November 2013), and his letters to the editor and op-eds have been published in *USA Today*, *The Houston Chronicle*, *The Washington Times*, *The Hill*, *American Thinker*, and *Human Events*. He is the author of "Frac Sand Study: Lots of Scare, Little Science," published in the *Milwaukee Journal Sentinel* in October 2014. He has spoken to nearly a dozen audiences and recorded more than a dozen podcasts on energy and environment topics for The Heartland Institute, available on Heartland's YouTube channel at HeartlandTube.

Orr writes, "I grew up on a dairy farm, and I want to preserve rural America, and rural American values. Along with agriculture, I am fascinated by geology, mining, groundwater, and other environmental issues."

ATTACHMENT B

GAINES TOWNSHIP

December 16, 2020

Natural Resources Management, LLC 1

0392 & 10388 Kalamazoo Avenue Groundwater & Surface Water Evaluation

NRM Natural Resources Management, LLC
7901 Sylvania Avenue
Sylvania, Ohio 43560
Local 419-841-3232
Fax 419-882-8772
www.NRMsolution.com

December 16, 2020

Stoneco of Michigan
3700 Patterson Road
Middleville, Michigan 49333

Attention: **Mr. Tony Halloran**

Reference: **10392 & 10388 Kalamazoo Avenue**
Groundwater and Surface Water Evaluation

Dear Mr. Halloran,

On behalf of Stoneco of Michigan (Stoneco), Natural Resources Management, LLC (NRM) has conducted a site visit and detailed data review of the surface and groundwater settings at the above referenced property (the subject properties). The purpose of this letter is to prepare and provide you with our findings and opinions of the surface and groundwater characteristics on the properties and more specifically, our opinion as to the low water elevation of the pond located on a common property boundary shared by the property owners. We also have assessed the potential for impacts to the pond from the existing and proposed 100th Street sand and gravel operation as previously completed in earlier reports. This letter and enclosures serve as an addendum to those evaluations.

Subject Properties Historical Review & Site Visit Summary

Previously, NRM reviewed a limited amount of historical aerial photographs for the subject properties and surrounding area. For this report, NRM conducted a more extensive review and obtained additional aerial photographs; the most recent being from the year 2020 and the oldest one being 1938. Historical topographic maps and wetland maps from various readily available sources were reviewed. A detailed review of the available domestic well logs on the subject properties was conducted that allowed for the construction of cross-sections relative to the reported groundwater tables and ground surface elevations. A site visit was conducted on December 11, 2020 with the property representatives at which time we made observations of the subject properties, collected photographs, and conducted personal interviews. The following is a summary of our findings and opinions:

- In addition to the United States Geological Survey historical topographic maps for the years 1943, 1967, 2014, 2017 and 2019 previously reviewed, NRM obtained the most recently available LiDAR data for Kent County from the USGS National Land Cover Database and the Kent County GIS Parcel Mapper. This topographic layer is shown in the enclosed Subject Properties Topography Figure 1A. Based upon this review, the area of the pond on the subject properties are shown to have an elevation of approximately 838-feet, mean sea level (ft, msl) around the top of bank to approximately 834-ft, msl in elevation at its lowest mapped depressional area. The well locations on the subject properties in reference to the pond are presented in Figure 1A. The approximate elevation of the ground surface at the well location identified as 10392 Kalamazoo Avenue appears to be at 865-ft, msl (see Figure 1A and Photograph 1). The approximate elevation of the ground surface at the water well location for the Barn at 10388 is also identified in the well log as an "irrigation" well (see attached well log ID 4100001874). The elevation of this well appears to be at 846-ft, msl. This is the well on the property located at 10388 Kalamazoo Avenue and nearest to the pond. The ground surface elevation of a third domestic well reported to be a deep bedrock well for the domestic supply (Deep Well Location for 10388) is approximately 863-ft, msl.

- The pond on the subject properties was observed on several historical aerial photographs dated from 1938 through 2020 (see ERIS Historical Aerial Report Dated December 15, 2020). As stated in our previous reports, the surface water elevation in the pond appears to fluctuate seasonally as well as annually, likely based on available precipitation. Since at least 1938, it appeared the water contained in the depression appears nearly dry in some years and having more open water elevations in others. All photographs have indications that the pond exhibits characteristics of an emergent wetland with seasonal open water and is characteristic of seasonal and annual fluctuations in available precipitation. The pond surface is covered in vegetation in most of the photographs.

- Domestic water supply well logs on the subject properties and surrounding parcels were reviewed to determine the subsurface characteristics of the soils and evaluate the approximate groundwater elevation. Four well logs were reviewed and three wells appear to have been installed in the sand and gravel aquifer beneath the quarry floor (see Figure 2 for well locations and cross-section line A-A'). These three wells included; 1) the residence located at 10034 Kalamazoo Avenue (well ID 16558), 2) the well identified as an irrigation well located at the barn with the address 10388 Kalamazoo Avenue (well ID 18704), and 3) the residence located at 10392 Kalamazoo Avenue (no well ID). Static water elevations were recorded on the well logs for these wells.

  Using the topographic information presented in Figure 2 and reported information on the well logs, the approximate elevation of the ground water table at 10034 Kalamazoo Avenue, 10392 Kalamazoo Avenue and the Barn or "irrigation" well at 10388 Kalamazoo Avenue was inferred to be at an elevation of approximately 809-ft, msl and 810-ft, msl and 812-ft, msl respectively. The surface material was described as Brown Clay and Sand and Sand & Gravel to elevations of 778-feet, msl; 757-ft, msl; and 759-ft, msl respectively. The well ID 23726 located at 10388 Kalamazoo Avenue was a deep well screened within the bedrock aquifer and therefore, not used for this evaluation but is depicted on the cross-section drawing.

  A cross-section A-A' (enclosed) was constructed using this information and is presented in Figure 3. The cross section suggests that groundwater encountered in the vicinity of the subject property has static elevations of approximately 810-feet, msl (rounded) and occurs within the underlying sand and gravel at quantities sufficient for domestic supply. Although these water elevations were reported at different time periods, the elevations in these wells are fairly consistent with the expected groundwater elevations as reported in previous evaluations for the adjoining mining operation. We therefore consider the inferred general groundwater elevation to be approximately 810-feet, msl and likely fluctuates with available recharge.

- Elevations of the adjoining quarry floor are at elevations of 830-ft, msl and therefore, would be expected to be approximately 20-feet above the inferred groundwater table.

- Based upon the topographic information above, the bottom elevation of the pond is approximately 833 to 830-feet, msl and would also be several feet above the inferred ground water table.

- Historical precipitation data was obtained from the Byron Center, MI Weather Underground data base. The monthly and annual precipitation data is presented in the attached Table 1. The recorded precipitation for the year 2020 up to November 30, 2020 was reported as 33.9-inches. Only a trace of precipitation had been recorded at this station for the first 11 days of December 2020. The average annual precipitation for the four previous years was 43.5-inches. We compared the monthly recorded levels from the four previous years to the 2020 annual records. It appears with the exception of July 2020, the monthly precipitation levels during the summer and fall months were below average. Records indicate recorded precipitation for the months of August, September and October were *significantly* lower and would therefore, not contribute to surface water recharge as it would have in a year with normal precipitation levels. Evidence of the fluctuating water levels can be seen in the historical aerial photographs dating back to 1938.

- A site visit was conducted on December 11, 2020 by representatives of NRM, Stoneco of Michigan and the respective property owner representatives. See attached Photograph Log and Wetland Maps dated December 11, 2020 for reference. We reviewed the well locations for the properties and the pond characteristics on the subject property. The ground surface at the domestic well location at 10392 Kalamazoo Avenue appeared to be approximately 20 to 30-feet above the observed elevation of the bottom of the pond (Photograph 1), consistent with the topographic maps.

  Based on the observed watermarks on the surrounding bank of the pond and dormant vegetation species, the ordinary high-water mark appeared to be approximately three (3) to four (4) feet above the bottom substrate and the top of bank appeared to be approximately 5-feet above the bottom of the pond. The pond appeared to have standing water in isolated low-lying pockets within the substrate at the time of the site visit. The substrate was observed to be of a sandy silt-to silty clay with high organic content. A layer of decaying leaves was observed throughout the bottom of the substrate. The banks of the pond were observed to be gray to tan fine sand and topsoil.

  Dormant vegetation was observed in all areas of the exposed pond substrate that included but was not limited to lilly pad roots, reed canary grass stems, cattail stems, moss and lichen species. Portions of the banks included various species of shrubs. Bank erosion was observed along the banks. These observations are representative characteristics of shallow open water and emergent wetland habitats. This is supported by the fact that the area has been mapped as emergent wetlands with isolated fresh water pockets on the US Fish & Wildlife National Wetlands Maps (See Map 1 and Map 2 on the enclosed Photograph and Wetland Map Log).

  It was reported that the pond was excavated several years prior and not artificially lined. It was also reported by the property owners that surface water is directed to the pond through field tile from the wetland complex located on the Barnaby property located approximately 300-feet from the north end of the pond. Additionally, field tile entering the pond was observed at the southwest edge of the pond. Extent or functionality of any of the field tiles observed or reportedly entering the pond were not determined at the time of the site visit.

Based on the above information, it is likely the bottom of the pond is situated within sandy silt or silty clay material that is poorly drained and would therefore hold water for a period of time. Surface water recharge is directly related to available precipitation. Evidence was observed indicating the pond is a shallow emergent wetland that contains areas of open water seasonally. The depth of the pond, surface area and amount of emergent vegetation that covers the surface in the growing season makes is more susceptible to evaporation and evapotranspiration. This would therefore, impact the surface water elevations more prominently in years exhibiting mild to severe drought conditions. The isolated nature of the perched semi-permeable layers will also allow the pond to leak into the dry sand and gravel and eventually into the ground water table, impacting the water levels more readily during seasons without normal rainfall.

Based on our interpretation of the static ground water elevations reported in the domestic well logs along with the topographic maps, the inferred ground water table would be approximately 15-feet below the apparent bottom elevation of the pond and therefore, this emergent wetland is not likely connected to the shallow groundwater table. It can further be documented from the historical aerial photographs, the pond on the properties has a history of higher and lower water elevations and varying surface water extent since at least 1938. Observed vegetation in the pond substrate and watermarks on the banks and shrubs indicate the pond can be characterized as a shallow open water and emergent wetland habitat. There is no evidence that the adjoining mining activities, which are being conducted above the inferred ground water elevation, would have any impacts to the surrounding wetlands or ponds. No active dewatering is occurring at the adjoining mining operation. We would expect the pond surface water levels to recharge as precipitation events reflect normal or above normal recorded levels.

As stated in our previous assessments, the information presented above supports our professional opinion that no significant environmental impacts would be expected from the proposed mining activities. The currently observed low water elevation of the pond is likely due to low recharge rates associated with the below-normal precipitation recorded in the area. This is supported by the fact that the pond substrate shows characteristics of a leaky or semi-confining layer that would allow surface water to infiltrate into the underlying sand and gravel aquifer that is inferred to be over 10-feet below the bottom of the pond. More importantly, the pond has been identified as an emergent wetland habitat with isolated pockets of open water and the findings presented herein support the fact that this condition has existed since at least 1938.

This evaluation and our opinions rely on some information presented by others and therefore, NRM reserves the right to revise this report if additional information is presented. We trust this clearly outlines our findings and opinions for your consideration with respect to the proposed mineral extraction operation. At this time, we would recommend the property owners install rain gauges to record precipitation events and install a staff gauge in the pond to record periodic observations of water levels throughout the year. Please contact me with any questions.

Sincerely,

Chip Tokar

Chip Tokar, CPG, CPESC, CMS
Natural Resources Management, LLC

c: Ms. Susanne Haaf, P.E. Stoneco of Michigan, via electronic mail

Figure 1A Topographic Map & Well Locations

December 16, 2020

Figure 2 Cross Section Location Map

December 16, 2020

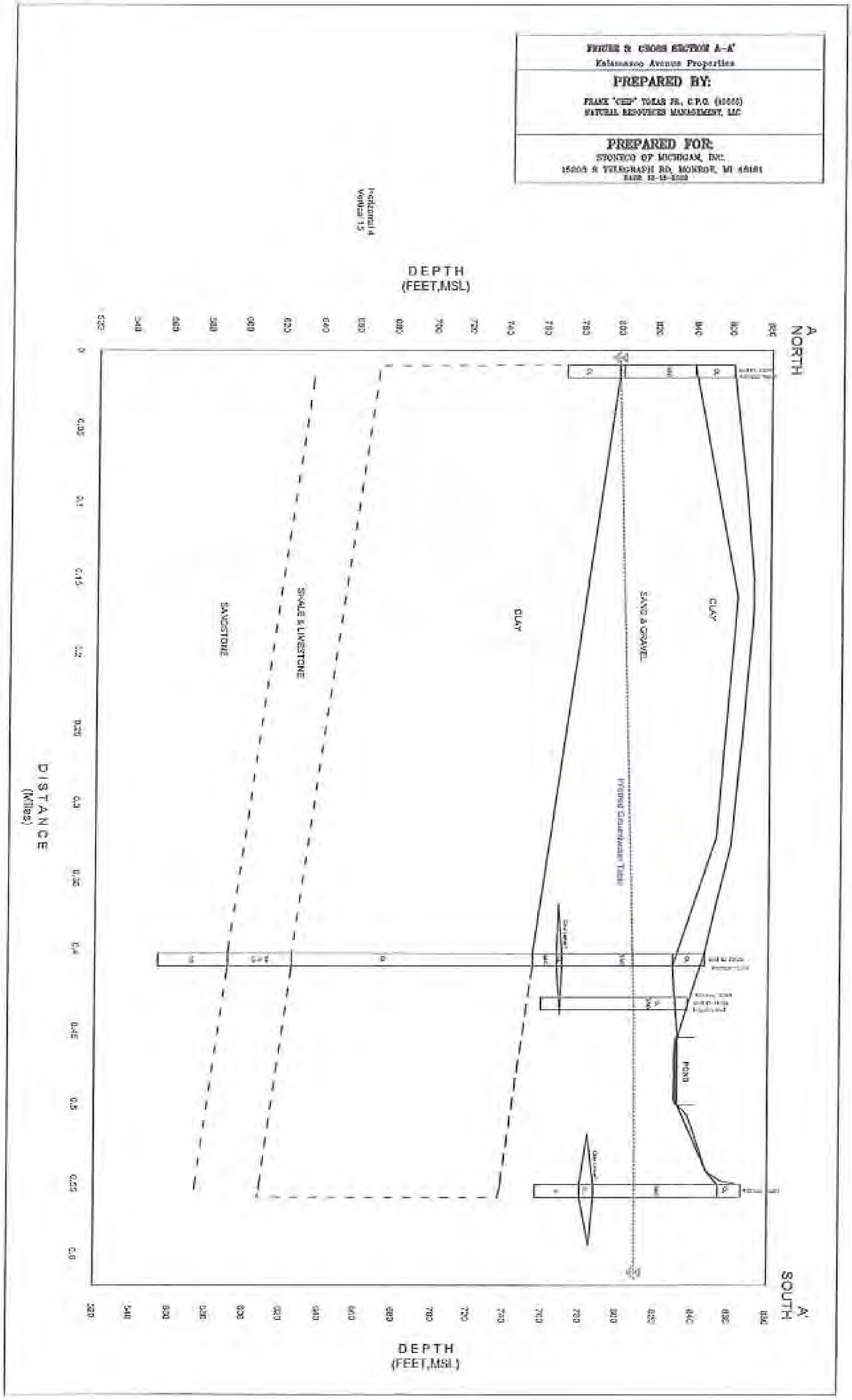

CROSS SECTION A-A'
Kalamazoo Avenue Properties
PREPARED BY:
NATURAL RESOURCES MANAGEMENT, LLC
PREPARED FOR:
STONECO OF MICHIGAN, INC.
DEPTH
(FEET,MSL)
DISTANCE
(Miles)
A
NORTH
A'
SOUTH
CLAY
SAND & GRAVEL
SHALE & LIMESTONE
SANDSTONE
POND

Table 1:
Monthly Precipitation
Byron Center, MI
12/11/2020

Month	Year (Precipitation in inches)					
	2016	2017	2018	2019	4-yr ave.	2020
January	1.71	3.00	2.02	2.67	2.35	3.22
Feburary	2.73	1.47	4.62	3.23	3.01	0.98
March	3.97	3.80	0.91	2.10	2.70	3.26
April	3.73	5.32	2.91	3.67	3.91	3.98
May	3.44	2.45	5.64	6.04	4.39	4.26
June	1.15	4.88	2.50	4.36	3.22	2.84
July	4.75	1.12	2.20	3.92	3.00	4.75
August	7.97	1.72	5.36	3.41	4.62	2.60
September	2.21	0.66	5.64	7.32	3.96	2.57
October	6.34	9.66	5.97	6.75	7.18	3.17
November	3.16	2.80	2.61	2.94	2.88	2.27
December	2.43	1.64	1.35	3.60	2.26	--
SUM:	43.59	38.52	41.73	50.01	43.46	33.90

Four Year Average Annual Precipiation (2016 - 2019) is 43.5-inches
Precipitation data collected from WeatherUnderground.com from Byron Center, MI

DEQ

Water Well And Pump Record

Completion is required under authority of Part 127 Act 368 PA 1978. Failure to comply is a misdemeanor.

