STATUS OF INFRASTRUCTURE RELATED TO CRUDE OIL TRANSPORTATION IN THE GREAT LAKES/ST. LAWRENCE RIVER REGION

Prepared for the Great Lakes Commission by

Dr. Bradley Hull III, John Carroll University

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Notice

Any opinions, findings, or conclusions expressed in this paper are those of the authors, and do not necessarily represent the views of their employers, the Great Lakes Commission or its member states and provinces or the C.S. Mott Foundation

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Author's Bio

Bradley Hull III is Associate Professor of Supply Chain Management at John Carroll University in Cleveland, Ohio. At John Carroll, he researches Great Lakes logistics issues and, with the late Arnie de la Porte, developed a justification for the Cleveland Europe Express. Previously he was a supply chain manager at BP Oil and BP Chemicals Company for three decades. During that time, he developed many mathematical models for crude oil logistics. He was responsible for moving crude oil into the Great Lakes Basin from Canada, Alaska, the US West Coast, and the US Gulf Coast. Thus, he is familiar with North American crude oil and refined products pipelines, tankers, rail, and barge movements. Education: B.S. in Mathematics (University of Pennsylvania), M.S. in Operations Research (Stanford University), PhD. in Operations Research (Case Western Reserve University)

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EXECUTIVE SUMMARY

The Great Lakes States and Provinces host a large population and manufacturing base. They also possess a transportation infrastructure connecting the east, west, north, and south coasts of North America to one another and to Europe. As one example of this, grain from the US Great Plains and Canadian Prairies moves by rail to Lake Superior and from there onward by ship to Europe and West Africa or by rail and truck to the Mississippi River for transit to New Orleans for export. As another example, the city of Chicago handles more international containers than any port city in the US or Canada. The factual reason for this is that long distance movements of containers from the major east and west coast seaports tend to go through Chicago. The deeper reason for the many Chicago routings relates to the rail infrastructure – virtually all of the major North American railroads start or end at Chicago, making Chicago the natural hub for through movements.

From the above two examples, it can be seen that the unique geographical location of the Great Lakes States and Provinces makes them a logistical hub for North American trade, in addition to being a major producing and consuming location.

The same geography pertains to crude oil logistics. The Great Lakes States and Provinces host a significant refining capacity to support its large population and manufacturing base. It possesses a unique transportation infrastructure that delivers crude oil from anywhere in the world to its refineries. Its infrastructure also transships crude moving long distance the west (Canada, North Dakota, and Texas/Oklahoma) to other North American refineries on the East and Gulf coasts, and to export.

Despite more than 90 percent of crude oil moving by pipeline, rail and barge movements in recent years have been appreciable and well publicized. This paper examines the infrastructure of all three modes, identifying the routes, capacity, spare capacity, and age distribution. In addition, for each mode it discusses its flexibility and responsiveness to change. Each mode of transportation adds its particular contribution to the overall crude oil logistics network.

The pipeline system has gateways through which Canadian, Midcontinent, and foreign crude oil can enter the Great Lakes region. Canadian crude oil from Alberta enters the region at Clearwater WI, from where it can access regional refineries or be transshipped to the US Gulf Coast. Midcontinent crude oil enters the region in southern Illinois and Cincinnati OH, for delivery to regional refineries, including those in Montreal and Quebec. Foreign crude oil tankers can be unloaded in New Orleans and pumped directly to the Illinois gateway for delivery into the region.

Despite the many pipeline gateways and interconnections, though, the pipeline system does not cross the Appalachian Mountains. To move Canadian or Midcontinent crude oil to the East Coast refineries, a rail option forms part of the overall infrastructure. Rail cars are transshipped on a west-east route from oil fields to Chicago, and then across the region to East Coast destinations. Similarly, rail cars destined to the US Gulf coast often travel through the region on their way south.

Waterways facilitate pipeline and rail operations. Confined to the lakes and rivers, they no access to oil fields, relying on pipeline or rail terminals as their source of crude. They essentially extend the reach of rail and pipeline systems. As examples, crude oil is loaded to barge in the Chicago and southern Illinois areas from pipeline for delivery south to the Gulf Coast along the Mississippi River. This capability is useful especially when pipeline capacity to the Gulf is limited. Further, US and Canadian crude oil is also loaded from pipe in Montreal and then delivered by tanker to Quebec City on the St Lawrence River. This allows the Quebec City refinery access to US and Canadian sources instead of being exclusively reliant on foreign crude sources. As a second example, rail cars can be unloaded at two terminals in Albany for barge delivery to east coast refineries.

