

PRELIMINARY ASSESSMENT OF LOWER MUSKEGON RIVER WATERSHED OIL FIELD

Prepared for:

Muskegon County Oil Field Work Group

Prepared by:

Westshore Consulting

Funded by:

**Community Foundation for Muskegon County
Laketon Township, Muskegon County**

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TABLE OF CONTENTS

1.0	Introduction.....	1
1.1	<i>Project Goals</i>	2
1.2	<i>Oil Field History.....</i>	3
2.0	Oil & Gas Well Mapping.....	4
2.1	<i>Methods.....</i>	4
2.2	<i>Products</i>	5
3.0	Preliminary Assessment	6
3.1	<i>Types of Wells</i>	6
3.2	<i>Current Land Use</i>	7
3.3	<i>Potential Concerns.....</i>	8
3.4	<i>Associated Factors.....</i>	9
3.5	<i>Resources</i>	10
4.0	Conclusions & Recommendations	11

Figures

- Figure 1 - Overview Map
- Figure 2 - Residential Neighborhood Example
- Figure 3 - Rural Example
- Figure 4 - Institutional Example
- Figure 5 - Municipal Water Supply

Attachments

- Attachment A - Central Michigan University Essay on the History of Muskegon Petroleum Exploration

1.0 Introduction

From the late 1920's to approximately 1970, a very large number of oil and gas wells were drilled in the Muskegon area. A few of these wells remain in production, though the bulk have been abandoned. Human health and environmental concerns associated with the abandoned borings and associated facilities include drinking water contamination, surface water, soil and groundwater contamination, and possibly explosive or fire hazard conditions.

To date, the community has dealt with this legacy of oil and gas exploration and development in a piece-meal, *ad hoc* fashion. Public and private entities have been forced to expend significant time and money to investigate these old wells and facilities as they were identified in the course of other activities. While the actual risks have frequently proved relatively minor, project delays and expenses are the norm. Other times, the risks have proved significant and difficult to address. As of this writing, crude petroleum is leaking into a canal in a residential neighborhood off Bear Lake, and a longtime, ongoing leak is suspected in another nearby tributary. Petroleum and associated brine contamination has been found in groundwater, forcing the re-drilling of water wells and the extension of the municipal water supply. Other hazards and risks have forced expensive clean-ups and affected residential homeowners, and work to improve fish, wildlife and wetland habitats has been hindered.

The vast majority of these old wells and associated facilities have never been investigated, including those in the middle of residential neighborhoods. As a result, the risks to human health and the environment are mostly unknown. While recognized as an issue by government agencies, the resources to characterize and soundly manage these risks have never been made available.

To try and address this issue, a group of local government officials, in concert with a local engineering firm, approached the Community Foundation for Muskegon County in the Spring of 2010 to request seed money to begin an effort to better understand and manage these old wells. The intent of this effort was two-fold:

- Develop a useful set of maps of these old oil and gas borings to help better define the associated risks; and
- Form a Work Group to review these maps, the associated issues, and recommend what if any actions should be taken.

The focus area for this initial effort was necessarily limited to an especially dense swath of old oil and gas borings in Laketon and Muskegon Townships, north of Muskegon and Bear Lakes. While oil and gas borings, and their attendant problems, have been identified throughout Muskegon County, this area was judged to be the greatest priority for an initial assessment.

The Community Foundation granted the requested funds, and led by Laketon Township and staffed by Westshore Consulting, the Work Group consisted of the following individuals/entities:

MUSKEGON COUNTY OIL FIELD WORK GROUP

Kim Arter, Supervisor, Laketon Township
David Kieft, Supervisor, Muskegon Charter Township
Vicki Webster, Environmental Health Supervisor, Public Health - Muskegon County
Dave Glotzbach, Chief, Muskegon Township Fire Department
Dave Fisher, Muskegon County Drain Commissioner
Kathy Evans, West Michigan Shoreline Regional Development Commission
and Muskegon Lake Watershed Partnership
Adam Rosema, Sanitarian, Public Health - Muskegon County
Rod Siegel, Inspector, Laketon Township
Lori Archer, Treasurer, Laketon Township
Carolyn Weng, Muskegon Lake Watershed Partnership
Dennis Dunlap, Chief Engineer, Westshore Consulting
Jerry Garman, Project Manager, Westshore Consulting

While not formal members of the Work Group, Tom Berdinski of the Water Resources Division, and Paul Jankowski, Manager of the Orphan Well Program, both of the Michigan Department of Natural Resources and Environment, were valuable contributors to the project.