Wellogic

Import ID:

Tax No: | Permit No: | County: Kent | Township: Gaines

Well ID: 41000016558

Town/Range: 05N 11W | Section: 33 | Well Status: Active | WSSN: | Source ID/Well No:

Distance and Direction from Road Intersection: 291 FEET SOUTH OF 100TH 81 FEET EAST OF KALAMAZOO

Elevation:

Latitude: 42.781967

Longitude: -85.624309

Method of Collection: Address Matching-House Number

Well Owner: KATHY VANDERSTIL

Well Address: 10034 KALAMAZOO CALEDONIA, MI 49316

Owner Address: 10034 KALAMAZOO CALEDONIA, MI 49316

Drilling Method: Cable Tool
Well Depth: 79.00 ft. Well Use: Household
Well Type: Replacement Date Completed: 10/21/2004

Casing Type: Steel - galvanized Height: 1.00 ft. above grade
Casing Joint: Threaded & coupled
Casing Fitting: Drive shoe

Diameter: 4.00 in. to 72.00 ft. depth

Borehole: 3.88 in. to 88.00 ft. depth

Pump Installed: Yes Pump Installation Only: No
Pump Installation Date: 10/26/2004 HP: 0.75
Manufacturer: Goulds Pump Type: Submersible
Model Number: 10GS07 Pump Capacity: 17 GPM
Drop Pipe Length: 65.00 ft. Pump Voltage:
Drop Pipe Diameter: 0.75 in. Drilling Record ID:
Draw Down Seal Used: Yes

Pressure Tank Installed: No
Pressure Relief Valve Installed: No

Static Water Level: 52.00 ft. Below Grade
Well Yield Test: Yield Test Method: Plunger
1.00 hrs. at 30 GPM

Formation Description	Thickness	Depth to Bottom
Red Clay Sandy	21.00	21.00
Gravel & Sand	35.00	56.00
Sand W/Gravel	10.00	66.00
Sand Wet/Moist Fine	14.00	80.00
Sand Gravel Clay	2.00	82.00
Gray Clay	6.00	88.00

Screen Installed: Yes Filter Packed: No
Screen Diameter: 3.00 in. Blank:
Screen Material Type: Stainless steel-wire wrapped
Screen Installation Type: Telescoped

Slot	Length	Set Between
7.00	7.00 ft.	72.00 ft. and 79.00 ft.

Fittings: Bottom plug

Well Grouted: Yes Grouting Method: Driven/dry grout

Grouting Material	Bags	Additives	Depth
Bentonite dry granular	1.00	None	0.00 ft. to 72.00 ft.

Geology Remarks:

Wellhead Completion: Pitless adapter, 12 inches above grade

Nearest Source of Possible Contamination:

Type	Distance	Direction
Septic tank	50 ft.	East

Drilling Machine Operator Name: DENNIS AYERS
Employment: Employee

Contractor Type: Water Well Drilling Contractor Reg No: 41-2028
Business Name: Buer Well Drilling
Business Address: 239 E Main, Caledonia, MI, 49316

Abandoned Well Plugged: No
Reason Not Plugged: Owner is plugging well

Water Well Contractor's Certification

This well was drilled under my supervision and this report is true to the best of my knowledge and belief.

Signature of Registered Contractor Date

General Remarks:

Other Remarks: Map Scale:Unknown

EQP-2017 (4/2010) Page 1 of 1 Contractor 10/28/2004 11:55 AM

Water Well And Pump Record

Completion is required under authority of Part 127 Act 368 PA 1978.
Failure to comply is a misdemeanor.

Import ID:

Tax No:	Permit No:
County: Kent	Township: Gaines
Town/Range: 05N 11W	Section: 33
Well Status: Active	WSSN:
Source ID/Well No:	

Well ID: 41000018704

Elevation:
Latitude: 42.776443
Longitude: -85.619704
Method of Collection: Interpolation-Map

Distance and Direction from Road Intersection:
0.75 MILE NORTH 108TH AVENUE AND 0.25 MILE EAST KALAMAZOO AVENUE; 10388 KALAMAZOO AVENUE CALEDONIA MICHIGAN

Well Owner: JOHN ANEMA

Well Address: 10388 KALAMAZOO AVENUE CALEDONIA, MI 49316

Owner Address: 10388 KALAMAZOO AVENUE CALEDONIA, MI 49316

Drilling Method: Rotary
Well Depth: 87.00 ft. **Well Use:** Irrigation
Well Type: New **Date Completed:** 12/3/2005
Casing Type: PVC plastic **Height:**
Casing Joint: Unknown
Casing Fitting: None

Diameter: 5.00 in. to 77.00 ft. depth

Borehole: 8.50 in. to 87.00 ft. depth

Pump Installed: Yes **Pump Installation Only:** No
Pump Installation Date: **HP:** 1.00
Manufacturer: Grundfos **Pump Type:** Submersible
Model Number: 16S10-10 **Pump Capacity:** 16 GPM
Drop Pipe Length: 60.00 ft. **Pump Voltage:**
Drop Pipe Diameter: **Drilling Record ID:**
Draw Down Seal Used: No
Pressure Tank Installed: No
Pressure Relief Valve Installed: No

Static Water Level: 34.00 ft. Below Grade
Well Yield Test: **Yield Test Method:** Air
Pumping level 55.00 ft. after 1.00 hrs. at 60 GPM

Formation Description	Thickness	Depth to Bottom
Brown Clay Sand Gravel	68.00	68.00
Brown Sand & Gravel Water Bearing	19.00	87.00

Screen Installed: Yes **Filter Packed:** Yes
Screen Diameter: 5.00 in **Blank:** 'u
Screen Material Type: PVC-slotted
Screen Installation Type: Attached

Slot	Length	Set Between
15.00	10.00 ft.	77.00 ft. and 87.00 ft.

Fittings: None

Well Grouted: Yes **Grouting Method:** Unknown

Grouting Material	Bags	Additives	Depth
Bentonite slurry	8.00	None	0.00 ft. to 75.00 ft.

Geology Remarks:

Wellhead Completion: Pitless adapter

Drilling Machine Operator Name: DAVE HAZEN
Employment: Employee

Nearest Source of Possible Contamination:

Type	Distance	Direction
Septic tank	300 ft.	West

Contractor Type: Water Well Drilling Contractor **Reg No:** 03-1601
Business Name: KRAAI WELL DRILLING INC
Business Address:

Water Well Contractor's Certification

This well was drilled under my supervision and this report is true to the best of my knowledge and belief.

Signature of Registered Contractor Date

General Remarks:
Other Remarks:

EQP-2017 (4/2010) Page 1 of 1 State of Michigan 1/26/2006 9:04 AM

DEQ

Water Well And Pump Record

Completion is required under authority of Part 127 Act 368 PA 1978.
Failure to comply is a misdemeanor.

Wellogic

Import ID:

Tax No: | Permit No:

Well ID: 41000023726

Elevation:
Latitude: 42.77855
Longitude: -85.61784
Method of Collection: GPS Std Positioning Svc SA Off

County: Kent | Township: Gaines
Town/Range: 05N 11W | Section: 33 | Well Status: Active | WSSN: | Source ID/Well No:

Distance and Direction from Road Intersection:
3/4 MI N 108th Ave & 1/4 MI E Kalamazoo Ave

Well Owner: JOhn Anema

Well Address:
10388 Kalamazoo Ave
Caledonia, MI 49316

Owner Address:
10388 Kalamazoo Ave
Caledonia, MI 49316

Drilling Method: Rotary
Well Depth: 292.00 ft. Well Use: Household
Well Type: Replacement Date Completed: 10/9/2012

Casing Type: PVC plastic Height: 1.00 ft. above grade
Casing Joint: Solvent welded/glued
Casing Fitting: Shale packer/trap

Diameter: 5.00 in. to 200.00 ft. depth SDR: 21.00
5.00 in. to 240.00 ft. depth SDR: 17.00

Borehole: 8.75 in. to 240.00 ft. depth
4.50 in. to 292.00 ft. depth

Pump Installed: Yes Pump Installation Only: No
Pump Installation Date: 10/9/2012 HP: 1.50
Manufacturer: AquaDuty Pump Type: Submersible
Model Number: 20fv15p4-2w230 Pump Capacity: 20 GPM
Drop Pipe Length: 144.00 ft. Pump Voltage: 230
Drop Pipe Diameter: 1.25 in. Drilling Record ID:
Draw Down Seal Used: No

Pressure Tank Installed: Yes
Pressure Tank Type: Diaphragm/bladder
Manufacturer: Well-X-Trol
Model Number: wx-302 Tank Capacity: 30.0 Gallons
Pressure Relief Valve Installed: Yes

Static Water Level: 73.00 ft. Below Grade
Well Yield Test: Yield Test Method: Air
Pumping level 120.00 ft. after 1.00 hrs. at 30 GPM

Screen Installed: No Intake: Bedrock Well

Formation Description	Thickness	Depth to Bottom
Brown Clay & Sand	16.00	16.00
Sand & Gravel	57.00	73.00
Brown Clay	5.00	78.00
Sand & Gravel	14.00	92.00
Gray Clay	128.00	220.00
Shale & Limestone	33.00	253.00
Sandstone	39.00	292.00

Well Grouted: Yes Grouting Method: Grout pipe outside casing

Grouting Material	Bags	Additives	Depth
Bentonite slurry	21.00	None	0.00 ft. to 240.00 ft.

Geology Remarks:

Wellhead Completion: Pitless adapter

Nearest Source of Possible Contamination:

Type	Distance	Direction
Drainfield/Dry well	80 ft.	West

Drilling Machine Operator Name: Mitch Vickery
Employment: Employee

Abandoned Well Plugged: Yes

Casing Diameter: 5 in. Casing Removed: No
Plugging Material: Bentonite chips/pellets
No. of Bags: 20.00 Well Depth: 292 ft.

Contractor Type: Water Well Drilling Contractor Reg No: 03-1601
Business Name: Ronald Kraal Well Drilling
Business Address: 110-124th Avenue, Shelbyville, MI, 49344

Water Well Contractor's Certification

This well/pump was constructed under my supervision and I hereby certify that the work complies with Part 127 Act 368 PA 1978 and the well code.

Signature of Registered Contractor Date

General Remarks: casing broke apart @ 105ft flushed out to bottom, continuely filled in to 105ft. Therefore, top 105ft was plugged with bentonite chips bottom 187ft filled with clay & silt

Other Remarks:

EQP-2017 (4/2010) Page 1 of 1 Contractor 10/11/2012 11:03 AM

5-20 7/2/96

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER WELL AND PUMP RECORD

TAX NO:

PERMIT NO: Prior to 1998 no well permits were needed

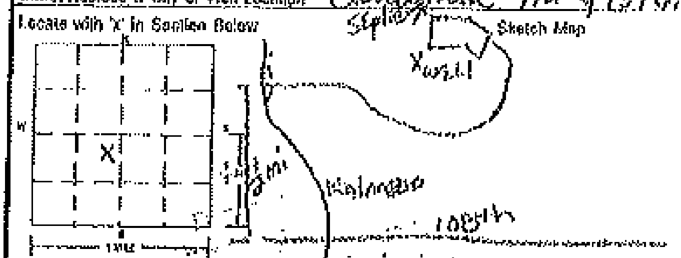
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
Kent	Gaines	NW 1/4 NE 1/4 SW 1/4	33	5 N	11 W

Distance and Direction from Road Intersection: Approx 3/4 mi North of 108th on East side of Kalamazoo, Approx 400 yards East of Kalamazoo, 10393 Kalamazoo S.E.

Street Address & City of Well Location: Caledonia MI 49316

Locate with 'X' in Section Below — Sketch Map



3. OWNER OF WELL: Estate of Cheryl Marcus
Address: 5480 Ramblers Hill, Grand Rapids, MI 49546
Address Same as Well Location: ☐ Yes ☒ No

4. WELL DEPTH: 109 ft. Date Completed: 5/15/97 ☒ New Well ☐ Replacement Well

5. ☐ Cable Tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Auger/Bored ☐ Jetted ☐

6. USE: ☒ Household ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat Pump ☐ Test Well ☐ Type IIb Public ☐

7. CASING: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded ☐ Other
Height: Above/Below Surface: 1 ft.
Diameter: 5 in. to 109 ft. depth; ___ in. to ___ ft. depth
Weight: SDR 21 lbs/ft.
BOREHOLE: Diameter: 8 1/2 in. to 109 ft. depth; ___ in. to ___ ft. depth
☐ Drive Shoe ☐ Shale Packer

2. FORMATION DESCRIPTION

Formation Description	Thickness of Stratum	Depth to Bottom of Stratum
Red Clay, sand	3	3
Little Red Clay, sand	10	13
Gravel, sand	16	29
sand	34	63
Gravel, sand	12	75
sand	5	80
Little Red Clay, sand	6	86
Fine Silty Sand	11	97
sand	12	109

109' SDR 21 5" PVC Well Casing
Bottom 10' w/ 5/16" Holes Drilled / Bypass
5" PVC Cap on Bottom

USE A 2ND SHEET IF NEEDED

8. SCREEN: ☐ Not Installed ☐ Gravel-Packed
Type: Slotted Diameter: 3" Pipe Size
Slot/Gauze: 10 Length: 9'
Set between 99 ft. and 109 ft.
FITTINGS: Top ☒ K-Packer ☐ Bronze Check ☒ Blank Above Screen ___ ft. Other 7' Between Screen

9. STATIC WATER LEVEL: 56 ft. Below Land Surface ☐ Flowing

10. PUMPING LEVEL: Below Land Surface ___ ft. After ___ hrs. Pumping at 50 G.P.M.
☐ Plunger ☐ Bailer ☒ Air ☐ Test Pump

11. WELL HEAD COMPLETION: ☒ Pitless Adapter ☒ 12" Above Grade ☐ Basement Offset ☐ Well House

12. WELL GROUTED? ☐ No ☒ Yes From 0 to 95 ft.
☐ Neat Cement ☒ Bentonite ☐ Other
No. of Bags 5 Additives C-2 Mud

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type ___ Distance ___ ft. Direction N
Type not located Distance ___ ft. Direction ___

14. PUMP: ☐ Not Installed ☐ Pump Installation Only
Manufacturer's Name: Fairbanks
Model Number: 18B 153 HP 1 1/2 Volts 230
Length of Drop Pipe 40-1 1/4" ft. Capacity 20 G.P.M.
TYPE: ☒ Submersible ☐ Jet ☐ Other
PRESSURE TANK: Manufacturer's Name: Champion ex. Tank
Model Number: 17002 Capacity ___ Gallons 26

15. ABANDONED WELL PLUGGED? ☐ Yes ☐ No
Casing Diameter: Not Used Depth ___ ft.
PLUGGING MATERIAL: ☐ Neat Cement ☐ Bentonite Slurry ☐ Cement/Bentonite Slurry ☐ Concrete Grout ☐ Bentonite Chips
No. of Bags ___ Casing Removed? ☐ Yes ☐ No

16. REMARKS: (Elevation, Source of Data, etc.)
50 GPM w/Air
Lemigold… LPPM …

17. DRILLING MACHINE OPERATOR: ☒ Employee ☐ Subcontractor
Name: Douglas Franklin

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Newton's Well Service Inc. 2167
REGISTERED BUSINESS NAME — REGISTRATION NO.
Address: 5508 E Cloverdale Rd Hastings, MI 49058
Signed: Michael T. Keeler Date 5/18/97
AUTHORIZED REPRESENTATIVE

GQ-2-220 9/93

GEOLOGICAL SURVEY COPY

Authority: Act 368 PA 1978. Completion: Required. Penalty: Conviction of a violation of any provision is a misdemeanor.

95 ~ 8606 ft / 75 ft

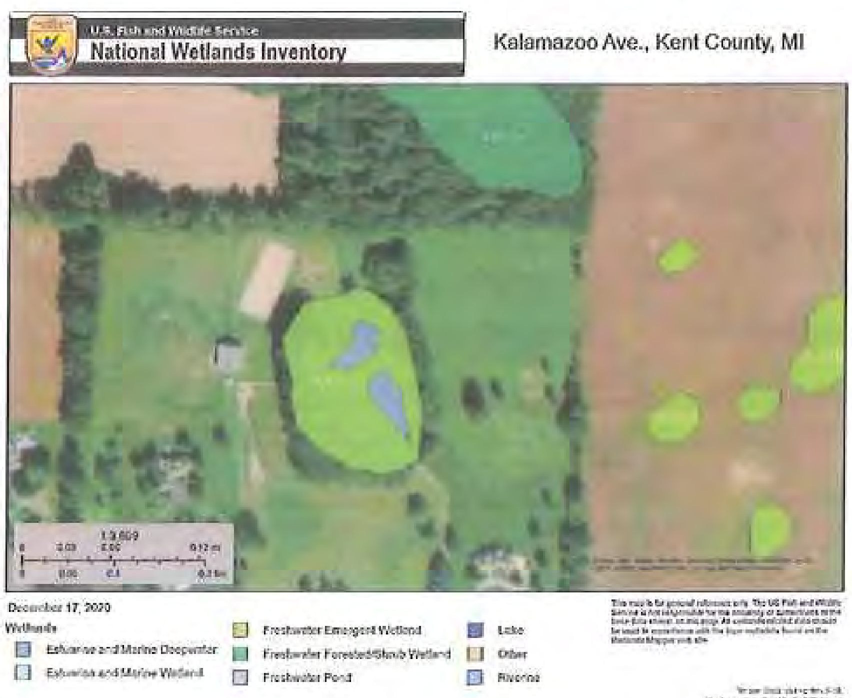
Photograph 1: Domestic well located at 10392 Kalamazoo Avenue looking north-northeast.