The overall transportation infrastructure is quite responsive to market demands. Pipelines are the least cost mode but face long lead times for permitting and construction. Many face environmental opposition. Rail is more expensive, but responds quickly to new sources of oil and refineries that may not have pipeline access. Barge and ship extend the reach of these two modes to additional markets.

In addition to responsiveness, the transportation infrastructure often responds in unexpected ways to market shifts. As example, the contested Dakota Access Pipeline, scheduled to begin operations in June 2017 will transport North Dakota crude oil directly to Gulf Coast refiners. This has already reduced rail shipments from North Dakota through the region to east coast refineries, and may eliminate them altogether. As another example, the Transmountain Pipeline expansion will divert significant quantities of Canadian oil to the West Coast. This will at least temporarily free up pipeline capacity to the region, and reduce rail transport.

In short, while the crude oil infrastructure is quite adaptable to market demands, it can respond in unexpected ways. Thus, proposed changes to the infrastructure routes need a thorough analysis as to their consequences.

SECTION 1: INTRODUCTION

The Great Lakes-St. Lawrence Region (GLSLR) comprises the States and Provinces that touch the Great Lakes and St. Lawrence River. The Region has a large population base and lies at the crossroads of many trade routes. Beginning in the early 1800s, furs from the Rocky Mountains passed through the Region en route to the countries of Europe utilizing the waterway system. Today, many other cargos transit the Region en route to other destinations. As only a few examples:

1. Grain from the Great Plains and the Prairies passes through the GLSLR en route to foreign markets. Grain also moves down the Mississippi River to the US Gulf Coast for export
2. International containers entering the US in Los Angeles/Long Beach travel by rail through Chicago for local delivery or redistribution to Mid-West and East Coast markets.
3. Almost all containers handled on the CSX Railroad from any East Coast or West Coast origin move through the Toledo Ohio area, en route to their ultimate destination.

Due to its central geographical location in North America, the GLSLR became a hub connecting outlying North American locations with each other as well as Europe. In supporting this hub, the GLSLR has developed a unique transportation infrastructure to complement its unique geography:

1. The St. Lawrence Seaway links the North American heartland to Europe on an east-west plane
2. The Ohio, Illinois, and Mississippi River uniquely link the GLSLR to the US Gulf Coast (these rivers all pass through the GLSLR) on a north-south plane.
3. <u>All but one</u> major North American railroad (Canadian and US) connect in Chicago, where they can interchange rail cars. Chicago handles more international containers than any other city in the United States, including the port cities of Los Angeles/Long Beach and New York.
4. At least 10 interstate highways cross the GLSLR with more than 8500 truckloads per day. This makes it one of the most heavily travelled regions in North America.

The GLSL Region infrastructure allows high volumes of cargos to "pass through" to other locations while continuing to serve its own major population base. This "pass through" nature of the infrastructure (also known as a "hub") has resulted in numerous distribution centers being located in the Region.

The same is true of the crude oil supply chain. That is the topic of this paper.

The Great Lakes-St Lawrence Region hosts a significant number of oil refineries that provide petroleum products to its large population base. The infrastructure delivers crude oil to these refineries and allows crude oil to transit the GLSLR from multiple oil fields to refineries on the East Coast and Gulf Coast.

The crude-oil infrastructure has evolved over time, and continues to do so; as one source of crude oil depletes, another new source has always taken its place. Major crude oil supply regions have been (in chronological sequence): Ohio/Pennsylvania, Illinois, Texas/Oklahoma, Foreign Sources, Canada, and lately Bakken from North Dakota and Saskatchewan and Tar Sands from Alberta. Each time the crude supply locations have shifted, the GLSLR has adapted its existing structure and developed additional infrastructure to accommodate it.

Technology has played an important role as well. The first railroad tank cars were fabricated at the Rockefeller refinery in Lima, Ohio. Prior to World War II, crude oil moved almost exclusively by rail and truck. As a result, GLSLR refineries tend to have excellent rail connections. Following the end of World War II, developing technology resulted in pipelines replacing rail to supply crude oil. Since then, crude oil in the GLSLR has virtually all been by pipeline.