1.1 Project Goals

The goals of this project were to:

- Develop an improved set of maps that better characterize the location of these old wells relative to existing land uses.
- Establish a team of local experts and community leaders that dedicate themselves to addressing the concerns posed by these old oil and gas wells.
- Develop a preliminary assessment of the risks to human health and the environment posed by these wells, and
- Articulate community priorities and recommendations for addressing and managing these old wells.

1.2 Oil Field History

According to a Central Michigan University report (Attachment A), Muskegon became the focus of intense oil and gas exploration after natural gas was discovered at a depth of 1,640 feet below ground in the Reeths #1 well on December 8, 1927. Drilling continued to a depth of 1,700 feet, where oil began to flow. The well's crude oil flow peaked at a rate of 330 barrels per day, before stabilizing at approximately 50 barrels per day in later weeks. The discovery triggered a boom in oil and gas exploration, and with its location convenient to land and water shipping, Muskegon became a center of activity. Within four months, the Muskegon field was producing more than 1,000 barrels per day, making it at the time the biggest producer in Michigan. By November 1928, the Muskegon Chronicle reported approximately 70 drill rigs were active in the area, employing an estimated 1,000 people. Oil production peaked in 1929 at 3.1 million barrels, and natural gas peaked in March of that year at 429 million cubic feet.

Drilling continued in the Muskegon area for a number of decades, and some active petroleum production remains. Older borings, both successful and "dry hole," were abandoned using methods in use at the time. While many of these borings appear to have been successfully plugged, some were not, and the vast majority have never been investigated. Possible risks posed by these borings, and associated petroleum storage and production facilities, include contamination of groundwater and surface water, risks to drinking water wells, and atmospheric and indoor air releases.

2.0 Oil & Gas Well Mapping

In general terms, the mapping of oil and gas borings in the study area was accomplished by translating State of Michigan database files, and overlaying selected data on local tax maps and high resolution aerial photographs.

To give a general feel for the nature of these borings, they typically tapped geologic formations known as the Traverse or Dundee, and were commonly 1,500 to 2,000 feet in depth. Such borings were typically larger at the surface, with diameters as large as 36 inches, telescoping to smaller diameters as they extended downward.

2.1 Methods

The Office of Geological Survey in the Michigan Department of Natural Resources and Environment (DNRE) maintains Microsoft Access 2000 database files on the location coordinates and various aspects of all permitted, petroleum-related borings in the state. Westshore obtained this data for Muskegon County from the DNRE, and selectively organized it in Microsoft Excel files. The base maps for this effort were obtained from the Muskegon County Equalization Department. Map data provided by the County included roads and major features, tax parcels and high resolution, 2008 aerial photographs.

The study area of interest was defined by Westshore, in consultation with the Work Group, using DNRE Acrobat PDF maps of Muskegon County borings. While somewhat arbitrary, the vicinity of interest was clearly identifiable with respect to the general density of oil and gas borings in an approximately 28 square mile area in Laketon and Muskegon Townships, and the Cities of Muskegon and North Muskegon. While the DNRE database files included a range of information on the borings, for this preliminary assessment borings were classified as oil wells, gas wells, dry holes, brine disposal and unknown.

Using AutoCAD software, top of boring locations were then mapped and the various layers rectified for the study area. As an additional study item, a municipal water supply planning map was obtained from the West Michigan Shoreline Regional Development Commission. This latter file was provided as an Acrobat PDF map and converted to AutoCAD by manual programming. The Development Commission also provided a useful map showing future population growth projections.

We note that the well boring location data was not independently reviewed for this exercise. Based on Westshore Consulting's experience, the boring locations are commonly within ten yards of the plotted locations. Larger variation has been encountered and some borings can never successfully be located in the field.

2.2 Products

The resulting map data was analyzed, viewed and printed in different scales and formats. While an essentially infinite variety of views were available, for purposes of this preliminary assessment, two formats were found most useful:

- Figure 1 shows the entire study area with borings overlaid on the major features, roads and tax parcels at a scale of one inch equals 1000 feet. Borings for gas wells, oil wells, dry holes, brine disposal wells and wells of unknown type are shown.
- Figures 2, 3 and 4 show the borings overlain on the major features, roads, tax parcels and 2008 high resolution aerial photographs. The areas shown are roughly one square mile, at scales of one inch equals 200 or 300 feet.
 - Figure 2 shows an area of relatively dense, single family residential development in the vicinity of Dykstra, Horton, Whitehall and Giles Roads.
 - Figure 3 shows a relatively rural area with scattered single family houses near Weber, Fenner and Green Creek Roads.
 - Figure 4 shows an area in Muskegon Township and the City of Muskegon that contains two local colleges, and commercial and residential land uses.

In addition to these specific printouts, data files and maps were provided to various Work Group members.