Photograph 2: Taken from north end of pond looking south at exposed bottom substrate.

Photograph 3: Looking south-southwest at exposed substrate, dormant vegetation and west bank.

Photograph 4: Looking at southwest top of bank and exposed field tile entering pond.

Map 1: Area Identified as wetlands on the National Wetlands Inventory Maps and Michigan Resource Information System and contain mapped wetland soils (hatched area). Obtained from the EGLE Geowebface Data Base.



Map 2: Pond Area Identified dominantly as a Freshwater Emergent Wetland with isolated freshwater pond areas.

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

HISTORICAL AERIALS

Project Property: Barnaby Property
n/a
Byron Center MI
Requested By: Natural Resources Management, LLC
Order No: 20321400018
Data Completed: December 15,2020

Environmental Risk Information Services
A division of Glacier Media Inc.
1.866.517.5204 I info@erisinfo.com I erisinfo.com

Date	Source	Source Scale	Comments
2020	National Agriculture Information Program	1" to 500'	
2018	National Agriculture Information Program	1" to 500'	
2016	National Agriculture Information Program	1" to 500'	
2014	National Agriculture Information Program	1" to 500'	
2012	National Agriculture Information Program	1" to 500'	
2010	National Agriculture Information Program	1" to 500'	
2009	National Agriculture Information Program	1" to 500'	
2006	National Agriculture Information Program	1" to 500'	
2005	National Agriculture Information Program	1" to 500'	
1999	US Geological Survey	1" to 500'	
1993	National Aerial Photography Program	1" to 500'	
1981	National High Altitude Photography	1" to 500'	
1972	US Geological Survey	1" to 500'	Best Copy Available
1965	US Geological Survey	1" to 500'	Best Copy Available
1957	US Geological Survey	1" to 500'	
1950	Agriculture and Soil Conservation Service	1" to 500'	
1938	Agriculture and Soil Conservation Service	1" to 500'	

Environmental Risk Information Services
A division of Glacier Media Inc.
1.866.517.5204 | info@erisinfo.com | erisinfo.com

Year:2020
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2018
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2016
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2014
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2012
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2010
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2009
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2006
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:2005
Source:NAIP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:1999
Source:USGS
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

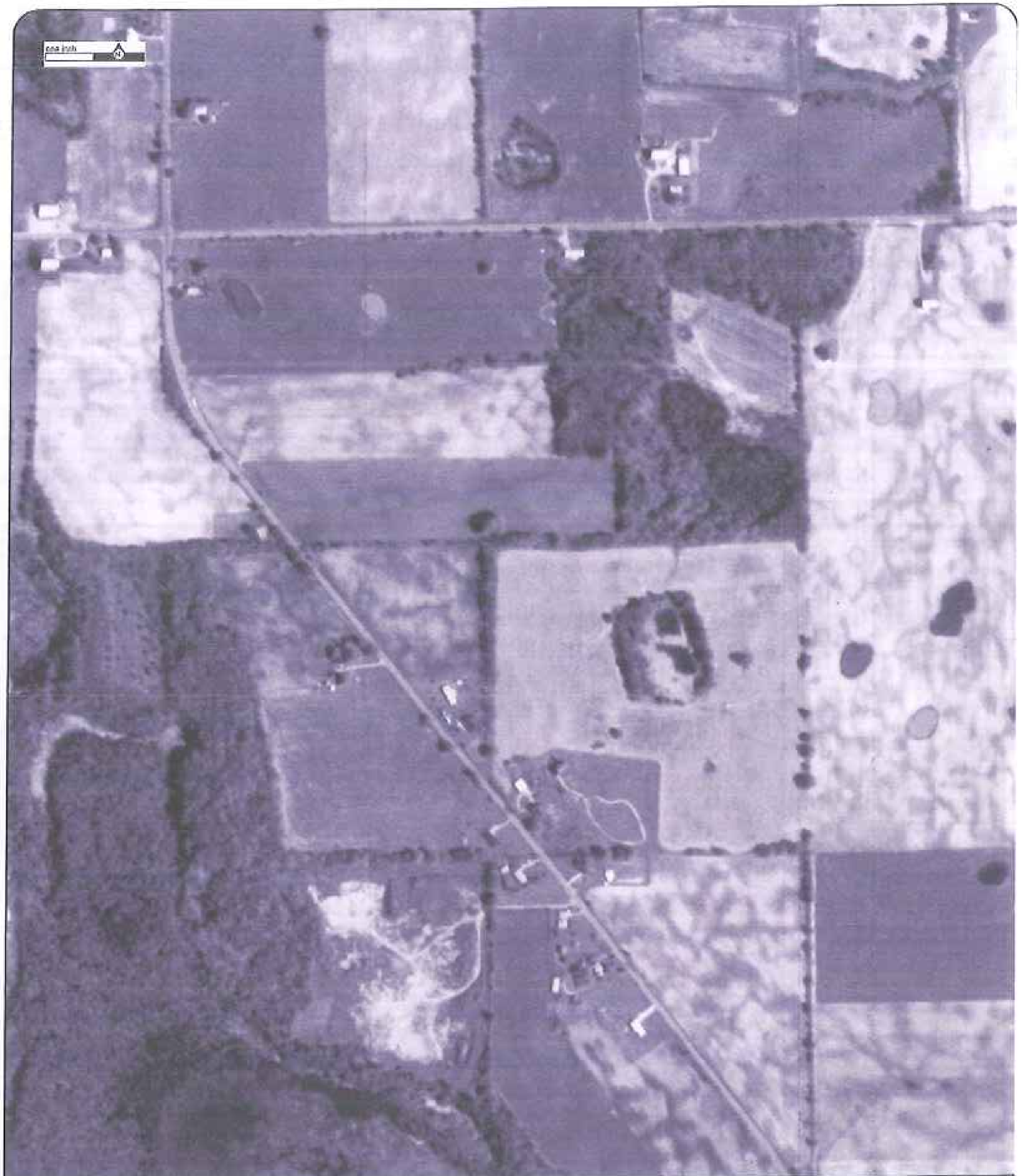
ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:1993
Source:NAPP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES



Year:1981
Source:NHAP
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

Year:1972
Source:USGS
Scale:1" to 500'
Comment:Best Copy Available

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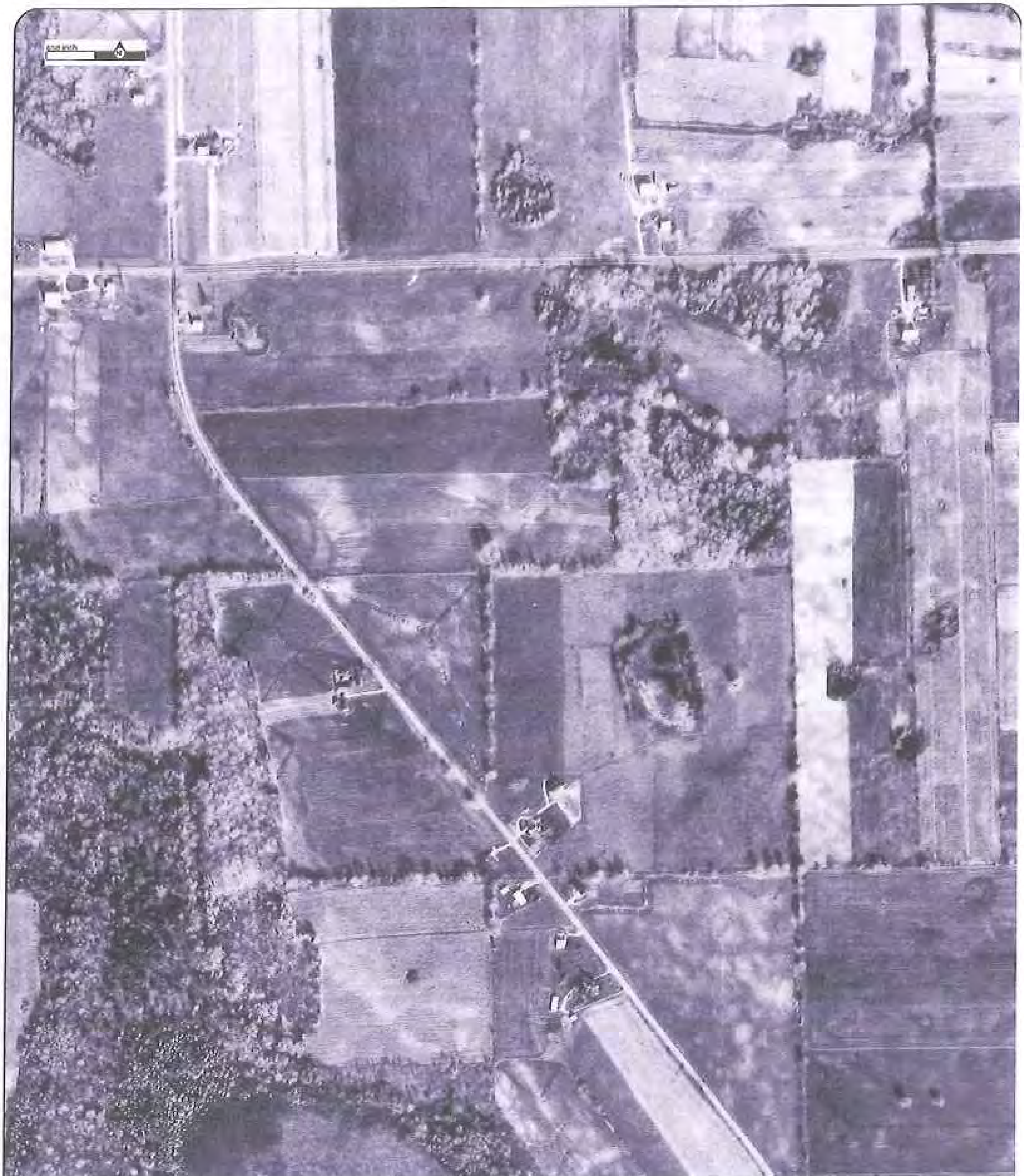
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES



Year:1965
Source:USGS
Scale:1" to 500'
Comment:Best Copy Available

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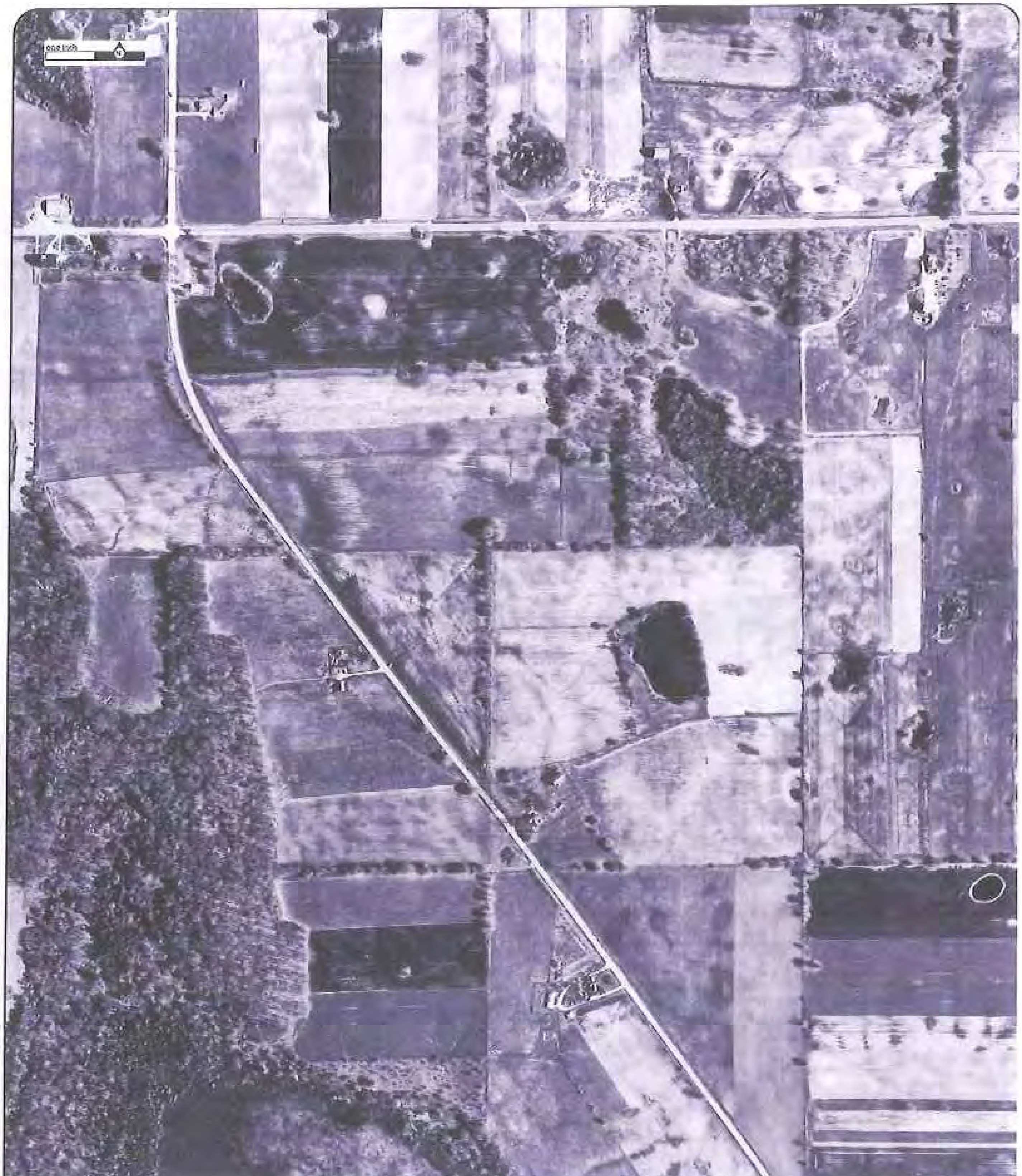
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES



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Source:USGS
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Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

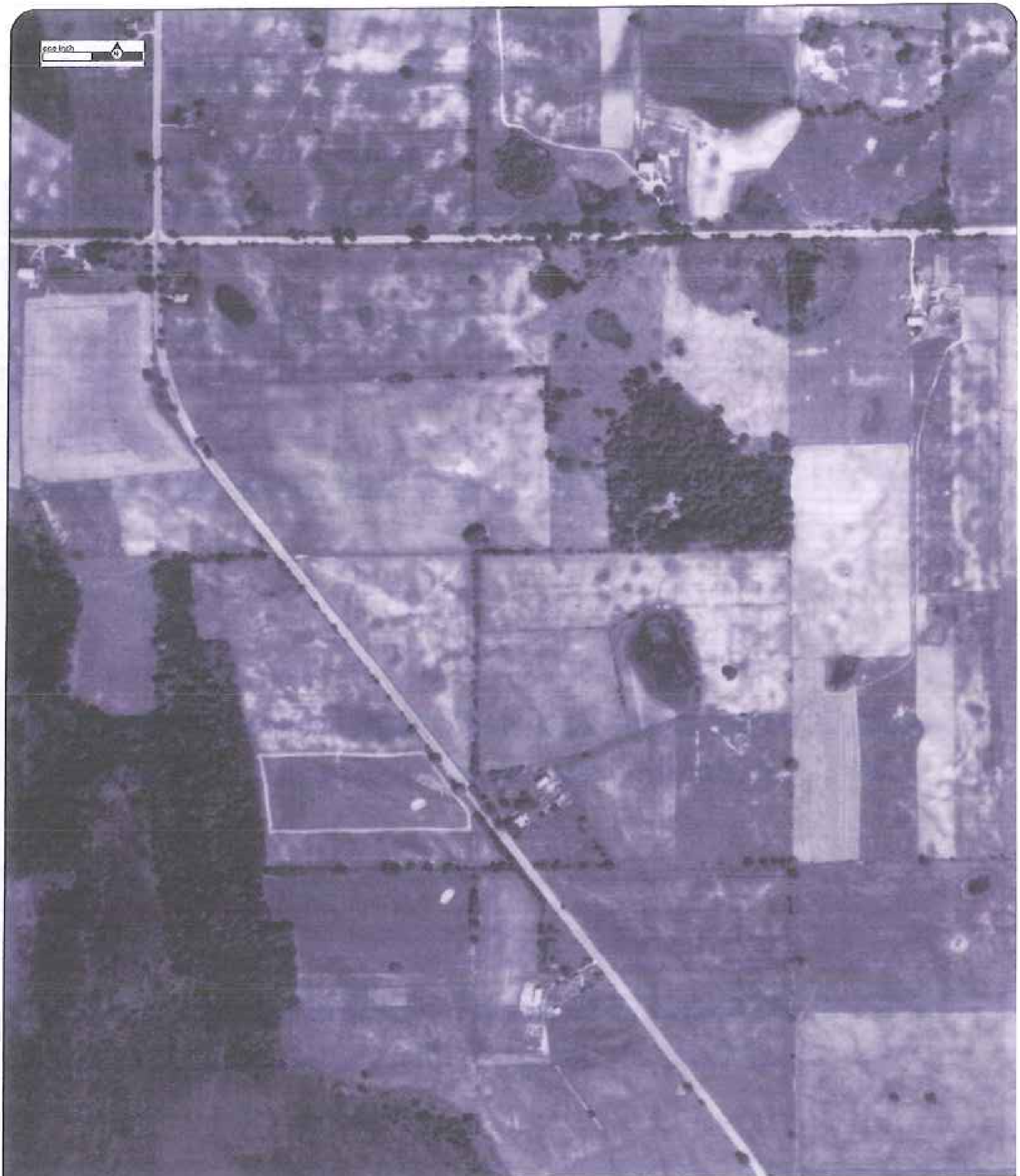
ERIS ENVIRONMENTAL RISK INFORMATION SERVICES

Year:1950
Source:ASCS
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES



Year:1938
Source:ASCS
Scale:1" to 500'
Comment:

Address:n/a, Byron Center, MI
Approx Center:42.77786403/-85.61904311

Order No:20321400018

ERIS
ENVIRONMENTAL RISK INFORMATION SERVICES

ATTACHMENT C

GAINES TOWNSHIP

10392 & 10388 Kalamazoo Avenue

2022 Correspondence and Photographs


December 13, 2022
10388 Kalamazoo Ave.