In recent years, hydraulic fracturing (fracking) and development of the oil sands has allowed access to heretofore-unreachable crude-oil supplies. In the case of Bakken crude, this development has propelled a resurgence in rail and barge movements of crude oil due to a lack of pipeline infrastructure in the North Dakota area.

A desire for energy independence has also played an important role in shaping the infrastructure as well. The US and Canada do not wish to be dependent on crude oil sourced from foreign countries that may have hostile intentions. Until recently, the refineries in Montreal, Quebec, and the US East Coast have relied exclusively on foreign sources to supply their oil since they had no access to North American supplies. With foreign crude-oil prices escalating, many of these refineries have shut down in recent years. However, by extending the infrastructure (by pipeline to Montreal, by pipeline/water to Quebec City, and by rail to the US East Coast) in the past few years, these refineries have could access North American sources at lower cost. As a result, the East Coast refineries became more viable and some of the previously shutdown refineries were able to reopen.

This paper reviews the crude-oil pipeline, rail, and waterborne infrastructure in the GLSLR. To place the discussion of these modes in perspective, crude-oil transportation in the GLSLR is mainly by pipeline, and secondarily by rail and water. Actual volumes moved in the GLSLR are not directly available but the facts below add perspective:

1. The Energy Information Administration (EIA) estimates that total 2016 US crude oil production was 8674mbd, with 4% moving by rail (390mbd).
2. The Canadian Association of Petroleum Producers (CAPP) estimates that total 2015 crude oil production was 4160mbd, with 3% moving by rail (140mbd).
3. In 2016, barge movement of domestic crude were 535mbd, and foreign crude were 240mbd.

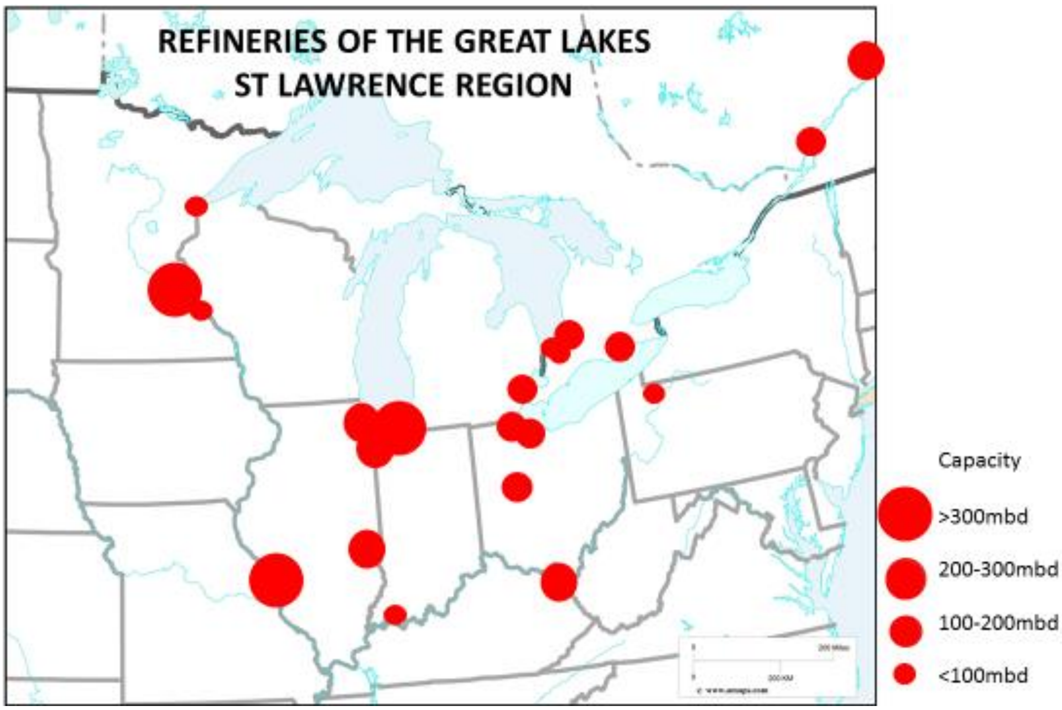
The above statistics demonstrate the overwhelming reliance of US and Canadian production on pipeline, relative to rail or barge. The GLSLR follows suit and relies predominantly on pipeline deliveries of crude.