3.0 Preliminary Assessment

The mapping revealed 621 known borings within the defined study area. The Reeths #1 well, identified as the well that started the Muskegon petroleum boom in 1927, was located just southeast of Giles Road and Getty Street in Muskegon Township. Additional borings are believed to have been completed prior to the enactment of the state permitting program, but the number and location of these borings was not determined in this initial assessment.

3.1 Types of Wells

All five boring classifications that were subject to this analysis were located within the study area:

Oil Wells These borings were among the most numerous. They were identified by the DNRE as wells that actively produced crude petroleum at one point in time. Based on the experience of Work Group members, crude petroleum, drilling muds and brines may have been released to the environment at these locations, and various types of equipment or subsurface anomalies (e.g., pits) may be present. The bulk of these wells were likely plugged successfully, but plugging may not have been fully successful and petroleum releases may have occurred or be ongoing. The presence of natural gas cannot be ruled out. Some wells may be in active production.

Dry Holes Also very numerous in the study area, these were borings that were never converted to active oil or gas production. This lack of production may have been the result of encountering no oil or gas, the volume of oil or gas was too small to be economically viable, or for other reasons. While not reported as active producers, dry holes may still be the site of former or ongoing releases of crude petroleum, brine, natural gas or drilling mud, and equipment or pits may remain.

Gas Wells Somewhat less common in the study area, but still widely present. These wells were identified as active producers of natural gas at one point in time. As with the other borings, they may still be in production and successful plugging may or may not have occurred. Former or ongoing releases of natural gas, crude petroleum, brine and drilling muds may have occurred, and equipment or pits may be present.

Unknown Type These were borings of an unidentified nature. They are less common but present in the study area. These borings may or may not have been put into oil or gas production, and may or may not have been successfully plugged. They may be the locations of ongoing or former releases of crude petroleum, natural gas, brine and drilling muds, and may have equipment or pits associated with them.

Brine Disposal These borings were used to re-inject brine that was a by-product of oil or natural gas production. They are present in the study area but are not common. The status and risks associated with these wells is less clear, though the potential

for brine releases appears to be the most likely concern. The potential remains for these borings to be the location of former or ongoing releases of crude petroleum, natural gas, brine and drilling muds, and equipment or pits may also be present.

3.2 Current Land Use

The study area was found to have a wide range of land uses, all of which contained borings. Borings or wells were plotted such that they appeared on undeveloped land, under or in close proximity to buildings, in yards, in wetlands or water, and near or under roads and municipal infrastructure. Based on the 2008 aerial photographs, borings were found to coincide with the following land use categories:

Residential Wells appeared in dense single family neighborhoods, areas of multi-family housing, and scattered single family/rural areas. Two larger neighborhoods of single family housing that contained a significant number of borings included an area around Horton and Dykstra Roads in Laketon Township, and around Giles and Holton Road in Muskegon Township. The presence of borings near single family housing was noted across the study area.

Rural/Undeveloped A number of wells were noted on undeveloped land. Some of these may have been at or near agricultural land, though little active farming appeared to take place in the study area. Scattered single family homes or other land uses were usually in the vicinity.

Institutional/Commercial Wells were co-located with commercial and institutional activities, the latter including schools and churches. Borings were located around public school buildings near Getty Street and Giles Road, and the local colleges near Marquette Avenue and Quarterline Road. Commercial land uses corresponded to wells along Whitehall Road, and in the Marquette/Quarterline neighborhood. Given the scattered nature of these land uses and the widespread occurrence of the borings, the overlap of wells with these land uses likely occurred elsewhere, especially along major thoroughfares.

Wetland & Open Water Wells were noted in areas of open water and marsh or swampland, some likely as a result of landscape changes since the time of their first being drilled. The northern shorelines and wetlands or flats above Bear and Muskegon Lakes were the main areas of such wells, though they were scattered and likely included other canals, bayous or ditches.

3.3 Potential Concerns

A review of the presence of oil and gas wells in the study area revealed a range of potential concerns. A variety of problems with respect to human health and welfare, other environmental concerns, or economic development may be associated with these old wells.

Soil, Groundwater & Surface Water Contamination Contamination may be present as a result of releases of crude petroleum and brine across the study area. Such contamination may be localized, or spread over a larger area as the result of its migration with groundwater or surface water, or releases from multiple sources/wells. Soil, groundwater and surface waters may be contaminated.

Drinking Water Contamination Potable water supply wells in the area may tap into groundwater contaminated with crude oil, natural gas or brine. Given the limited availability of the municipal water supply (see below), drinking water wells are present in much of the study area. The use of contaminated wells may result in direct human ingestion of petroleum or brine pollutants.

Ecological Risk Crude petroleum or brine releases may adversely impact wildlife, fish and vegetation. Terrestrial, wetland and surface water biota may be affected. Natural resource and habitat improvement efforts can be hindered by the presence of these old borings.