Gmail Alyssa Grell <agrell@nrmsolution.com>

Fwd: Doretta's pond 3/16/22

1 message

Chip Tokar <ctokar@nrmsolution.com> Thu, Jun 30, 2022 at 10:06 AM
To: Alyssa Grell <agrell@nrmsolution.com>

Please copy these into the file for this site. Doretta Anema

Kind Regards,

Chip Tokar, CPG
Professional Geologist

Natural Resources Management, LLC
7901 Sylvania Avenue
Sylvania, Ohio 43560
(419) 841-3232 ext. 1303 office
(419) 466-9648 mobile
(419) 882-8772 fax
www.NRMsolution.com

---------- Forwarded message ---------
From: **Halloran, Tony W (Michigan Paving and Materials)** <THalloran@mipmc.com>
Date: Thu, Jun 30, 2022 at 9:50 AM
Subject: Fwd: Doretta's pond 3/16/22
To: Chip Tokar <ctokar@nrmsolution.com>, Sniegowski, Dan J (Michigan Paving and Materials) <DSniegowski@mipmc.com>

Tony

Begin forwarded message:

> **From:** "Leach, Steve (Michigan Paving and Materials)" <steve.leach@mipmc.com>
> **Date:** June 30, 2022 at 9:41:54 AM EDT
> **To:** "Halloran, Tony W (Michigan Paving and Materials)" <THalloran@mipmc.com>, "Lenon, Dan (Michigan Paving and Materials)" <DLenon@mipmc.com>
> **Subject: Doretta's pond 3/16/22**

Steve Leach
Plant Manager
Div. 484 – 100th St

Stoneco of Michigan
A CRH COMPANY
900 100th St SE
Byron Center, MI 49315

C +1(269) 838 1217
E steve.leach@mipmc.com

www.stoneco.net

Gmail Alyssa Grell <agrell@nrmsolution.com>

Fwd: Doretta's pond 6/30/22

1 message

Chip Tokar <ctokar@nrmsolution.com> Thu, Jun 30, 2022 at 10:06 AM
To: Alyssa Grell <agrell@nrmsolution.com>

Same here

Kind Regards,

Chip Tokar, CPG
Professional Geologist

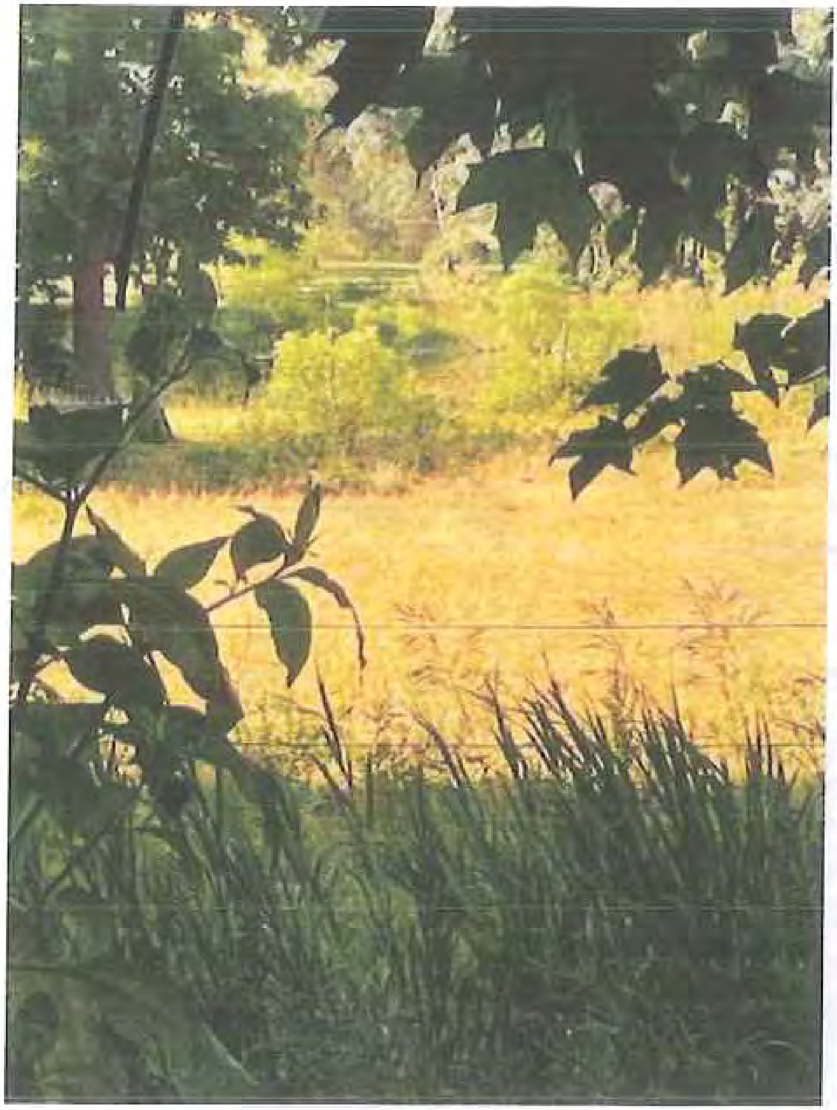
Natural Resources Management, LLC
7901 Sylvania Avenue
Sylvania, Ohio 43560
(419) 841-3232 ext. 1303 office
(419) 466-9848 mobile
(419) 882-8772 fax
www.NRMsolution.com

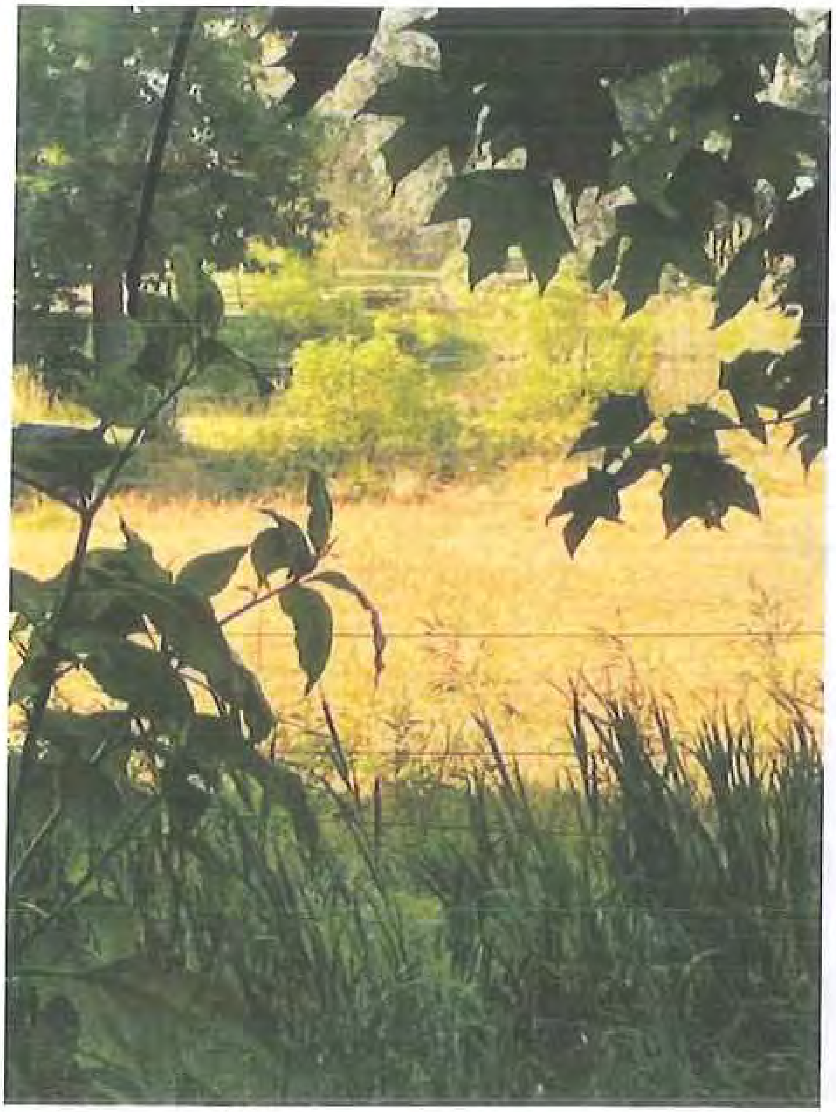
---------- Forwarded message ---------
From: **Halloran, Tony W (Michigan Paving and Materials)** <THalloran@mipmc.com>
Date: Thu, Jun 30, 2022 at 9:50 AM
Subject: Fwd: Doretta's pond 6/30/22
To: Chip Tokar <ctokar@nrmsolution.com>, Sniegowski, Dan J (Michigan Paving and Materials) <DSniegowski@mipmc.com>

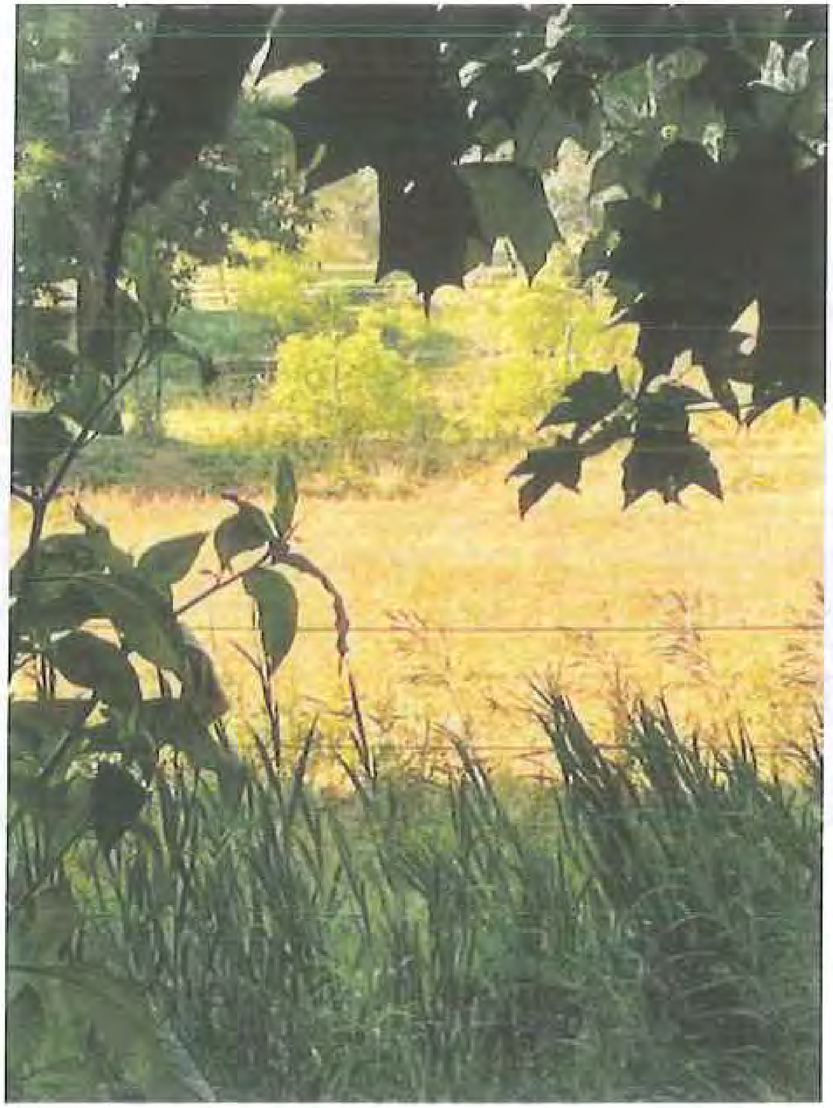
Tony

Begin forwarded message:

> **From:** "Leach, Steve (Michigan Paving and Materials)" <steve.leach@mipmc.com>
> **Date:** June 30, 2022 at 9:42:05 AM EDT
> **To:** "Halloran, Tony W (Michigan Paving and Materials)" <THalloran@mipmc.com>, "Lenon, Dan (Michigan Paving and Materials)" <DLenon@mipmc.com>
> **Subject: Doretta's pond 6/30/22**







Steve Leach
Plant Manager
Div. 484 – 100th St

Stoneco of Michigan
A CRH COMPANY
900 100th St SE
Byron Center, MI 49315

C +1(269) 838 1217
E steve.leach@mipmc.com

www.stoneco.net

ATTACHMENT D

GAINES TOWNSHIP

June 24, 2019 Paula Hitzler Letter

June 14, 2019

Gaines Charter Township
Planning Commission
8555 Kalamazoo Ave. SE
Caledonia, Michigan 49316-8270

To whom it may concern,

My name is Paula Hitzler. I have a Bachelor of Science degree in Animal Science. For the last thirty years, I have been the manager of the Michigan State University Horse Teaching and Research Center. I have over 40 years of professional experience with various breeds of horses, and am very familiar with the sensitivities and behaviors of horses.

In my experience, while all horses, including Friesans, may exhibit some degree of sensitivity to loud and strange noises, horses also tend to acclimate, and become less sensitive to the same types of noises, even loud noises, over time, when exposed to such noises with some degree of regularity. For example, the sound of a gun shot would likely cause a horse who is not used to the sound of a gun shot to become startled. However, horses that are used for hunting or live in close proximity to hunting grounds or shooting ranges, become accustomed to the sound of gun shots, and do not typically exhibit any negative reaction.

In my opinion, horses that have lived in relatively close proximity to daily mining activities for over a year are not likely to exhibit negative reactions to the continuation of those mining activities at the same or similar distances. According the Friesian breed standards, Friesian horses are considered to be a gentle and docile breed. They were bred to be a warhorse due to their lack of volatility and reactivity. I am comfortable, that any breed of horse, with continued noise exposure of a consistent nature can become desensitized to that noise.

Horses also can be sensitive to dust. However, in my experience, that sensitivity tends to be similar to that of a human, such that at levels that would not cause an unreasonable degree of discomfort to human, I would not expect horses, including Friesians, to exhibit any elevated level of discomfort.

Paula Hitzler

31326700.2

ATTACHMENT E

Compilation and Evaluation of Ambient Respirable Crystalline Silica Air Quality Data near Sand Quarries and Processing Facilities

Atmosphere 2021

atmosphere

Article

Compilation and Evaluation of Ambient Respirable Crystalline Silica Air Quality Data near Sand Quarries and Processing Facilities

John Richards * and Todd Brozell

Air Control Techniques, P.C., 301 East Durham Road, Cary, NC 27513, USA; todd.brozell@aircontroltechniques.com
* Correspondence: john.richards@aircontroltechniques.com; Tel.: +1-919-460-7811

Abstract: Ambient respirable crystalline silica air quality is of concern to many communities near mineral processing facilities and to regulatory agencies serving these communities. Accurate air quality data are needed to compare measured respirable crystalline silica concentrations at the fencelines of mineral processing facilities with the published health effect guideline published by the California Office of Health Hazard Assessment (OEHHA). This article is a compilation and evaluation of air quality studies around a diverse set of nineteen sand producing facilities. The respirable crystalline silica air quality data compiled by Air Control Techniques, P.C. and most of the data compiled by other researchers cited in this article have been measured using EPA Reference Method samplers adjusted for respirable crystalline silica sampling and NIOSH Method 7500 X-ray diffraction analyses. The authors conclude that (1) the ambient concentrations in the diverse set of mineral processing facilities were consistently lower than the 3.0 microgram per cubic meter chronic reference exposure level (REL) adopted by OEHHA, (2) upwind-to-downwind fenceline concentration differences were small, and (3) the fenceline t concentrations were often at background concentration levels. The authors recommend additional sampling studies to better characterize background concentrations of ambient respirable crystalline silica.