The next section briefly discusses the GLSLR refineries being the ultimate consumers of the crude oil. The following three sections discuss the pipeline, rail, and water infrastructure individually. Then comes a discussion of infrastructure projects outside of the GLSL Region that may have significant impact on the Region as well as a discussion of crude oil supply projections and the impact we might expect on the Region. The study ends with a recap describing the infrastructure.

SECTION 2: REFINERY INFRASTRUCTURE

To support its population base, the Great Lakes-St Lawrence Region developed several refineries to produce the gasoline, diesel and other petroleum products needed. The refinery map in Figure 1 shows the locations and capacities of the Region's 23 refineries. These refineries are the "customers" for the crude oil delivery infrastructure. Appendix A contains a detailed list of the individual refineries and their capacities:

Figure1: Refineries of the GLSL Region



Outline map courtesy of amaps.com, locations and capacities added by B. Hull

The GLSLR refineries collectively have a capacity of 3853mbd of crude oil, comprising 19 percent of the crude oil refining capacity in North America. Significant refining capacity is located Illinois/Indiana as is seen in the table below. Within Illinois/Indiana, the capacity is concentrated in three Chicago-area refineries: Exxon/Mobil, BP, and Citgo. Other areas, such as Minnesota, Ohio, and Quebec have significant capacity as well. As a point of clarification, the Marathon Catlettsburg, KY refinery is on the fringe of the GLSLR. It is included in the map since its crude oil access routes transit the GLSLR.

Table 1: GLSL Region Refining Capacity Summary

Great Lakes/St Lawrence Region Refining Capacity		
	MBD	**State/Province**
	1,371	Illinois
	448	Indiana
	132	Michigan
	437	Minnesota
	585	Ohio
	76	Pennsylvania
	45	Wisconsin
	392	Ontario
	367	Quebec
	3,853	**TOTAL GLSLR REFINING CAPACITY**
	20,516	**TOTAL NORTH AMERICA**
	19%	PERCENT OF TOTAL NORTH AMERICA

Despite having a significant refining capacity, the GLSLR imports refined products by pipeline from the US Gulf Coast and by ship from abroad into the Quebec region. The need for imports indicates the refineries operate at a high percentage of capacity.

Regarding the refining infrastructure, one immediately notices from the map that many of the refineries are located on the Great Lakes or rivers, and as such have the opportunity to receive crude by water. In reality, no crude oil moves on the Great Lakes. Limited quantities of crude oil moves on the river system in barges. The primary water movements in the Region have been by crude-oil tanker from Montreal to a Quebec refinery on the St. Lawrence River.

The GLSLR refineries were built prior to World War II when rail was the primary delivery mode for crude oil as well as the finished petroleum products. As a result, the GLSLR refineries have excellent rail connections. Many of them can receive crude oil by rail and several have constructed rail racks for this purpose in the past few years. The others would have little difficulty in doing so if the opportunity arose. Just as with water, the quantity of crude received by rail is limited.

In fact, the GLSLR refineries rely on pipeline to connect them to the crude oil markets. Pipelines from the south of the United States can deliver US Gulf Coast, offshore, and foreign crudes. Pipelines from the northwest can deliver Canadian and Bakken crude. Finally, pipelines from the southwest can deliver domestic Texas/Oklahoma crudes. This gives the GLSLR low-cost access to all the major global crude oil markets.

SECTION 3: PIPELINE INFRASTRUCTURE

The section below discusses the crude-oil pipeline infrastructure for the Great Lakes-St Lawrence Region. Pipelines, as will be seen, are the dominant (and for that matter, almost exclusive) form of crude-oil transportation   We begin with some basics of the petroleum pipeline industry. Next, we discuss the existing pipeline network, system metrics (such as capacity, capacity utilization, and pipeline age), and then identify flexibilities within the infrastructure.