Indoor Vapors Given the presence of wells near or under buildings, the potential for natural gas or crude petroleum vapors to occur in buildings cannot be ruled out. Risks may include long-term exposure affects on health, and more acute concerns such as fire or explosion. Water supply wells can act as conduits and allow for natural gas vapors to be released at water faucets or taps.

Cave-In/Falling, Unstable Soils & Equipment The presence of old pits or borings presents risks for cave-in, unstable soil conditions (e.g., sinkholes) and falling hazards. Old petroleum exploration or production equipment may present risks to children, or construction and utility workers in cases where it may not be visible on the land surface.

Economic Development & Jobs Business and community investment can be hindered by the presence of these old wells and facilities. Investigation and management costs may be a significant hurdle to investment, land development and job creation.

3.4 Associated Factors

In the course of the Work Group's deliberations, several additional and important considerations were identified:

Municipal Water Supply Much of the study area within Laketon and Muskegon Townships depends on groundwater as a potable drinking water source. As a result, the drinking water supply in these areas may be contaminated with crude oil, natural gas or brine. Public Health – Muskegon County has reported instances where attempts to drill new water wells has encountered contamination, and there remains a significant potential for existing water supply wells to be contaminated. The Work Group was not aware of any testing or other programs to address this risk. To better understand this issue, a planning map showing the municipal water supply was overlaid on the oil and gas well map for the study area (Figure 5). As can be seen, much of the study area does not have a municipal water supply, thus indicating a potential for ongoing drinking water contamination. This concern has specifically resulted in the extension of the municipal water supply in selected portions of Laketon Township; the extent of the risk in other areas is unclear.

Muskegon Lake Watershed Muskegon Lake is an internationally designated Area of Concern for the Great Lakes due to historical environmental damage. As a result, state and federal agencies oversee and support efforts to improve the lake and its watershed, and these efforts are coordinated locally by the Muskegon Lake Watershed Partnership. The goal of these efforts is to improve the environmental condition of the lake and watershed to a degree that would allow Muskegon Lake to be de-listed as an Area of Concern. Formally designated impairments to the Area of Concern include the Degradation of Fish and Wildlife Habitat, Degraded Fish and Wildlife Populations, and Degradation of Aesthetics, all of which are adversely impacted within the study area by contamination from oil and gas wells. As a result, the Watershed Partnership and supporting state and federal agencies should view the need to address these oil and gas wells as a priority.

Future Population Growth The study area is projected to experience increasing population growth and density as the greater Muskegon area grows to the north. The Muskegon Areawide Plan, developed by the West Michigan Shoreline Regional Development Commission, predicts that residential, commercial and industrial development will significantly expand in the study area. Increasing population density and land development would be expected to increase the risks posed by these old oil and gas borings. Efforts to address these borings before land development and population growth would be more efficient, cost effective, and more likely to prevent unacceptable exposures and risks.

Government Involvement Muskegon County governments have been forced to deal with the risks of old oil and gas borings and facilities as a result of their land use planning and permitting, zoning, public health and emergency response mandates. The State of Michigan has expended significant resources to investigate and

clean-up specific sites of concern. All these activities have been highly limited, on a case-by-case basis, and have resulted in significant expenditures of energy, time and money. Opportunities for a better, more holistically planned and executed effort have not been explored. The Work Group felt strongly that all levels of government should place a higher priority on this issue of the risks posed by these old oil and gas borings. Local governments at the County, City and Township level should evaluate ways they can better manage these risks with the hope that wiser efforts may stop or prevent adverse consequences. The State and Federal government should look for ways to assist and better address the risks posed by these old borings and facilities.

3.5 Resources

While the degree of active management of these oil and gas well borings has to date been limited, a number of organizations are available for assistance going forward. A brief listing of these entities follows.

GOVERNMENTAL

Public Health – Muskegon County

Muskegon Township

Laketon Township

Muskegon County Office of the Drain Commissioner

Muskegon Conservation District

West Michigan Shoreline Regional Development Commission

Michigan Department of Natural Resources and Environment

United States Environmental Protection Agency

PRIVATE SECTOR

Environmental Science & Engineering Consultants

Petroleum Exploration & Environmental Cleanup Contractors

Environmental Laboratories and specialty providers

NON-PROFITS

Muskegon Lake Watershed Partnership

4.0 Conclusions & Recommendations

A total of 621 borings were identified and mapped in an especially dense area in Laketon and Muskegon Townships, and the Cities of Muskegon and North Muskegon. Borings included oil and gas wells, dry holes, brine disposal wells, and those of unknown type. These borings coincided with residential, institutional, commercial, rural, wetland and open water land uses and landscapes.