Keywords: ambient respirable crystalline silica; air quality; health effects; fenceline sampling; sand production; ambient air sampling; mineral industries; community air quality

check for updates

Citation: Richards, J.; Brozell, T. Compilation and Evaluation of Ambient Respirable Crystalline Silica Air Quality Data near Sand Quarries and Processing Facilities. *Atmosphere* **2021**, *12*, 903. https://doi.org/10.3390/atmos12070903

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Accepted: 28 June 2021
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1. Introduction

There have been significant community concerns expressed regarding respirable crystalline silica particulate matter air quality in the vicinity of sand quarries, sand trans-load operations, sand processing facilities, and other mineral processing facilities. Prior to 2005, there were no ambient air quality standards or guidelines to evaluate possible health effects of ambient respirable crystalline silica. In 2005, the California Office of Environmental Health Hazards Assessment (OEHHA) published a chronic reference exposure limit of 3 micrograms per cubic meter for ambient respirable crystalline silica [1]. OEHHA based this guideline on industrial hygiene health effects studies conducted with PM_4 crystalline silica personal occupational exposure samplers. In both the occupational hygiene studies and the air quality studies addressed in this article, PM_4 is defined as particulate matter having aerodynamic sizes equal to or less than 4 micrometers as measured in accordance with NIOSH Method 0600 or equivalent procedures.

OEHHA set their REL at a very low concentration of 3 micrograms per cubic meter ($\mu g/m^3$) to protect sensitive individuals subject to exposure to respirable crystalline silica in ambient air. The NIOSH 0600 samplers used to assess exposure to the much higher concentrations in occupational work areas are not capable of accurate measurement at this low REL concentration set for ambient air exposure. The NIOSH 0600 samplers have low sample flow rates and are operated only for 8 to 10 h work shifts. To increase measurement sensitivity to the low OEHHA REL level, Richards and Brozell [2] and other researchers have adapted EPA $PM_{2.5}$ Reference Method samplers meeting the requirements of 40 CFR Part 50, Appendix L requirements, which operate at much higher sample flow rates and operate for 24 h periods. The air flow rates in these modified $PM_{2.5}$ samplers were adjusted to (1) provide a 50% cut size of 4 micrometers and (2) maintain a size-efficiency curve closely matching the NIOSH 0600 personal samplers. To provide consistency with the crystalline silica data used by OEHHA, the filter samples from the flow rate adjusted $PM_{2.5}$ samplers were analyzed using X-ray diffraction in accordance with NIOSH Method 7500. With this combined sampling and filter analytical approach, the lower limit of quantification for crystalline silica was 0.31 $\mu g/m^3$—a value well below the OEHHA REL of 3.0 $\mu g/m^3$.

Richards et al. [3] used this newly developed ambient respirable crystalline silica measurement method in 2006 to conduct short-term studies at two facilities in California. The California Air Resources Board and the South Coast Air Quality Management District (Los Angeles area) used a similar sampling method in several short-term studies [4,5]. All of these short-term California studies indicated very low ambient respirable crystalline silica concentrations.

In 2012, Richards and Brozell [6] initiated three-year sampling programs at three frac sand quarries and one sand processing facility located in Wisconsin. Richards and Brozell [7] also conducted tests at six other frac sand facilities in Wisconsin and Minnesota [8]. All of the average ambient respirable crystalline silica concentrations measured in these studies were below the OEHHA REL. The upwind-to-downwind concentrations measured in these sampling programs indicated very little contribution from the sources monitored. The majority of the 24 h concentration measurements summarized in Wisconsin and Minnesota tests [6,7] were below the limit of quantification of 0.31 $\mu g/m^3$ and were close to background concentration levels. The Minnesota Pollution Control Agency (MPCA) [8–11] published short-term ambient respirable crystalline silica monitoring programs at several sand quarries and a trans-load facility. Despite using different samplers, the MPCA data were similar to those of Richards and Brozell [6,7] and the California-based studies [3–5] conducted earlier. Peters et al. [12] published ambient monitoring data at seventeen residences located within 800 m of frac sand quarries in western Wisconsin and found ambient respirable crystalline silica concentrations below the OEHHA REL in samples obtained during 48 h sampling periods.

To provide a more comprehensive set of air quality data, this paper summarizes ambient respirable crystalline silica concentration measurements over long time periods at numerous additional mineral facilities having diverse process equipment, production capacities, and surrounding terrain features that could potentially affect dispersion of fugitive dust emissions. This much larger and diverse data set created by the addition of recently completed ambient monitoring programs [13] provides an improved basis for evaluating respirable crystalline silica air quality in communities near mineral processing facilities. Acronyms and definitions of terms used are listed at the end of this article.

2. Ambient PM_4 Crystalline Silica Measurement

2.1. Facilities

The facilities sampled had a wide variety of production rates, mineral characteristics, plant process equipment, and surrounding terrain features. A summary of their diverse characteristics is provided in Table 1. Details concerning the characteristics of the facilities, process types, terrain characteristics, sampling location arrangements, and other factors potentially affecting the measured ambient PM_4 respirable crystalline silica are provided in references [3–13].

Table 1. Characteristics of the facilities.

Location	Type	Production Rate	Product	Topography and Community Characteristics	Ref.
Wedron, IL	Quarry and Processing	High	Frac Sand	Small hills and a river valley, located close to a small community	[13]
Menomonie, WI	Quarry and Processing	Moderate	Frac Sand	Very small hills, rural area	[13]
Kasota. MN	Quarry and Processing	High	Frac Sand	Flat plain, lightly vegetated, close to town of Kasota, Minnesota	[13]
Sparta, WI	Quarry and Processing	High	Frac Sand	Small hills, lightly vegetated. adjacent to a residential community	[13]
Berkeley Springs, WV	Quarry and Processing	Moderate	Milled Sand	Mountain valley	[13]
Chippewa Falls, WI	Processing	High	Frac Sand	Flat terrain, near residential area	[6]
DS Mine, WI	Quarry	Moderate	Frac Sand	Rolling hills, rural agricultural area	[6]
S&S Mine, WI	Quarry	Moderate	Frac Sand	Rolling hills, rural agricultural area	[6]
DD Mine, WI	Quarry	Moderate	Frac Sand	Rolling hills, rural agricultural area	[6]
Maiden Rock, WI	Quarry and Processing	Large	Frac Sand	Steep river valley	[7]
Cataract Green, WI	Greenfield	None	N/A	Rolling hills, rural agricultural area	[7]
Cataract Green, WI	Quarry and Processing	Moderate	Frac Sand	Rolling hills, rural agricultural area	[14]
Downing, WI	Quarry	Moderate	Frac Sand	Rolling hills, rural agricultural area	[7]
Jordan Sands, MN	Quarry and Processing	Large	Frac Sand	Rolling hills, rural agricultural area	[8]
Winona, MN	Trans-Load	N/A	Frac Sand	Community	[10]
Stanton, MN	Greenfield	None	N/A	Rural	[10]
Shakopee, MN	Quarry and Processing	Moderate	Frac Sand	Rolling hills, rural agricultural area	[9]
Titan, MN	Trans-Load	Moderate	Frac Sand	Rolling hills, rural agricultural area	[10]
Duarte, CA	Quarry and Processing	Large	Frac Sand	Flat terrain at base of mountains	[4,5]
San Diego, CA	Quarry and Processing	Large	Construction Sand	Flat terrain	[3]
Vernalis, CA	Processing	Large	Construction Sand	Flat terrain	[3]

Most of the studies had sets of samplers arranged in an upwind-downwind configuration at the fencelines of the facilities. Some of the sampling programs used collocated samplers at the downwind sites to evaluate the precision of the ambient PM_4 crystalline silica 24 h average concentration measurements.

Many of the sampling programs operated samplers on either a once-every-three day or once-every six-day schedule. The sampling programs that included collocated samplers operated those collocated samplers on a once-every twelfth -day schedule. Essentially all the sampling programs operated on the calendar day-specific sampling schedule specified by EPA for each calendar year. Accordingly, the day-by-day respirable crystalline silica concentration variations could be compared with air quality variations measured on the same days by the state agency and EPA $PM_{2.5}$ and PM_{10} samplers located near the sampling locations.

2.2. Sampling and Analytical Procedures

The characteristics and study periods of the various sampling programs evaluated in this paper are summarized in Table 2.

Table 2. Sampling program characteristics.

Figure	Type and Number of PM Samplers	Sampling Frequency	Sampling Period (Month/Year)	Sampler Operator	Ref.
Wedron	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 3	2/15 to 3/16	Contractor	[13]
Menomonie	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 6	7/14 to 11/15	Employee	[13]
Kasota	1 PM_4 CS Partisol 2000*i*, Locations 1, 2, and 3	1 day in 6	3/14 to 4/19	Employees	[13]
Sparta	1 PM_4 CS, Partisol 2000*i* downwind	1 day in 6	9/12 to 2/20	Employees	[13]
Berkeley Springs	2 PM_4 CS, Partisol 2000*i* downwind 1 PM4 CS, Partisol 2000*i* upwind	1 day in 6	7/12 to 7/13	Employee	[13]
Chippewa Falls	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 3	8/12 to 12/14	Contractor	[6]
DS Mine	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 3	8/12 to 12/14	Contractor	[6]
S&S Mine	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 3	8/12 to 12/14	Contractor	[6]
DD Mine	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 3	11/12 to 12/14	Contractor	[6]
Maiden Rock	1 PM_4 CS, Partisol 2000*i*, Loc. 1 1 PM_4 CS, Partisol 2000*i*, Loc. 2 1 PM_4 CS Partisol 2000*i*, Loc. 3	1 day in 3	3/13 to 3/14	Contractor, resident	[7]
Cataract Green	None	N/A	9/12 to 12/13	Contractor	[7]
Cataract Green	1 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 6	12/13 to	Contractor	[7]
Downing	2 PM_4 CS, Partisol 2000*i* downwind 1 PM_4 CS, Partisol 2000*i* upwind	1 day in 6	8/12 to 9/13	Contractor	[7]
Jordan Sands	1 PM_4 CS, Partisol 2000*i*, downwind 1 PM_4 CS Partisol 2000*i*, upwind	1 day in 6	9/14 to 12/16	Employee contractor	[8]
Winona	1 PQ200 CS downwind	1 day in 6	2/14 to 12/14	MPCA	[9]
Stanton	None	1 day in 6	1/14 to 12/14	MPCA	[9]
Shakopee	Unknown	1 day in 12	8/12–12/13	Employee	[11]
Titan	Unknown	1 day in 6	9/13 to 9/15	Employee	[12]
Duarte	1 PM_4 CS, Unknown downwind	1 day in 6	5/6 to 9/6	SCAQMD	[4,5]
San Diego	2 PM_4 CS, Partisol 2000*i*	N/A	9/6	ACTPC	[3]
Vernalis	2 PM_4 CS, Partisol 2000*i*	N/A	9/6	ACTPC	[3]

Most of the sampling programs measured PM_4 respirable crystalline silica data using Partisol 2000*i* samplers meeting the performance requirements of 40 CFR Part 50, Appendix L and adjusted to provide a cut size of 4 micrometers rather than 2.5 micrometers (All particulate matter size data are expressed as aerodynamic diameters). These PM_4 sampling procedures were developed by Richards and Brozell in 2005 [2] in response to the publication of the OEHHA REL [1]. The South Coast Air Quality Management District developed and used a similar approach [4,5]. The crystalline silica samples were analyzed using NIOSH reference method 7500 [14].

The quality assurance procedures used for sampling PM_4 respirable crystalline silica were based on EPA specified quality assurance procedures for $PM_{2.5}$ sampling [15]. These quality assurance procedures included routine sampler audits, independent audits of the samplers, blank filter analyses, collocated sampler-primary sampler precision analyses, and detailed laboratory procedures. The Wisconsin Department of Natural Resources (WDNR) and the Minnesota Pollution Control Agency (MPCA) reviewed the sampling protocols for several of the studies and audited the samplers in several of the studies. EPA reviewed the sampling procedures and data for a sampling program at a facility in Illinois.

2.3. Crystalline Silica Characteristics

Quartz, cristobalite, and tridymite forms of crystalline silica were included in the scope of the sampling programs. Of these three forms—quartz is by far the most common. Quartz is the second most common mineral in the Earth's crust and is present in most rocks and soils in most geographical locations.

All three forms of crystalline silica are especially hard and resist size reduction down to particles with an aerodynamic particle size of 4 micrometers. Ambient air concentrations are low due to the low formation rate of particles that can be entrained in the wind. Accordingly, the sampling and analytical procedures used in these air quality sampling studies had to have the capabilities of measuring low ambient mass concentrations and accurately quantifying small amounts on the sampled filters.

The PM_4 particulate matter samples were collected on PVC filters rather than the Telfon®filters used for $PM_{2.5}$ and PM_{10} sampling. These filter samples were analyzed at qualified laboratories using NIOSH Method 7500 X-ray diffraction. This is the method most often used for industrial hygiene PM_4 crystalline silica sampling. The limit of quantification using the sample flowrate modified Partisol 2000*i* samplers with NIOSH Method 7500 was 0.31 micrograms per cubic meter of crystalline silica. All three common forms of crystalline silica were detectable using this sampling and analytical approach.

3. Ambient Air Concentrations Data, Recently Tested Facilities

The PM_4 respirable crystalline silica data compiled in the various sampling studies described above are summarized in Table 3.

Table 3. Ambient PM_4 respirable crystalline silica concentration data.

Facility	Sampling Location	Sampling Period (Month/Year)	Number of 24 h Samples	Avg. with ND = LOQ/$\sqrt{2}$ μg/m^3	Max., μg/m^3	UCL95%, Average with ND = LOQ/$\sqrt{2}$
Kasota	470th St.	3/14 to 4/16	135	0.46	4.89	0.54
	480th St.	4/16 to 4/19	182	0.47	11.58	0.58
	Town	3/14 to 4/19	307	0.33	2.24	0.35
	Prairie	3/14–4/19	297	0.40	5.05	0.45
Menomonie	North, downwind	7/14 to 7/15	62	0.28	0.81	0.31
	South, upwind	7/14 to 7/15	60	0.24	0.50	0.31
Wedron	North, downwind	2/15 to 3/15	130	1.56	10.1	1.85
	South, upwind	2/15 to 3/15	127	0.25	0.69	0.27
Sparta	One, downwind	1/15 to 2/20	344	0.22	1.81	0.32
Berkeley Springs	One, upwind	7/12 to 7/13	61	0.38	1.91	0.40
	Two, downwind	7/12 to 7/13	60	1.73	5.80	2.05
Cataract Green (background site)	One, upwind	12/13 to 10/15	102	0.23	0.75	0.24
	Two, downwind	12/13 to 10/15	108	0.23	0.56	0.24
Chippewa Falls	North, downwind	8/12 to 12/13	155	0.33 [1]	1.44	0.36
	Southwest, upwind	8/12 to 12/13	153	0.26 [1]	1.44	0.27
	North, downwind	1/14 to 12/14	118	0.31 [1]	1.13	0.34
	Southwest, upwind	1/14 to 12/14	116	0.22 [1]	0.44	0.23

Table 3. *Cont.*

Facility	Sampling Location	Sampling Period (Month/Year)	Number of 24 h Samples	Avg. with ND = LOQ/ $\sqrt{2}$ µg/m³	Max., µg/m³	UCL95%, Average with ND = LOQ/$\sqrt{2}$
DS Mine	Upwind	8/12 to 12/13	151	0.24 [1]	0.63	0.24
	Downwind	8/12 to 12/13	150	0.26 [1]	1.10	0.27
	Upwind	1/14 to 12/14	121	0.24e [1]	0.88	0.24
	Downwind	1/14 to 12/14	121	0.23 [1]	1.38	0.23
S&S Mine	Upwind	8/12 to 12/13	149	0.30 [1]	2.13	0.33
	Downwind	8/12 to 12/13	149	0.24 [1]	0.60	0.25
	Upwind	1/14 to 12/14	118	0.27 [1]	0.88	0.29
	Downwind	1/14 to 12/14	117	0.24 [1]	0.75	0.26
DD Mine	Upwind	11/12 to12/13	139	0.25 [1]	1.31	0.27
	Downwind	11/12 to 12/13	136	0.25 [1]	0.69	0.26
	Upwind	1/14 to 12/14	118	0.22 [1]	0.50	0.23
	Downwind	1/14 to 12/14	117	0.23 [1]	0.56	0.23
Maiden Rock	Town	3/13 to3/14	124	0.25	0.7	0.27
	Southwest	3/13 to 3/14	125	0.55	2.2	0.61
	Northeast	3/13 to 3/14	124	0.28	2.4	0.34
Cataract Green	Background	9/12 to 12/13	60	0.26	0.81	0.27
Downing	Southwest	8/12 to 9/13	62	0.29	1.3	0.33
	Southeast	8/12 to 9/13	63	0.27	0.88	0.30
Jordan Sands	Upwind	8/14 to 8/17	141	0.20 [6]	1.0	0.25
	Downwind	8/14 to 8/17	165	0.245 [6]	0.90	0.30
Winona	Single [2,3]	2/4 to 12/14	48	0.23 [7]	0.40	0.24
Stanton	Single [2,3]	2/14 to 12/14	55	0.27 [7]	0.80	0.30
Titan	Single [3,4]	9/13 to 9/15	81	1.28 [4]	6.0	ND [8]
Shakopee	Single [2,3]	8/2 to 12/13	44	0.75 [5]	1.80	ND [8]
Duarte	Single	5/6 to 9/7	19	0.60	1.10	0.63
Vernalis	Upwind	9/6	3	1.10	1.30	N/A
	Downwind	9/6	3	0.77	1.10	N/A
San Diego	Upwind	9/6	3	2.0	2.80	N/A
	Downwind	9/6	3	0.57	0.90	N/A
Total Number of 24 h Samples			5226			

[1] Values below the LOQ in the studies conducted at these plants were calculated as the LOQ/2 rather than the LOQ/$\sqrt{2}$ in the other studies included in Table 3. The data shown in Table 3 have been adjusted to values calculated as LOQ/$\sqrt{2}$. [2] All data for these sources have been estimated from bar charts published on the MPCA website; [3] There were long interruptions in this sampling program; [4] The LOQ for the Titan data have been assumed to be 1.3 µg/m³; [5] The LOQ for the Shakopee data have been assumed to be 1.0 µg/m³; [6] The LOQ for the Jordan Sands is 0.31 µg/m³; [7] The LOQ for the Winona and Stanton data have been assumed to be 0.31 µg/m³; [8] UCL95% confidence values of the arithmetic mean were not calculated due to difficulty in interpreting available data.