3.1 Pipelines 101[1]

Crude oil and refined products virtually never travel in the same pipeline. The reason for this is that crude oil, being the raw material of refining, contains many impurities pumped to the surface of oil wells. These impurities would contaminate refined products that have tight, government-mandated specifications. Thus, North America contains two separate systems of pipelines – one for the crude oil and the other for finished, refined products. Both sets of pipelines remain full even if they are not operating since allowing air to enter the pipeline would create a hazard. If a pipeline is emptied for testing or decommissioning, the air space filled with nitrogen gas to avoid this hazard.

Pipelines are slow. The speed at which crude oil moves through a pipeline varies depending on the diameter of the pipeline and the volume and viscosity of the product; a rule of thumb would be approximately 5-7 miles/hour.

Light crudes, such as Bakken and WTI, have low viscosity and are easy to pump. Heavy crudes from Canada often have high viscosity and need to be "thinned out" with a lighter diluent to lower their viscosity so that they can be pumped. The thinned-out product is called dilbit (diluted bitumen).

Pipelines are classified as either "common stream" or "batch". The Enbridge Pipeline System is a good example of batch pipelines in that batches of multiple different crude oil types move in the line "back to back" with no barrier between them. By controlling the speed of the pipeline, each individual batch remains intact with less than .1% of two contiguous batches mixing. These batches enter the pipeline in sequence in Alberta. The integrity of each batch is important since the refinery-purchaser of a crude oil batch may have paid a premium for a crude oil type with specific chemical properties and insists on receiving their batch uncontaminated.

Common-stream pipelines are somewhat different. These pipelines move only a single type of crude oil, and as such, the identity of a specific batch is not as important. For such pipelines, pushing a barrel of the common crude oil type into the line forces a barrel of the same common crude out of the line at destination. Thus, though the speed of the pipeline may be 6-7 miles per hour, the delivery is instantaneous. Integrity of the crude oil in the pipeline is guaranteed, since only a single type of oil

[1] See http://www.aopl.org/pipeline-basics/pipeline-101/ and Hull, Bradley, *"Oil Pipeline Markets and Operations",* Journal of the Transportation Research Forum 44 (2), Summer 2005, pp. 111-125

moves in the line therefore eliminating the risk of mixing two different types. The Dakota Access Pipeline is common stream, since it will only carry Bakken crude oil.

3.2 Existing Pipelines in GLSLR

An intricate network of pipelines delivers virtually all the oil processed by GLSLR refineries. This same GLSLR network further serves a Marathon refinery on the periphery of the GLSLR (on the Ohio/Kentucky border in Catlettsburg Kentucky). Figures 2a and 2b below show these pipelines along with their capacities. Note that the map refers to the "Chicago Area". This term refers to the Chicago area refineries, as well as nearby pipeline terminals at Griffith, Lockport, and Flanagan. Collectively referring to these locations allows for map simplification.