Potential risks to human health and the environment associated with these borings and related facilities include soil, groundwater and surface water contamination, drinking water contamination, ecological, fish and wildlife impacts, indoor vapors, cave-in and falling hazards, and hurdles to economic development and job creation.

The vast majority of these borings have never been investigated and the actual risks to human health and the environment are unknown. When borings have been investigated as a result of drinking water well permitting, private investments or other reasons, cases of both minimal risk, and unacceptably high risk have been identified. While most borings likely present a limited concern, the potential remains for high risks to exist and be unknown to the community.

The Work Group concludes that the status quo is not acceptable. A way to address these concerns needs to be found. While not wanting to cause undue alarm, there is a clear need to investigate and pursue sound management of these old borings. Resources need to be found to locate in the field, inspect, and otherwise investigate these borings and associated facilities as necessary to determine the actual risks they pose. Where individual borings and facilities are found to present real risks to human health and the environment, sound management, clean-up and other steps to terminate or contain and reduce these risks to acceptable levels need to be implemented.

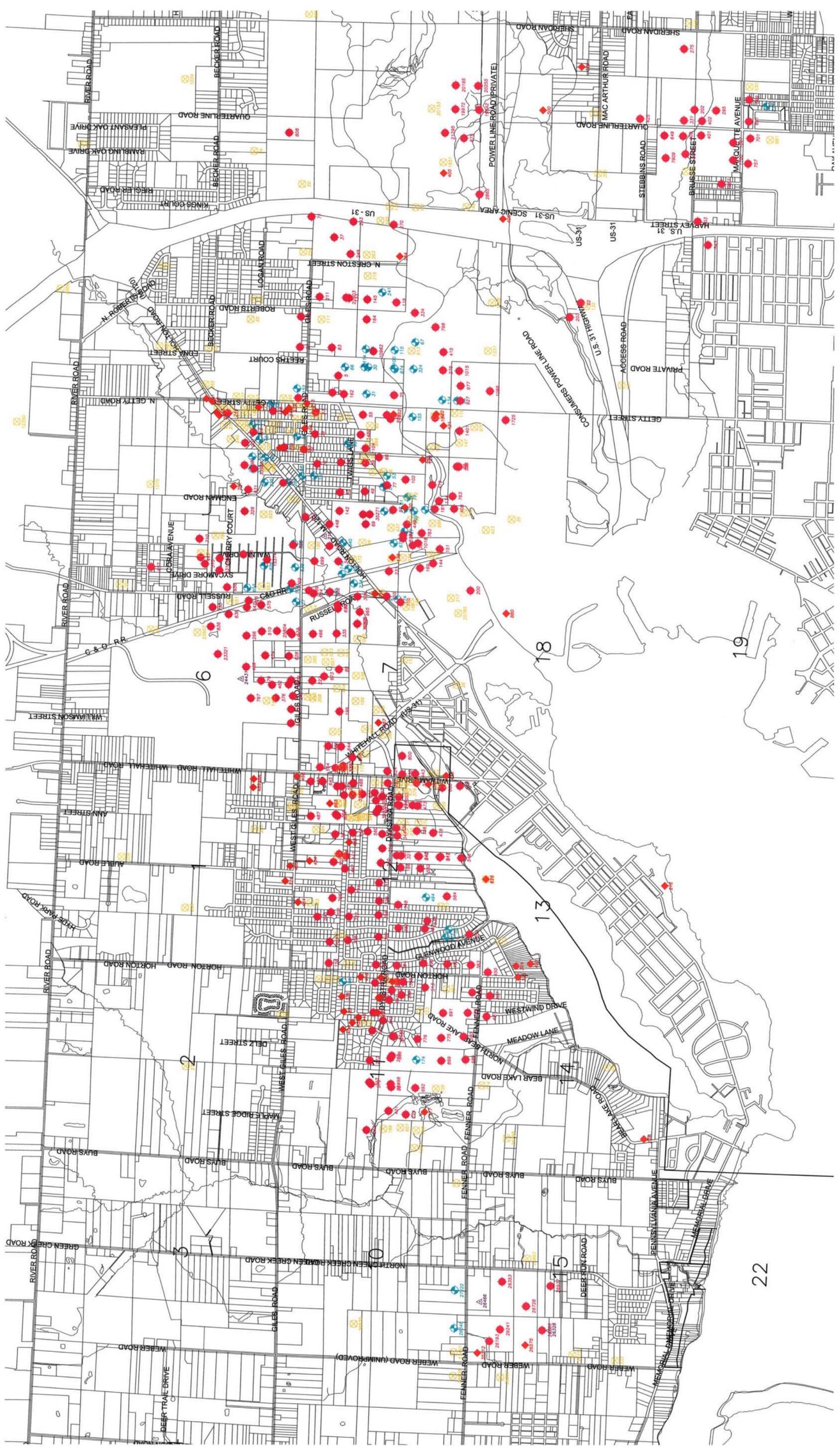
In general terms, the Work Group recommends:

- The community should be educated about the nature of these old oil and gas borings and associated facilities, and the human health and environmental risks they pose. By improving our understanding, we will be better able to help address these issues as individuals and as a community. Support for a more holistic, comprehensive approach will likely result from increased comprehension.
- Programmatic tools and resources should be identified to assist a response to these risks by private individuals, and facilitate the development of a more comprehensive, community-wide effort.
- Existing government and community programs, resources, ordinances and policies should be evaluated with respect to these old borings, and improved and tailored to help address the associated risks. The Work Group strongly urges local agencies and governing bodies to look for ways to address this issue by reviewing their land use planning, zoning and permitting, construction and inspection, public health and emergency response programs.

- The old petroleum borings and facilities should be investigated and the attendant risks defined. Funding should be allocated to locate and field investigate these borings and their surroundings to determine if unacceptably high risks to human health and the environment are present.
- Where specific borings and facilities are found to present a real risk, the resources must be dedicated to soundly manage and reduce the risk to an acceptable level. The full tool kit of environmental management techniques should be considered as necessary to stop or prevent human health risks or environmental damage.

FIGURES

- Figure 1 - Overview Map**
- Figure 2 - Residential Neighborhood Example**
- Figure 3 - Rural Example**
- Figure 4 - Institutional Example**
- Figure 5 - Municipal Water Supply**



LEGEND

- GAS WELL
- OIL WELL
- DRY HOLE
- WELL (UNKNOWN TYPE LOCATION ONLY)
- ▲ BRINE DISPOSAL WELL

NO.	DATE	DESCRIPTION	BY	CHK'D	DATE

DESIGNED BY:	JRG
CHECKED BY:	BJA
SURVEYED BY:	08/13/10
DATE:	
DWG NAME:	

WESTSHORE
 CONSULTING
 Engineers • Scientists • Surveyors • Planners

WESTERN MICHIGAN
 2534 Block Creek Road
 Muskegon, MI 49444
 Ph: (231) 777-3447
 Fax: (231) 773-3453
 Service@westshoreconsulting.com

NORTHERN MICHIGAN
 P.O. Box 7
 Muskegon, MI 49660
 Ph: (231) 920-5818
 Fax: (231) 773-3453
 Service@westshoreconsulting.com

PROJECT NAME:
MUSKEGON OIL FIELD
WEBER ROAD
 LAKETON TOWNSHIP,
 MUSKEGON COUNTY, MICHIGAN

RURAL EXAMPLE
 (WEBER RD.)
 PROJECT: 3906-1
 FIGURE: 3



NO.	DATE	DESCRIPTION	BY	CHK'D	DATE

DESIGNED BY:	JRG
CHECKED BY:	BJA
DATE:	08/13/10
DRAWN BY:	