The ambient PM4 respirable crystalline silica datasets had numerous values below the 0.31 ug/m³ limit of quantification of the sampling/analytical method in most of the sampling programs summarized in Table 3. The averages have been tabulated using non-detect values expressed as the limit of quantification (LOQ) divided by the square root of 2. The latter approach is based on the method recommended by Hornung [16]. The use of the LOQ/$\sqrt{2}$ to express the non-detect values is more reasonable than assigning zero values to the non-detects considering that crystalline silica is a ubiquitous material in most rocks and soils in most locations. Some very small amount of crystalline silica is almost certainly present in most ambient air samples. However, with this procedure for expressing non-detect values, the minimum respirable crystalline silica concentration that can be reported is 0.22 μg/m^3.

The Titan [10] and Shakopee Sands [11] sampling programs conducted in Minnesota had high quantification limits of 1.0 to 1.3 μg/m^3. These LOQ values are three to four times higher than the LOQ values in most of the sampling programs such as [3–7,14]. Expressing the numerous non-detect values in these datasets as the LOQ/$\sqrt{2}$ increased the UCL95% average values in these sampling programs.

4. Discussion

All of the facilities had UCL95% arithmetic average concentrations ranging from 0.22 to 1.73 μg/m^3 (ND = LOQ$\sqrt{2}$) regardless of facility's production rates, topography, and/or climate conditions. The highest PM4 respirable crystalline silica levels were found at Wedron and Berkeley Springs, two of the largest facilities addressed in this article. However, facility size may not have been the dominant factor influencing the observed concentrations. The Wedron downwind sampling location was especially close to the plant processing equipment and plant buildings. Accordingly, the Wedron data may not be representative of fenceline concentrations in most mineral processing facilities. The Berkeley Springs plant produced a finely milled silica product using a large number of grinding circuits in series. The product mass median size distribution was very small. Furthermore, the Berkeley Springs processing plant and quarry are located in a narrow mountain valley, and the only location with available electrical power to operate the samplers was near the processing area and far from the downwind fencelines. Even considering these atypical conditions favoring higher reported ambient concentrations, these two facilities had average concentrations well below the OEHHA REL of 3.0 μg/m^3.

Conversely, the very low ambient respirable crystalline silica concentrations observed at the Cataract Green facility may not be representative of most quarries or processing plants. This plant is located in a rural area without nearby agricultural operations. It was initially chosen as a background, greenfield site to provide information concerning regional background levels. The measured concentrations did not significantly increase after a moderately sized quarry was installed.

The upwind–downwind concentration differences averaged over the study periods were small except at the Wedron and Berkeley Springs facilities. The upwind–downwind differences are summarized in Table 4.

Table 4. Upwind–downwind concentration differences.

Facility	Upwind PM_4 Crystalline Silica Concentration, μg/m^3	Downwind PM_4 Crystalline Silica Concentration, μg/m^3	Difference, μg/m^3
Menomonie	0.31	0.31	0.00
Wedron	0.27	1.85	1.58
Berkeley Springs	0.40	2.05	1.65
Cataract Green	0.24	0.30	0.06
Chippewa Falls 2012–2013	0.26	0.33	0.07
Chippewa Falls 2014	0.22	0.31	0.09
DS mine 2012–2013	0.24	0.26	0.02
DS Mine 2012–2013	0.24	0.23	−0.01
S&S mine 2012–2013	0.30	0.24	−0.06
S&S mine 2012–2013	0.27	0.24	−0.03
DD Mine-2012–2013	0.25	0.25	0.00
DD Mine 2014	0.22	0.23	0.01
Downing	0.30	0.33	0.03
Jordan Sands	0.25	0.30	0.05

The highest maximum single day 24 h average concentration of 11.58 μg/m^3 was observed at Wedron. Maximum concentrations at the upwind sampling location in some of the studies were greater than 2 μg/m^3—probably due to the fugitive dust emissions from nearby agricultural operations.

The ambient PM_4 respirable crystalline silica data measured in all the sampling programs were quite similar. All of the UCL95% confidence levels for the arithmetic means were well below the healthbased OEHHA chronic exposure REL.

Climate conditions do not appear to a major factor in the differences in the UCL95% levels measured. For example, the PM_4 respirable crystalline silica UCL95% levels measured in essentially all the sampling programs in the midwestern U.S. with moderate rainfall levels were similar to the 0.4 to 1.1 μg/m^3 concentrations measured over a summertime four-month period by the South Coast Air Management District in the semi-arid Duarte, California [4,5] area.

The Duarte study conducted by the South Coast Air Quality Management District (Los Angeles area) is also of interest because the sampling location was on the grounds of a school surrounded on three sides by nearby large quarries and processing plants. The sampling location was also close to two major interstate highways with near-constant heavy traffic. A usually dry creek bed was on one side of the school. The daily off-shore and down-valley winds created by the nearby Pacific Ocean and the San Gabriel mountains usually generated air flow passing over at least one of the mineral industry sites, the interstate highways, and/or the dry creek bed toward the school sampling location. Despite these conditions, the ambient respirable crystalline silica conditions were only slightly higher than those measured in most of the midwestern U.S. sampling sites and were well below the California OEHHA chronic exposure REL.

The probable influence of agricultural operations on ambient concentrations is suggested by the differences in the Winona study [9] results and those from Stanton [10]. The Winona study consisted of a single PQA-200 instrument located on the roof of a YMCA building near a trans loading operation. During the 10-month study, two of the 48 samples obtained at Winona had greater than the detectable concentration limit of 0.31 μg/m^3. The concentrations at Winona were similar to other facilities discussed earlier in this article. The PM_4 respirable crystalline silica concentrations at Stanton [9] were slightly higher than at Winona despite the lack of a nearby mineral processing facility. The slightly elevated concentrations observed in this 10-month study at Stanton were probably due to fugitive dust emissions from agricultural operations. Similar agricultural operation impacts were observed at the DS mine study in Wisconsin.

The influence of the crystalline silica content of the material being handled does not appear to be large in this dataset. The crystalline silica levels of the construction sand handled in the San Diego and Vernalis [3] facilities sampled in California were lower than the >95% levels of crystalline silica in the frac sand-oriented sampling programs in the numerous studies in the upper midwestern U.S. However, the ambient PM_4 respirable crystalline silica levels were higher than in the frac sand related studies. The probable impact of nearby unpaved roads and agricultural operations in the California studies appears to overcome any differences due to mineral material crystalline silica content.

The sampling programs at the Titan trans-load facility [10] and at Shakopee Sands [11] used a sampler different from the Partisol 2000*i* samplers used in most of the studies discussed earlier. The estimated limit of quantification values ranged from 1.0 μg/m^3 at Shakopee to 1.3 μg/m^3 at Titan. These LOQ values are three to four times higher than those used in the studies conducted by Richards and Brozell [3,6,7,13] and by Jordan Sands [8]. Due to the high LOQ values at Titan and Shakopee, the average values and the UCL95% values are artificially inflated. Furthermore, the MPCA report concerning Titan indicated frequent quality assurance issues with the sampler flow rates.

Shiraki and Holmen [17] measured PM_{10} crystalline silica at a sand and gravel facility located near the Tracy, California airport. The authors did not detect respirable crystalline silica in the $PM_{2.5}$ particulate matter fractions—a conclusion that suggests low concentrations in the PM_4 respirable fraction. The PM_{10} crystalline silica data reported in this study cannot be accurately equated to the PM_4 respirable size fraction. Furthermore, the sand

and gravel facility sampled was almost completely surrounded by other sand and gravel producing facilities, the immediately adjacent Tracy airport, and nearby active agricultural operations. These adjacent sources may have influenced the measured PM_{10} crystalline silica levels.

Peters et al. [12] measured ambient PM_4 respirable crystalline silica at seventeen residences within 800 m of the fencelines of quarries and other mineral processing facilities in Western Wisconsin. The measured PM_4 crystalline silica levels were above the detection limit of 0.4 $\mu g/m^3$ in seven of the seventeen 48 h average samples. The authors concluded that the measured PM_4 respirable crystalline silica concentrations were below the OEHHA REL of 3.0 $\mu g/m^3$ adopted in California and Minnesota.

5. Summary

This paper summarizes PM_4 respirable crystalline silica concentrations at a wide variety of mineral producing facilities. The data were compiled during periods of one to three years at facilities of differing production rates, product characteristics, crystalline silica content of the minerals, climate conditions, and terrains. Most of the data were obtained during the 2012 to 2018 period when there was high demand for mineral products. The large majority of the data were obtained in strict accordance with EPA reference method procedures and quality assurance procedures. Accordingly, these studies help to characterize the range of ambient concentrations or PM_4 crystalline silica that exists in a broad sector of mineral industry sources.

The PM_4 respirable crystalline silica concentrations measured at the fifteen mineral producing facilities for which UCL95% values could be calculated had upper mean 95% average values from a low of 0.23 $\mu g/m^3$ to a high of 2.05 $\mu g/m^3$. None of the UCL95% values of the facility-specific data sets approached or exceeded the OEHHA lifetime REL of 3.0 ug/m^3.

Only two of the fifteen facility datasets had UCL95% values above 1.00 $\mu g/m^3$. Both of these sources were large facilities with downwind sampling locations very close to processing equipment and/or limited dispersion due to unfavorable terrain.

The upwind–downwind concentration differences confirm that the contributions of mineral processing facilities to the ambient air at the downwind fencelines are very small and are often near to the lower limit of quantification.

The similarities of the upwind-downwind concentrations data and the similarities of the maximum observed concentrations indicate that the PM_4 respirable crystalline silica concentrations at the downwind fencelines of mineral industry sources are at or near the background concentrations. Additional studies are needed to more fully characterize background respirable crystalline silica concentrations near mineral facilities, agricultural operations, unpaved roads, construction sites, and arid, unvegetated soil. These future studies may need sampling times higher than 24 h to reduce the limit of quantification below 0.31 $\mu g/m^3$.

The extensive PM_4 respirable crystalline silica data consisting of more than 5000 24 h average concentration values at 19 separate facilities compiled in this paper indicate that mineral processing facilities have a minimal effect on downwind ambient concentrations and do not cause exceedances of the OEHHA health-based REL. This is not a surprising conclusion considering that mineral processing facilities do not use process equipment or procedures that are sufficient to break down much of the very hard crystalline silica into the very small PM_4 size range.

The air quality conclusions based on the data evaluated are generally consistent with the conclusions of other researchers—including the Institute for Wisconsin's Health [18] and the Texas Commission on Environmental Quality [19].

6. Recommended Further Study

Additional study is needed to evaluate the seasonal variability of the background levels of PM_4 respirable crystalline silica concentrations in arid and semi-arid areas, near unpaved roads, in urban areas with active building construction, in areas downwind of controlled burning and wildfires, and in agricultural areas.

Author Contributions: Conceptualization, J.R. and T.B.; Methodology, J.R. and T.B.; Validation, J.R. and T.B.; Formal analysis, J.R. and T.B.; Resources, J.R.; Data curation, T.B.; Writing—original draft preparation, J.R.; Writing—review and editing, J.R. and T.B. Supervision, J.R. and T.B.; Project administration, J.R. Funding acquisition, J.R. and T.B. All authors have read and agreed to the published version of the manuscript.

Funding: The ambient monitoring studies were conducted under contract to the facilities sampled.

Institutional Review Board Statement: Not Applicable.

Informed Consent Statement: Not Applicable.

Data Availability Statement: The data are available from the authors.

Acknowledgments: We acknowledge the efforts made by many contractors, facility employees, and one community resident who changed the sampler filters, conducted routine audits, and shipped the filter samples to the analytical laboratorie throughout the long term studies. We also acknowledge the comments and recommendations provided by WDNR and MDNR in reviewing sampling program protocols and conducting audits of the samplers.

Conflicts of Interest: Air Control Techniques, P.C. is an independent, third-party engineering and testing consulting firm. We have designed and supervised ambient respirable crystalline silica sampling programs for industrial firms needing to respond to community groups and regulatory agencies requesting ambient air quality data. Air Control Technique, P.C. is a member company of the National Stone Sand and Gravel Association (NSSGA), which had no involvement in any of these ambient air sampling programs. No financial support was solicited or provided for the preparation of this article.

Abbreviations

Acronyms and Definitions	
ACTPC	Air Control Techniques, P.C.
Crystalline Silica	Quartz, Cristobalite, and Tridymite
EPA	U.S. Environmental Protection Agency
LOQ	Limit of quantification
MPCA	Minnesota Pollution Control Agency
ND	Non-detectable concentration
NAAQS	EPA National Ambient Air Quality Standards
NIOSH	National Institute of Occupational Safety and Health
OEHHA	California Environmental Health Hazard Assessment
PM_4	Particulate matter equal to and smaller than an aerodynamic diameter of 4.0 micrometers as measured in accordance with NIOSH Method 0600
PVC	Polyvinyl chloride
Respirable Crystalline Silica	Crystalline silica in the PM_4 size range
SCAQMD	South Coast Air Quality Management District
TCEQ	Texas Commission on Environmental Quality
WDNR	Wisconsin Department of Natural Resources
UCL95%	95% Upper confidence limit of the arithmetic mean
XRD	X-ray diffraction
Units of Measure	
$\mu g/m^3$	Micrograms per cubic meter at actual conditions when referring to PM_4 particulate matter.