Figure 2a: Crude Oil Pipelines in the GLSL Region

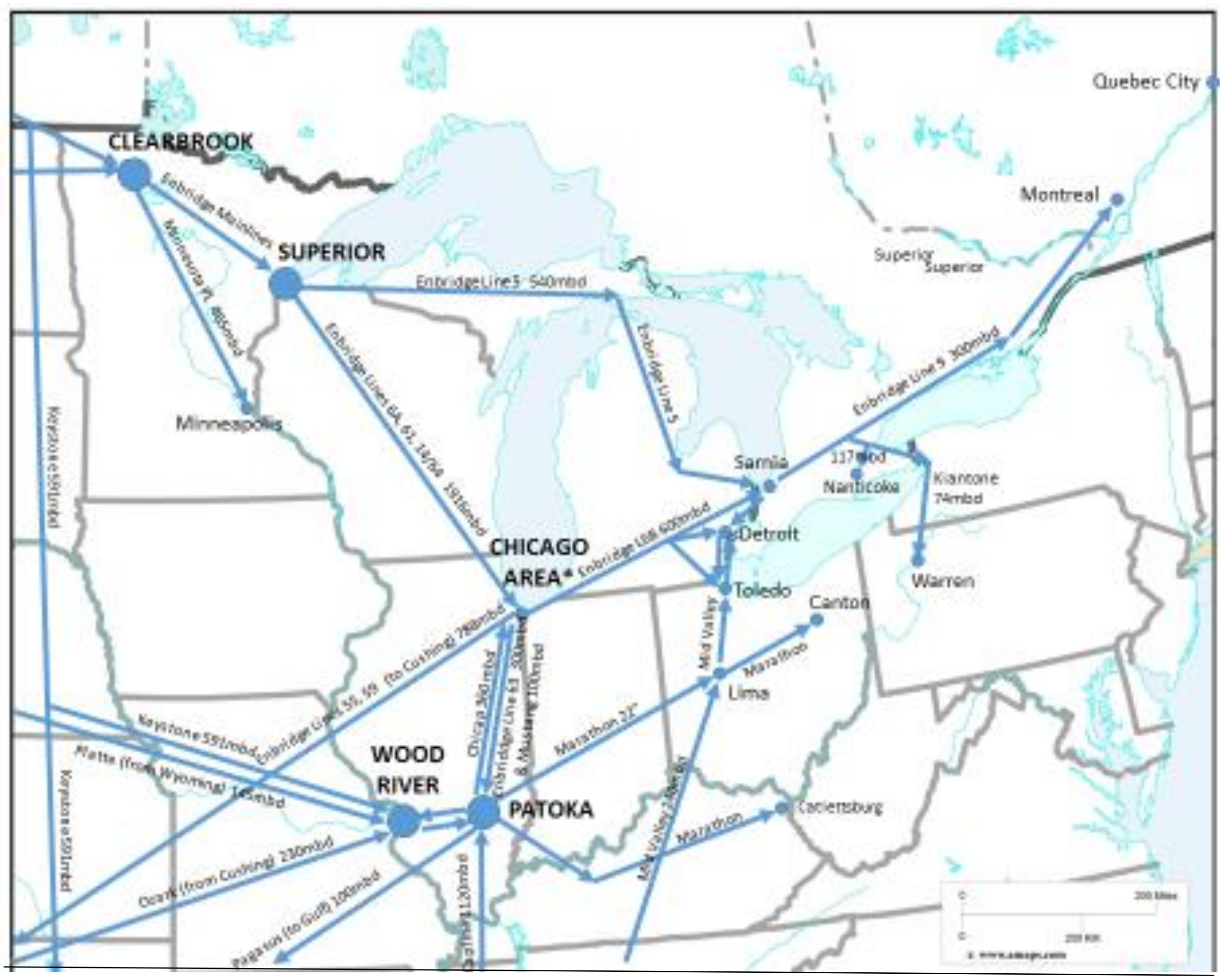


Figure 2b: Crude Oil Pipelines in the central area of the GLSL Region

For details about the pipelines shown in the above maps, including their capacities, diameters, flow rates, expansion plans, please refer to the pipeline table in Appendix B. Appendix B also indicates the sources from which this information was drawn.

Crude oil enters the GLSLR system at one of two gateway locations—Clearbrook, MN/Superior, WI and Patoka/Wood River, IL. It can also enter directly from the US Midcontinent via the Mid Valley Pipeline (see above), or from Enbridge Line 5 from Sarnia. After arriving in the system, the oil is destined to the GLSLR refineries, the Catlettsburg, KY refinery, or export to the US Gulf Coast. These four alternatives are below:

Clearbrook/Superior gateway: Both Canadian and Bakken crude oil flow into the Clearbrook. At Clearbrook, The Minnesota Pipeline can deliver crude to the Twin Cities refineries (Koch and Western Refining). Most of the crude, however, proceeds along the Enbridge Mainline to Superior, WI. At Superior, an Enbridge tank farm redirects the crude to the Chicago Area along a southern route through Wisconsin, or to Sarnia along a northern route, which crosses the Straits of Mackinac. The crude arriving in Chicago is pipelined to 1) local refiners, 2) east to Detroit, Toledo, and Sarnia along Enbridge Line 6B, or 3) south to Patoka along one of two lines, from which other GLSLR refineries and the Marathon Catlettsburg, KY refinery can be accessed.

Crude oil travelling the northern route from Superior is destined to Sarnia on Enbridge's Line 5. At Sarnia, the crude accesses the Sarnia refineries. It can also be shipped south to Detroit/Toledo using a Sunoco pipeline, or east to the other Ontario, Pennsylvania, Montreal, and Quebec City refiners.

As a point of flexibility, the Sarnia refiners as well as the Ontario and Quebec refineries further east, have two routes to receive crude oil – one through Line 5 and the other through Line 6B. With the Enbridge system operating relatively full, shutting down Line 5 may cause a capacity shortage on Line 6B when Canadian refiners try to redirect their crude flows.