WESTSHORE CONSULTING
 Engineers • Scientists • Surveyors • Planners

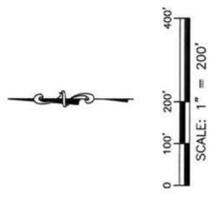
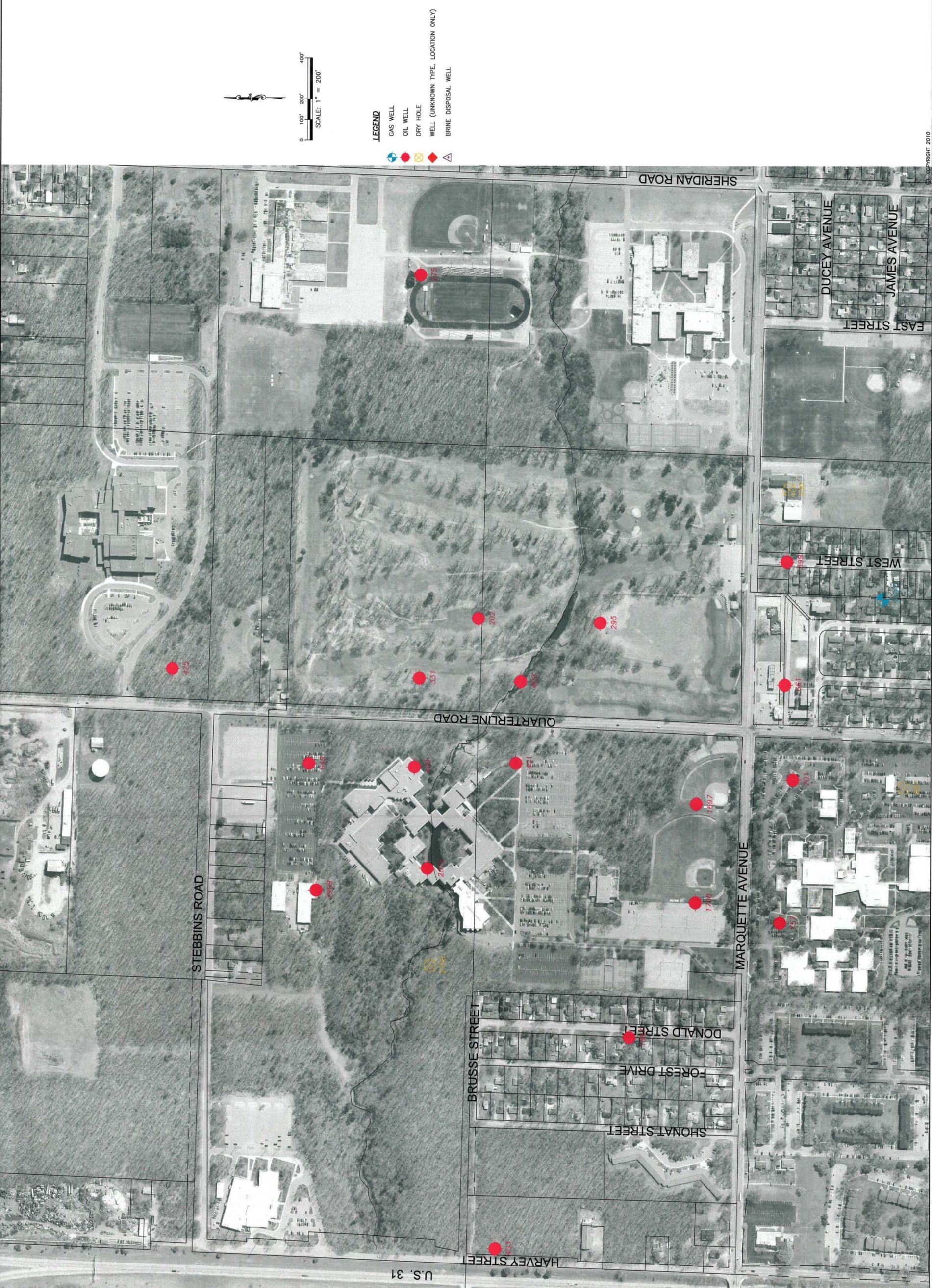
WESTERN MICHIGAN
 2534 Black Creek Road
 Muskegon, MI 49444
 Ph: (231) 773-3447
 Fax: (231) 773-3453
 Service@WestshoreConsulting.com

NORTHERN MICHIGAN
 P.O. Box 7
 Muskegon, MI 49660
 Ph: (231) 920-5818
 Fax: (231) 773-3453
 Service@WestshoreConsulting.com

PROJECT NAME:
MUSKEGON OIL FIELD
MARQUETTE AVE.
MUSKEGON TOWNSHIP,
MUSKEGON COUNTY, MICHIGAN

INSTITUTIONAL EXAMPLE
 (MARQUETTE AVENUE)

PROJECT: 3906-1
 FIGURE: 4



- LEGEND**
- GAS WELL
 - OIL WELL
 - ◆ DRY HOLE
 - ◆ WELL (UNKNOWN TYPE, LOCATION ONLY)
 - ◆ BRINE DISPOSAL WELL

ATTACHMENT A

**Central Michigan University
Essay on the History of
Muskegon Petroleum Exploration**

Link: <http://clarke.cmich.edu/oilandgas/historymuskegon.htm>



Muskegon Discovery Puts Michigan Solidly on the Oil Map

Following the 1925 discovery of oil in commercial quantities at the Saginaw Field, oil explorers in Ohio, Kentucky and Indiana, as well as local prospectors, became convinced that Michigan was the place to be for oil exploration. The Saginaw Field wells were commercial, but not spectacular, averaging 20-40 barrels per day. They were not particularly long-lived, as rapidly declining production rates would show over the last half of the 1920s. Nonetheless, out of state individuals and companies began to take oil leases in the state beyond the Saginaw area and local development companies were developed across the length and breadth of the state.

A host of test wells were drilled from 1925 to 1927, with minimal results. Michigan's days as an oil producing state might well have been numbered if not for the Muskegon Field. Oil and gas shows had been reported sporadically in Western Michigan wells drilled for salt and other purposes since the turn of the twentieth century. Muskegon County was considered prime petroleum prospecting territory. Intrigued by the oil and gas industry, brothers-in-law Charles Myler, an accountant, and Stanley Daniloff, a tailor, formed an oil company, Muskegon Oil Corporation (today Muskegon Development Company), raised capital, and drilled their first well. That well, drilled in July of 1926 reported light oil shows and was encouraging enough for investors to OK a second try.