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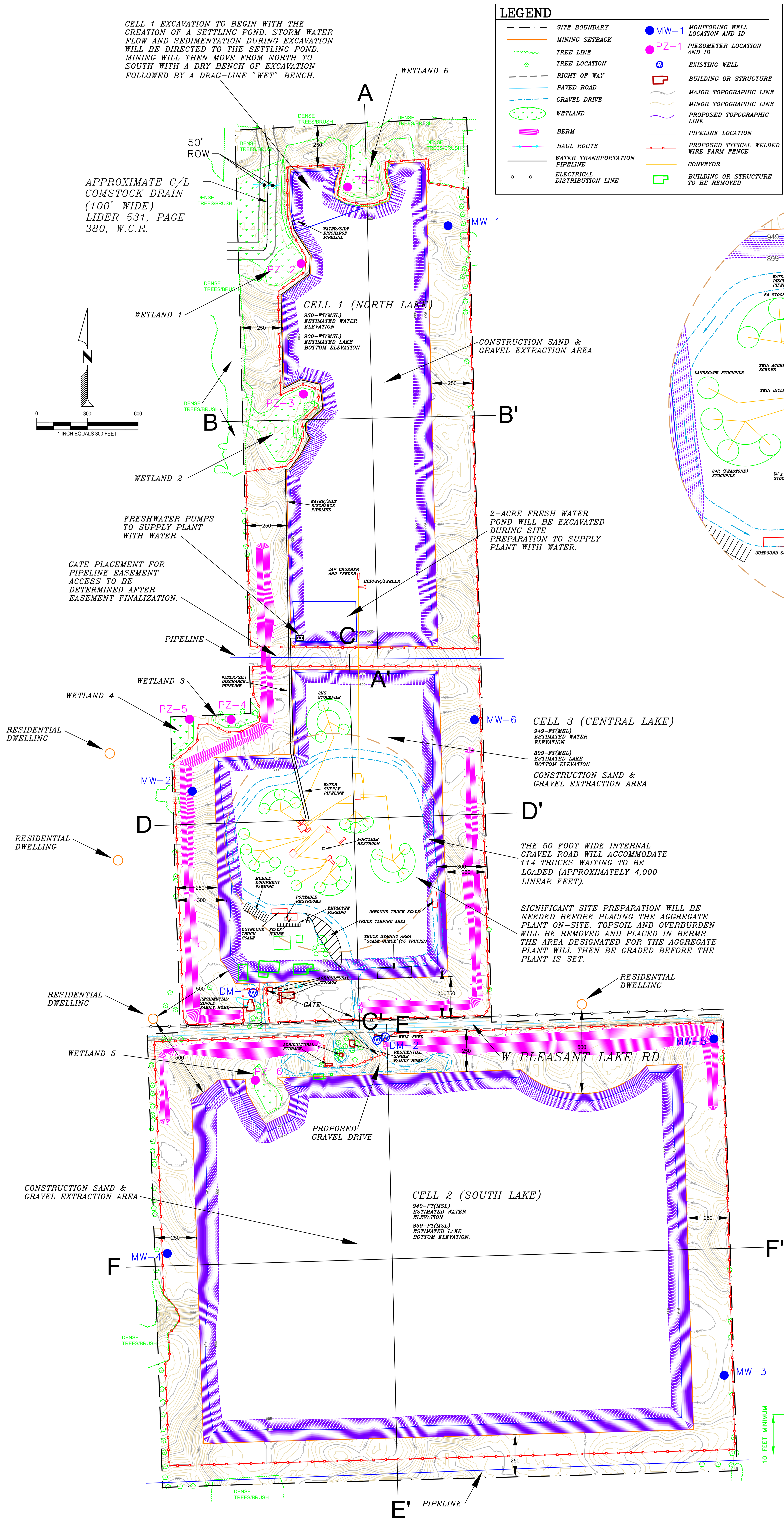

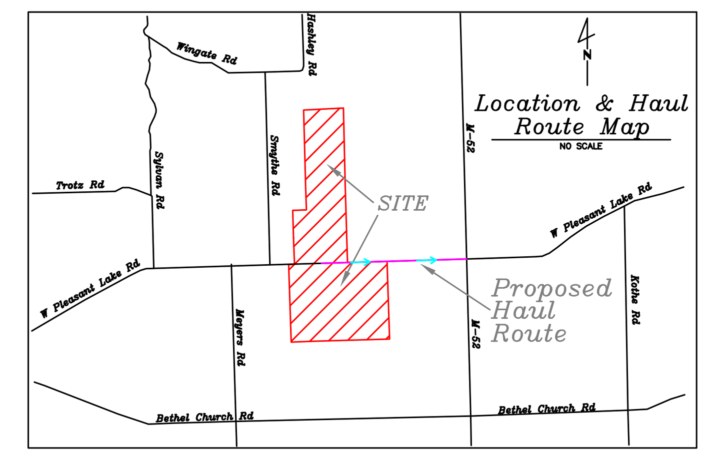

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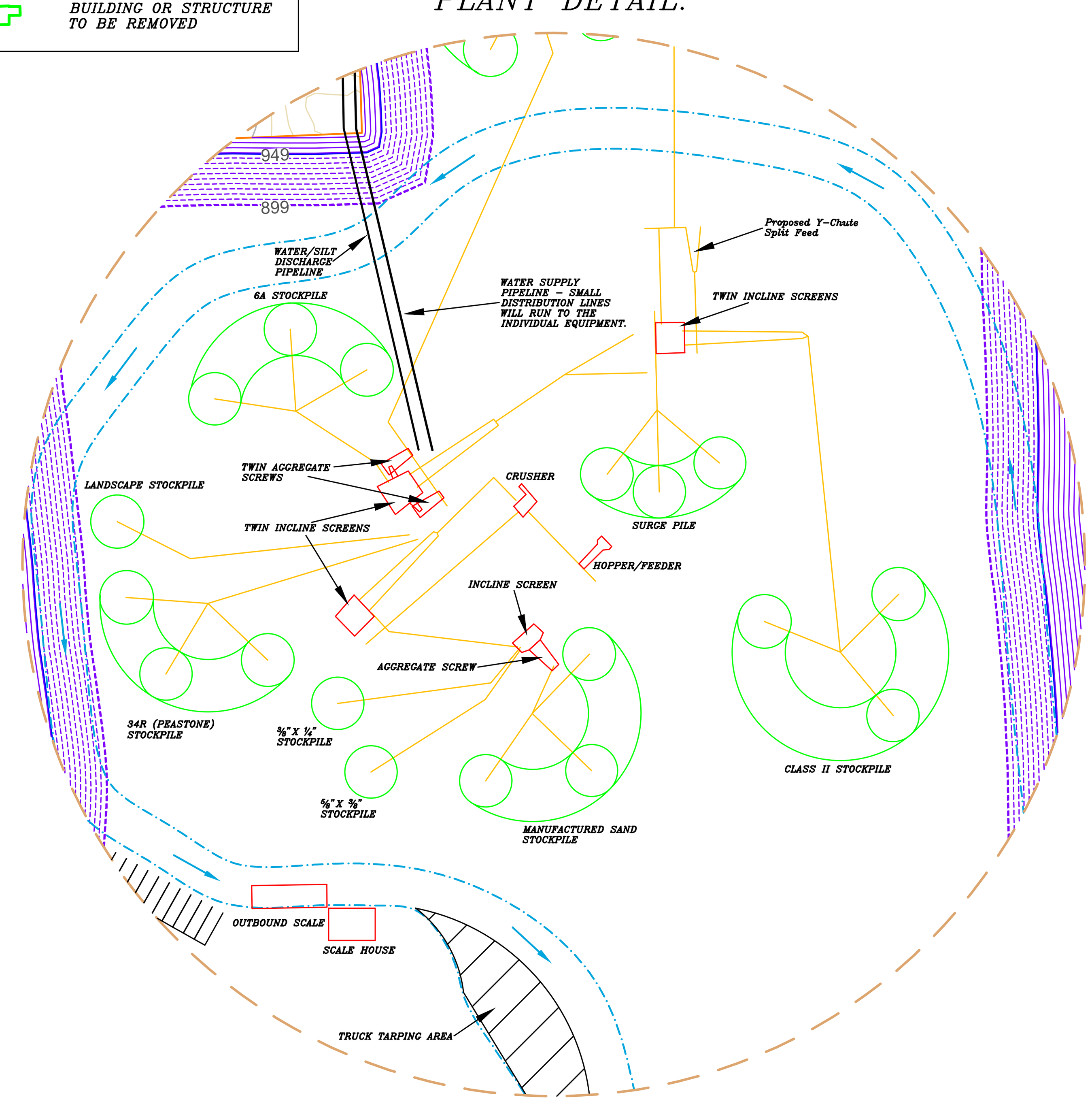

GENERAL NOTES:

1. THIS MINING OPERATION WILL BE REMOVING SAND AND GRAVEL CONSTRUCTION AGGREGATE FROM ALL 3 MINING CELLS.
2. ALL DISTURBED AREAS WILL BE SLOPED TOWARDS THE ON-SITE LAKES SO THAT ALL STORM WATER FLOWS WILL BE DIRECTED TO THE PROPOSED ON-SITE LAKES.
3. SETBACKS FOR THE PIPELINE ARE SUBJECT TO CHANGE BASED ON THE FINALIZED PIPELINE EASEMENT AREA.
4. BEFORE PLACING THE AGGREGATE PLANT ON-SITE, SIGNIFICANT SITE PREPARATION MUST BE COMPLETED. TOPSOIL AND OVERBURDEN WILL BE REMOVED FROM THE PROPOSED AGGREGATE PLANT LOCATION AND PLACED IN THE PROPOSED BERMS. A FRESHWATER POND, USED TO SUPPLY THE PLANT WITH WATER, WILL ALSO BE EXCAVATED IN THE SOUTHWEST CORNER OF CELL 1.
5. NO STRUCTURES ASSOCIATED WITH PROCESSING WILL BE TALLER THAN 45 FEET IN HEIGHT.
6. MINING IN CELL 1 WILL BEGIN AS DRY MINING MOVING FROM NORTH TO SOUTH. EQUIPMENT THAT MAY BE USED FOR DRY MINING ARE DOZERS, EXCAVATORS, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
7. WET MINING IN CELL 1 WILL BEGIN MOVING FROM NORTH TO SOUTH. EQUIPMENT THAT MAY BE USED FOR WET MINING ARE EXCAVATORS, DRAGLINES, DREDGES, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
8. WET MINING WILL NOT EXCEED 50-FEET BELOW THE WATER SURFACE.
9. MINING IN CELL 2 WILL BEGIN AS DRY MINING MOVING FROM SOUTH TO NORTH. EQUIPMENT THAT MAY BE USED FOR DRY MINING ARE DOZERS, EXCAVATORS, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
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11. MINING IN CELL 3 WILL BEGIN AS DRY MINING MOVING FROM NORTH TO SOUTH. EQUIPMENT THAT MAY BE USED FOR DRY MINING ARE DOZERS, EXCAVATORS, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
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13. DURING MINING OF CELL 3 THE PROCESSING PLANT WILL BE REMOVED AND A PORTABLE PLANT WILL BE USED TO FINISH AGGREGATE PROCESSING.
14. CELL 1 HAS APPROXIMATELY 5,167,000 CUBIC YARDS OF MINABLE NATURAL RESOURCE MATERIAL. CELL 1 WILL TAKE APPROXIMATELY 3.5 YEARS TO COMPLETE MINING.
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17. BERMS WILL BE A MINIMUM HEIGHT OF 10-FEET TALLER THAN THE CENTERLINE OF THE ADJACENT ROAD OR INTERIOR PROPERTY LINE. THE SLOPE WILL BE 1(VERTICAL):3(HORIZONTAL) OR FLATTER.
18. BERMS WILL BE INSTALLED USING OVERBURDEN AND TOPSOIL STRIPPED FROM THE MINING AREAS.
19. BERMS WILL ALSO HELP PREVENT STORM WATER FROM THE PLANT AND STOCKPILE AREA FROM FLOWING OFF-SITE.
20. SLOPES WILL BE STABILIZED USING CREEPING RED FESCUE AND/OR PERENNIAL RYEGRASS OR EQUIVALENT MIXTURE, BASED ON EGLE SUGGESTED MIXTURE FOR WELL AND MODERATELY WELL DRAINED SAND AND LOAMY SAND (COARSE TEXTURED SOILS). STRAW OR ALTERNATE MULCHING MATERIAL WILL BE USED AFTER SEEDING TO PROTECT SOILS FROM IMPACT OF FALLING RAIN, PRESERVE SOIL MOISTURE AND TO PROTECT GERMINATING SEEDS.
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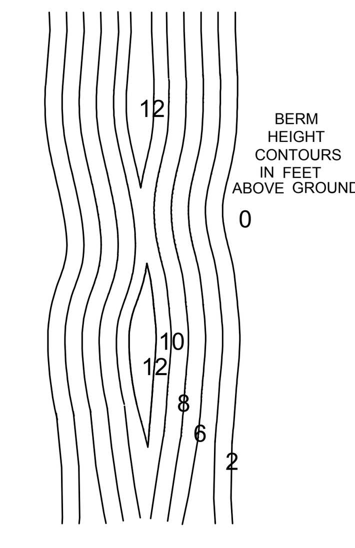
22. NO OFF-SITE POWER DISTRIBUTION LINES WILL BE AFFECTED BY THE PROJECT.
23. COMMERCIAL TRUCK TRAFFIC PATTERN WILL BE COUNTER CLOCKWISE.
24. PARKING AREA FOR MOBILE EQUIPMENT LOCATED JUST TO THE WEST OF THE OUT BOUND SCALE. THE SIZE OF THE PARKING SPACES ARE 15'X45'. THE SURFACE TYPE WILL BE GRAVEL.
25. THE FOLLOWING MINIMUM SETBACKS OF EQUIPMENT USED FOR SCREENING AND CRUSHING WILL APPLY:
    - 25.1. NOT LESS THAN 300 FEET FROM THE NEAREST PUBLIC ROADWAY.
    - 25.2. NOT LESS THEN 200 FEET FROM THE NEAREST ADJOINING NON-RESIDENTIAL PROPERTY LINE, AND 400 FEET FROM THE NEAREST RESIDENTIAL PROPERTY LINE.
    - 25.3. NOT LESS THAN 500 FEET FROM THE NEAREST RESIDENTIAL DWELLING ON ADJACENT PROPERTY AS OF THE DATE OF SUBMITTAL OF THE PLAN FOR EXTRACTION.
26. OPERATIONS WILL BE CONDUCTED IN ACCORDANCE WITH OPERATIONAL REQUIREMENTS OF SPECIAL LAND USE ORDINANCE 5.12.
27. STOCKPILES ASSOCIATED WITH THE MINING OPERATIONS WILL BE NO MORE THAN 25-FEET ABOVE THE SURROUNDING AREA GRADE.
28. THE GREEN HIGHLIGHTED BUILDINGS WILL BE REMOVED DURING THE MINING OF CELL 3.
29. ALL TREES WILL BE SUBJECT TO REMOVAL.
30. AREAS THAT HAVE NOT BEEN STRIPPED WILL BE MAINTAINED AS AGRICULTURAL UNTIL MINING IN THAT AREA BEGINS.

BERM CONSTRUCTION NOTES:

BERMS WILL BE BUILT TO A MINIMUM OF 1:3 SLOPE. BERMS WILL BE UNDULATING WITH CRESTS A MINIMUM OF 6 FEET ABOVE GENERAL LEVEL OF ADJACENT ROAD OR PROPERTY LINE.

DRAIN TILE WILL BE INSTALLED UNDER THE BERM IN AREAS WHERE SURFACE WATER MAY POOL BETWEEN THE BERM AND PROPERTY LINES. THIS WILL PREVENT SURFACE WATER FROM FLOWING OFF-SITE.

TYPICAL BERM LAYOUT



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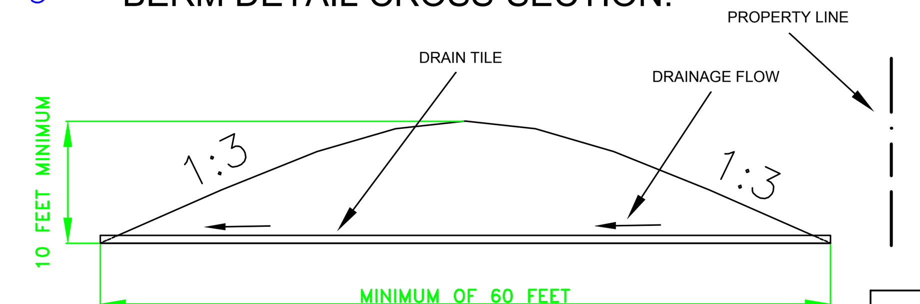

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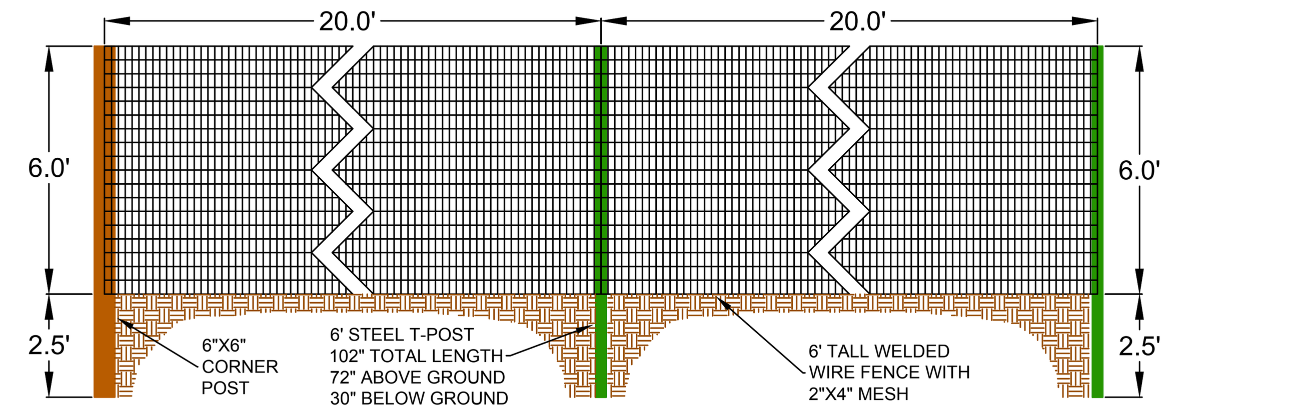

SHEET 3: MINING PLAN

MANCHESTER MINING OPERATION
19024 PLEASANT LAKE ROAD, MANCHESTER, MI 48158

Revised:
9-26-2022
11-28-2022
12-13-2022
3-24-2023

PREPARED BY:

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PREPARED FOR:

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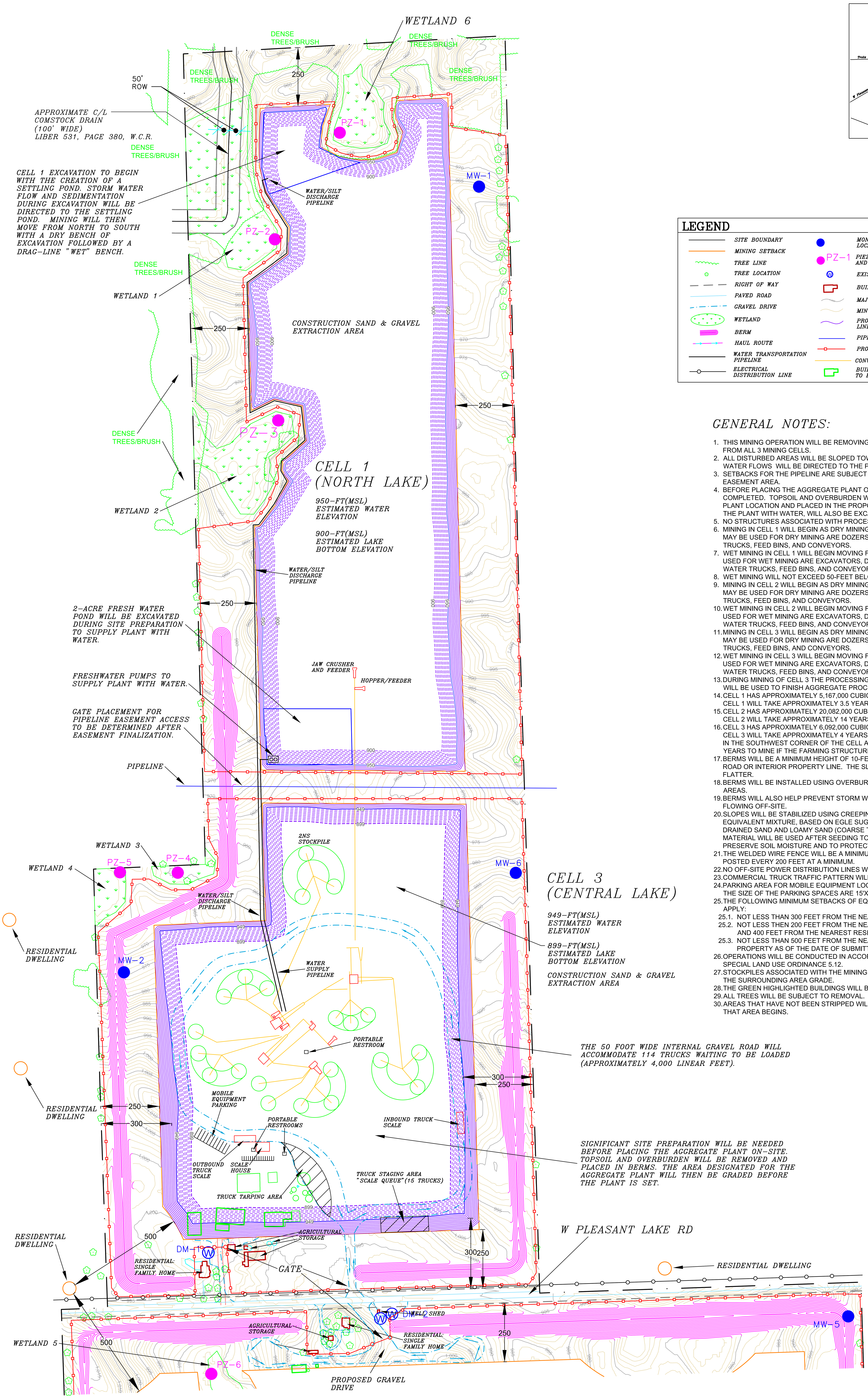
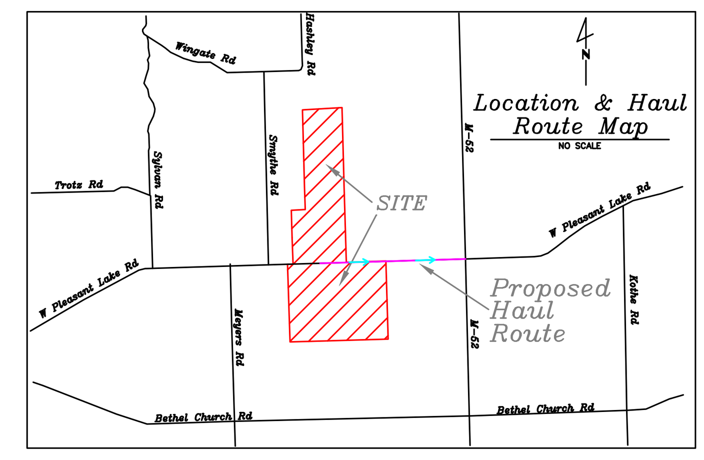
15203 S TELEGRAPH RD, MONROE, MI 48161
DATE: 2-8-2021

Susanne Hanf P.E.

Frank Tokar C.P.G.





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2. ALL DISTURBED AREAS WILL BE SLOPED TOWARDS THE ON-SITE LAKES SO THAT ALL STORM WATER FLOWS WILL BE DIRECTED TO THE PROPOSED ON-SITE LAKES.
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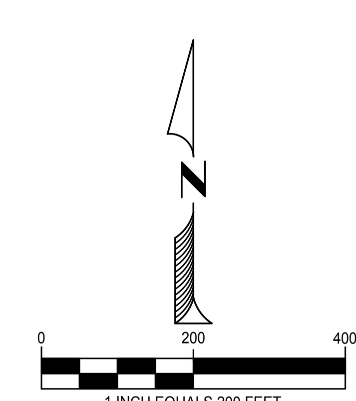

SHEET 3A: NORTH MINING PLAN DETAIL

MANCHESTER MINING OPERATION
19024 PLEASANT LAKE ROAD, MANCHESTER, MI 48158

PREPARED BY:

SUSANNE HANF P.E. (MI 6201056892)
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PREPARED FOR:

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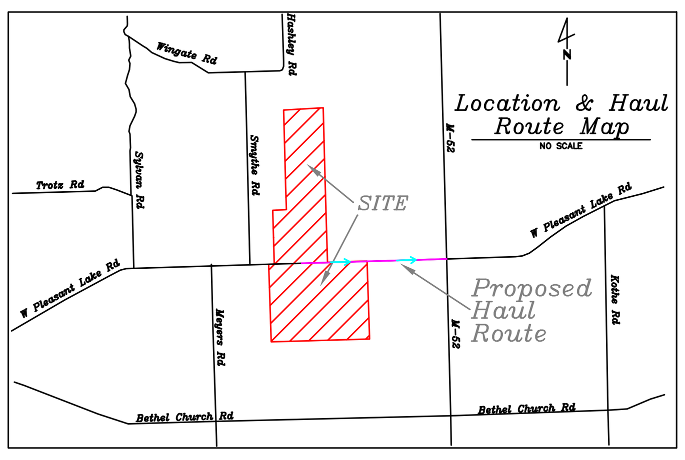

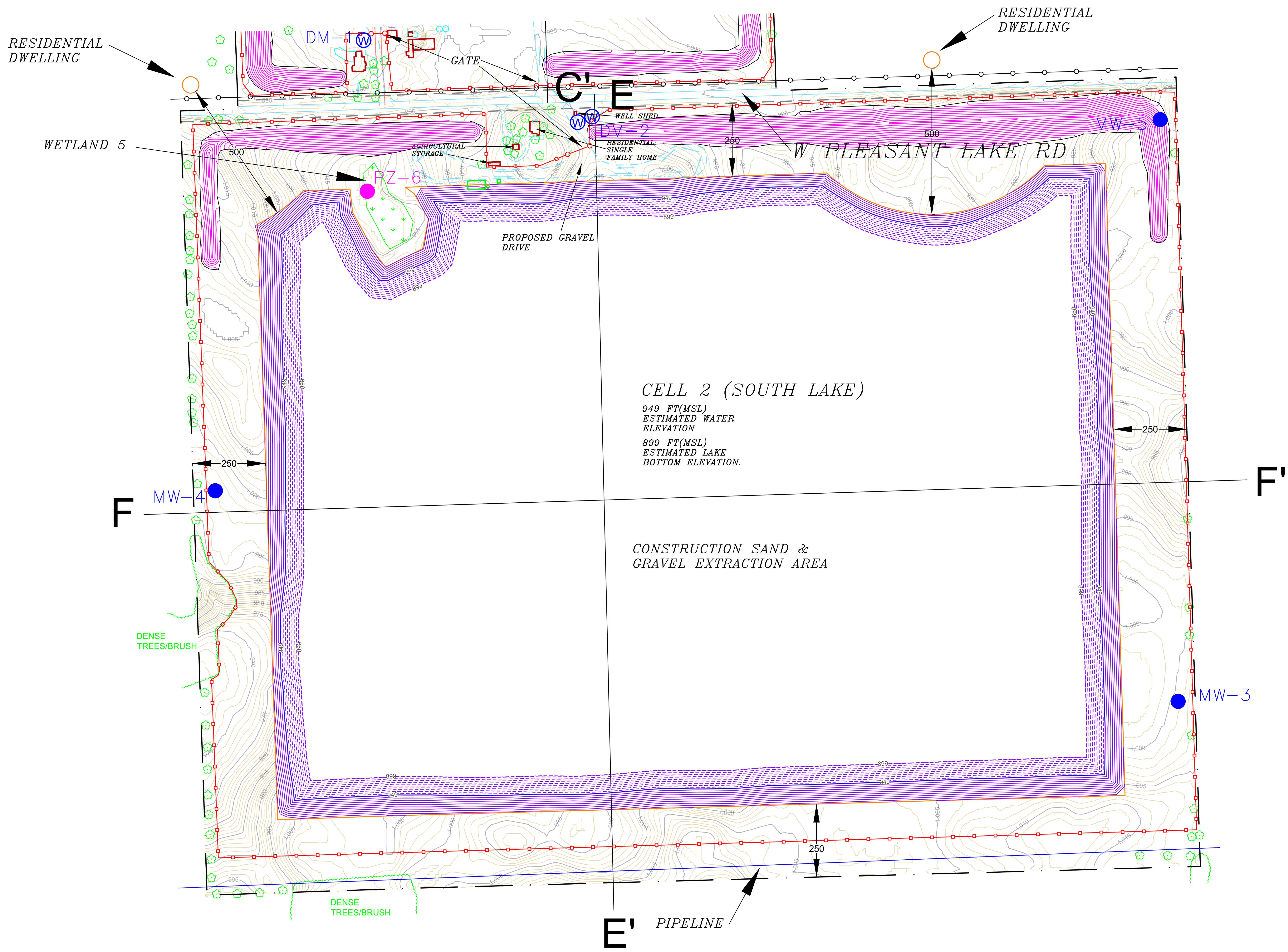

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5. NO STRUCTURES ASSOCIATED WITH PROCESSING WILL BE TALLER THAN 45 FEET IN HEIGHT.
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8. WET MINING WILL NOT EXCEED 50-FEET BELOW THE WATER SURFACE.
9. MINING IN CELL 2 WILL BEGIN AS DRY MINING MOVING FROM SOUTH TO NORTH. EQUIPMENT THAT MAY BE USED FOR DRY MINING ARE DOZERS, EXCAVATORS, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
10. WET MINING IN CELL 2 WILL BEGIN MOVING FROM SOUTH TO NORTH. EQUIPMENT THAT MAY BE USED FOR WET MINING ARE EXCAVATORS, DRAGLINES, DREDGES, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
11. MINING IN CELL 3 WILL BEGIN AS DRY MINING MOVING FROM NORTH TO SOUTH. EQUIPMENT THAT MAY BE USED FOR DRY MINING ARE DOZERS, EXCAVATORS, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
12. WET MINING IN CELL 3 WILL BEGIN MOVING FROM NORTH TO SOUTH. EQUIPMENT THAT MAY BE USED FOR WET MINING ARE EXCAVATORS, DRAGLINES, DREDGES, HAUL TRUCKS, LOADERS, WATER TRUCKS, FEED BINS, AND CONVEYORS.
13. DURING MINING OF CELL 3 THE PROCESSING PLANT WILL BE REMOVED AND A PORTABLE PLANT WILL BE USED TO FINISH AGGREGATE PROCESSING.
14. CELL 1 HAS APPROXIMATELY 5,167,000 CUBIC YARDS OF MINABLE NATURAL RESOURCE MATERIAL. CELL 1 WILL TAKE APPROXIMATELY 3.5 YEARS TO COMPLETE MINING.
15. CELL 2 HAS APPROXIMATELY 20,082,000 CUBIC YARDS OF MINABLE NATURAL RESOURCE MATERIAL. CELL 2 WILL TAKE APPROXIMATELY 14 YEARS TO COMPLETE MINING.
16. CELL 3 HAS APPROXIMATELY 6,092,000 CUBIC YARDS OF MINABLE NATURAL RESOURCE MATERIAL. CELL 3 WILL TAKE APPROXIMATELY 4 YEARS TO COMPLETE MINING IF THE FARMING STRUCTURES IN THE SOUTHWEST CORNER OF THE CELL ARE REMOVED. CELL3 WILL TAKE APPROXIMATELY 2.5 YEARS TO MINE IF THE FARMING STRUCTURES IN THE SOUTHWEST CORNER OF CELL 3 REMAIN.
17. BERMS WILL BE A MINIMUM HEIGHT OF 10-FEET TALLER THAN THE CENTERLINE OF THE ADJACENT ROAD OR INTERIOR PROPERTY LINE. THE SLOPE WILL BE 1(VERTICAL):3(HORIZONTAL) OR FLATTER.
18. BERMS WILL BE INSTALLED USING OVERBURDEN AND TOPSOIL STRIPPED FROM THE MINING AREAS.
19. BERMS WILL ALSO HELP PREVENT STORM WATER FROM THE PLANT AND STOCKPILE AREA FROM FLOWING OFF-SITE.
20. SLOPES WILL BE STABILIZED USING CREEPING RED FESCUE AND/OR PERENNIAL RYEGRASS OR EQUIVALENT MIXTURE, BASED ON EGLE SUGGESTED MIXTURE FOR WELL AND MODERATELY WELL DRAINED SAND AND LOAMY SAND (COARSE TEXTURED SOILS). STRAW OR ALTERNATE MULCHING MATERIAL WILL BE USED AFTER SEEDING TO PROTECT SOILS FROM IMPACT OF FALLING RAIN, PRESERVE SOIL MOISTURE AND TO PROTECT GERMINATING SEEDS.
21. THE WELDED WIRE FENCE WILL BE A MINIMUM OF 6 FEET TALL WITH "DANGER KEEP OUT" SIGNS POSTED EVERY 200 FEET AT A MINIMUM.
22. NO OFF-SITE POWER DISTRIBUTION LINES WILL BE AFFECTED BY THE PROJECT.
23. COMMERCIAL TRUCK TRAFFIC PATTERN WILL BE COUNTER CLOCKWISE.
24. PARKING AREA FOR MOBILE EQUIPMENT LOCATED JUST TO THE WEST OF THE OUT BOUND SCALE. THE SIZE OF THE PARKING SPACES ARE 15'X45'. THE SURFACE TYPE WILL BE GRAVEL.
25. THE FOLLOWING MINIMUM SETBACKS OF EQUIPMENT USED FOR SCREENING AND CRUSHING WILL APPLY:
    - 25.1. NOT LESS THAN 300 FEET FROM THE NEAREST PUBLIC ROADWAY.
    - 25.2. NOT LESS THEN 200 FEET FROM THE NEAREST ADJOINING NON-RESIDENTIAL PROPERTY LINE, AND 400 FEET FROM THE NEAREST RESIDENTIAL PROPERTY LINE.
    - 25.3. NOT LESS THAN 500 FEET FROM THE NEAREST RESIDENTIAL DWELLING ON ADJACENT PROPERTY AS OF THE DATE OF SUBMITTAL OF THE PLAN FOR EXTRACTION.
26. OPERATIONS WILL BE CONDUCTED IN ACCORDANCE WITH OPERATIONAL REQUIREMENTS OF SPECIAL LAND USE ORDINANCE 5.12.
27. STOCKPILES ASSOCIATED WITH THE MINING OPERATIONS WILL BE NO MORE THAN 25-FEET ABOVE THE SURROUNDING AREA GRADE.
28. THE GREEN HIGHLIGHTED BUILDINGS WILL BE REMOVED DURING THE MINING OF CELL 3.
29. ALL TREES WILL BE SUBJECT TO REMOVAL.
30. AREAS THAT HAVE NOT BEEN STRIPPED WILL BE MAINTAINED AS AGRICULTURAL UNTIL MINING IN THAT AREA BEGINS.

LEGEND

SITE BOUNDARY	MW-4 MONITORING WELL LOCATION AND ID
MINING SETBACK	PZ-1 PIEZOMETER LOCATION AND ID
TREE LINE	EXISTING WELL
TREE LOCATION	BUILDING OR STRUCTURE
RIGHT OF WAY	MAJOR TOPOGRAPHIC LINE
PAVED ROAD	MINOR TOPOGRAPHIC LINE
GRAVEL DRIVE	PROPOSED TOPOGRAPHIC LINE
WETLAND	PIPELINE LOCATION
BERM	PROPOSED FENCE
HAUL ROUTE	CONVEYOR
WATER TRANSPORTATION PIPELINE	BUILDING OR STRUCTURE TO BE REMOVED
ELECTRICAL DISTRIBUTION LINE	

SHEET 3B: SOUTH MINING PLAN DETAIL

MANCHESTER MINING OPERATION
19024 PLEASANT LAKE ROAD, MANCHESTER, MI 48158

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Susanne Hanf P.E.

Frank Tokar C.P.G.