Regarding crude oil types moved through the Clearbrook/Superior gateway, the Enbridge system batches a wide variety of Canadian crude oils from light sweet and sour oils, to heavy crude oils, to dilbit (diluted bitumen). This gateway also is the primary source of Bakken crude that GLSLR receives by pipe. This follows since the Bakken fields connect to the Enbridge system through multiple smaller pipeline connections in North Dakota and Saskatchewan. Enbridge has expanded its Bakken connections in recent years to compete with crude by rail shipments.

As a final note regarding crude oil types, Enbridge moves no bitumen (dilbit) on Line 5. All bitumen (dilbit) required by the Ontario, Quebec, and Pennsylvania refineries is delivered through Line 6B.

Patoka/Wood River Gateway: The Patoka/Wood River area is the second major gateway by which crude oil enters the GLSLR system. Inbound are pipelines from Canada carrying Canadian crude (and small quantities of Bakken), pipelines from the US Gulf Coast that can deliver cargoes of crude oil from foreign countries, and pipelines from the Texas/Oklahoma oil fields.

From Canada, the Platte Pipeline delivers Canadian crude along with small quantities of Bakken. In addition, the Keystone Pipeline (separate from Keystone XL) delivers Canadian crude.

From Cushing, OK, the Ozark pipeline brings Texas/Oklahoma crudes which would include Permian Basin crudes such as Eagle Ford and WTI.

From the Gulf Coast, Capline, with a capacity of 1200mbd has been the route of choice to import foreign cargos for many years. Currently, increased volumes of Canadian crude oil flow south from the Chicago Area to the Gulf Coast, creating significant competition for Capline, which moves cargos north to Patoka. As such, Capline has been operating at low rates, making it a reversal candidate to move Canadian oil south to the Gulf Coast at some point in the future. Plains, BP, and Marathon collectively own Capline. BP and Marathon, both of which own refineries in the GLSLR have both refused to reverse the line. One would expect that with both companies owning GLSLR refineries, they would want to keep an access route open so that they can purchase and receive foreign cargos. Capline is the only existing route by which the GLSLR can receive foreign cargos today.

Once crude has reached Patoka/Wood River by any of the above routes, 1) Phillips 66 refines it at their Wood River IL refinery, 2) pipelines ship it to the other GLSLR refineries, or 3) a Marathon pipeline delivers it to the Marathon refinery in Catlettsburg, KY. Patoka crude destined for Canada transits to Chicago and into Line 6B. The route across Ohio using the Marathon 22" pipeline can't access Sarnia.

Mid Valley Pipeline gateway: The Mid Valley pipeline connects the Texas-Oklahoma oil fields with Ohio and Michigan refiners. Per personal communication, the system typically runs full. However, the line does not have access to Canadian or other US refiners.

Pass-Through Routes: Canadian and Bakken crude can pass through the GLSLR network en route to US Midcontinent and US Gulf Coast refiners. In fact, there are three such routes. The first and oldest route, is the Pegasus Pipeline which is owned by Exxon/Mobil. Pegasus was constructed between 1949 and

1957 to move Texas crude to Mobil's Joliet, IL refinery. It was reversed in 2006, and is the first pipeline that moved Canadian crude oil to the Gulf Coast. The line is small, having a 20" diameter, and can move 100mbd. At nearly the same time, another old crude oil line was reversed. That being the Enbridge Line 55, or Spearhead Pipeline. Spearhead was constructed shortly after Pegasus, prior to 1957 to move domestic crude oil from Cushing OK to Chicago for Arco. Known originally as the Cushing-to-Chicago line; it was also reversed in 2006 and has a capacity of 193mbd. With significant production coming on stream in Canada, Enbridge constructed Line 57, also known as the Flanagan South Pipeline from the Chicago area to Cushing. This line with a capacity of 585mbd is the main pass-through route to the Gulf Coast.

The last component of the existing GLSLR network to discuss is the Canadian delivery system going east from Sarnia.