A Standard Oil of Indiana subsidiary, Dixie Oil Company, was also active in the Muskegon area adjacent to Muskegon Oil Company lease holdings. Dixie Oil Company geologist Hugh D. Crider was anxious for a proven well in the area to justify the leases his company had taken out. Crider advised Myler-Daniloff and their investors to drill at a location four miles north of Muskegon (the Reeths 1 well, NW NW Section 9-T10N-R16W, Muskegon Township, Muskegon County) near the town of North Muskegon in an area already subdivided for industrial and residential use.

On December 8, 1927, the Reeths 1 encountered natural gas in the Traverse at 1,640 feet. Drilling further, at 1,700 feet oil was encountered and started to flow. The flow reached a rate of 330 per barrels per day, and then settled in at about 50 barrels of oil per day in later weeks.

The Muskegon discovery, blessed with a prime location near a center with a shipping infrastructure by land and water, brought big companies and independents from across the state and nation. The "boom" intensified when Dixie successfully drilled a second well on 200 acres it had acquired in its arrangement with Muskegon Oil and Muskegon Oil started another well. Expanding its holdings to more than 50,000 acres as fast as leases could be written, Muskegon Oil Corporation organized Muskegon Development Company with three subsidiaries (Citizens Petroleum, Lakeshore Petroleum and Juliet-Morris Development Company).

By mid-February, 1928, Muskegon Development had two test wells drilling. Ten other companies, Dixie, J. S. Reed, Johnson Oil and Refining Company, Bower and O'Keefe, Bull Dog Oil and Gas, Citizens Petroleum, Mario-Caswell, Lakeshore Petroleum, Carter Hill and A.S. Cochran were either drilling test wells or moving in to drill.

Four months after the Muskegon Oil discovery, seven oil wells and two wells rated as natural gas wells were producing more than 1,000 barrels of oil per day, making the field the biggest in the state. Dixie Oil became the largest gatherer and purchaser of crude oil in the field, sending the oil across the state to the company's new refinery at Zilwaukee, near Saginaw. Muskegon Traction and Lighting, which was marketing manufactured gas to greater Muskegon, promptly tapped into the two natural gas wells making available more than one million cubic feet of natural gas a day.

Oil made Muskegon a boom town. The local newspaper, the Muskegon Chronicle, reported in November, 1928, an estimated 1,000 people were involved with some phase of the area's new oil industry. That publication reported that about 70 drilling rigs were active in the area, most operating 24 hours a day. It cost from \$12,000 to \$15,000 to drill a successful well, with dry holes averaging around \$10,000 each. Days were long with most shifts lasting 12 hours, but workers' wages were good. Drillers received about \$2,600 a year and tool dressers about \$2,340 a year in a world where a new car cost \$525, a house \$7,333 and a loaf of bread 10 cents. The newspaper estimated that oil had led to an investment of about \$2 million in the area, with another \$1 million in the current drilling operations.

Drilling successes and increased competition, also led to a quick jump in the price of leases. A dollar an acre lease rental had been about par before the boom, but after the discovery of oil lease prices soon climbed to \$5 an acre. In some cases leases cost \$10 to \$50 per acre, and one account of \$2,500 per acre was rumored.

The Muskegon Field accounted for 347 well completions in 1929 resulting in 264 oil wells, 23 gas wells and 60 dry holes in the field's peak activity, shielding many a Muskegonite from the effects of the Great Depression that began with the October, 1929 stock market collapse. Oil production in the field peaked in 1929 with 3.1 million barrels of oil. Natural gas output peaked in March of 1929 at 428.8 million cubic feet.

Assistant Michigan Supervisor of Wells Robert B. Newcombe's 1932 report stated there had been 629 wells started or completed in the Muskegon Field with 439 completed resulting in 304 Dundee oil wells, 57 Upper Traverse oil wells, 14 Lower Traverse oil wells, 14 Lower Traverse natural gas wells, two Monroe natural gas wells and 64 dry holes. The development had covered about 3,170 acres, which on an estimated 629 dry and productive well completion basis would represent a well density of one well per 5.039 acres, closer in some places.

The final years of the 1920s saw western Michigan oil and gas discoveries and development in places other than the Muskegon Field. Muskegon Development and its three affiliates (Citizens, Lake Shore and Joliet) worked out a deal with Dixie Oil Company to core test 60,000 acres in Ottawa County and later the group core tested and deep drilled in Shelby, Hart, Weare, Pentwater and Benonia Townships of Oceana County.