Sarnia Eastern Routes: Entering Sarnia from Enbridge Lines 5 and 6B, crude oil is either consumed by the local Sarnia refiners, shipped south through a Sunoco line (which is usually full), or shipped east on Line 7 or Line 9. Line 7 allows access to the Imperial Refinery at Nanticoke, ON and United Refining in Warren, PA. Line 9 operates from Sarnia to Montreal. Line 9 has a colorful history – it has been reversed twice. Built in 1976 it allowed the Montreal refiners to receive Canadian oil for first time – replacing foreign oil that arrived by ship. This provided energy independence for the Montreal refiners after the Arab oil crisis of 1978. However, by 1997, foreign crude had become increasingly attractive. So Line 9 was reversed to deliver foreign crude from Montreal westward to the other Ontario refiners. It's second reversal occurred in 2015 to provide Montreal refiners the ability to access Canadian crude oil (which had fallen in price due to high Alberta production rates) once again, making them independent of foreign crude suppliers. Suncor, the only remaining refiner in Montreal, is also a crude oil producer in Alberta. The Line 9 reversal has allowed Suncor to refine its own crude oil.

An added impact of the 2015 Line 9 reversal is that prior to 2015, the high price of foreign crude oil forced several Montreal refiners to shut down. This affected the Montreal chemicals industry negatively, since it relies on refinery products for feedstocks. With Line 9 reversed, Suncor regained viability and access to lower cost Canadian crude oil caused feedstocks to decrease in price – helping the Montreal chemical industry to regain viability.

The Line 9 reversal of 2015 has also provided Valero's Quebec City with access to lower cost Canadian crude and has allowed them to reduce foreign crude oil purchases. Without pipeline access to Montreal (Line 9 ends in Montreal), Valero now transports crude oil by ship from Montreal to Quebec City.

Additional information on the existing pipeline network are in Appendix B.

We next turn to system metrics, which we can use to further assess the status of the pipeline network.

Proposed Pipelines in GLSLR – TransCanada's Energy East Pipeline

In January 2017, the National Energy Board reopened hearings on the possibility of issuing permits to allow TransCanada to construct their Energy East Pipeline through six Canadian provinces, including Ontario and Quebec. With this pipeline potentially operating across two GLSLR Provinces (and six

Provinces in total), it is important to consider this possibility and its potential impact on the existing GLSLR system.

Energy East is set to be a 1100mbd pipeline that would move crude oil from Alberta and the Bakken fields to three refineries in eastern Canada and an export terminal so that Canadian oil can be shipped abroad to Europe and India. The refineries are Suncor in Montreal, Valero in Quebec City, Irving in St. John, New Brunswick, and an expansion of the Canaport oil terminal in New Brunswick or Port Hawkesbury NS

The line would be 4000km (2860miles) long, 70 percent of which would be an existing gas line converted for crude oil service. While routed through the Great Lakes-St Lawrence Region (that is, the contiguous States and Provinces, it largely avoids the Great Lakes Drainage Basin (that is, the geographical area that drains directly into the Great Lakes). In fact, from Lake Superior it is routed north along the Albert River (which flows to Hudson Bay) exiting the Great Lakes Basin, and then re-enters the Great Lakes Basin as it's route turns south along the Ottawa River into Montreal.

The line has two benefits. First, it allows the three-abovementioned Canadian refineries to receive Canadian crude oil. Currently, Suncor Montreal receives Canadian crude oil directly from the Enbridge system, Valero Quebec City receives Canadian crude by ship from Montreal, and Irving has no pipeline access to Canadian crude oil. Thus, Energy East allows these refineries to process Canadian crude as opposed to large quantities of foreign crude delivered by ship. Second, the line gives Canada excellent access to foreign markets instead of being reliant on US markets. With some of the deepest waters in North America, New Brunswick can load the largest crude oil tankers (called VLCCs, for very large crude carriers). Europe has several refineries that can process bitumen and some of them are Canadian oil producers. India has also expressed interest in Canadian crude oil from New Brunswick. Geographically, New Brunswick is closer to India (via the Suez Canal) than the West Coast of Canada, and the deep water and ice-free nature of Canaport in New Brunswick means that the cost economics of large tankers are compelling.

Energy East, if approved and constructed, would affect the GLSLR in two main areas. First, it would provide a greater measure of energy independence for the three Canadian refineries. Second, it would create competition for Canadian and Bakken flows that presently enter the GLSLR via the Enbridge and Platte systems for consumption and transshipment to the Gulf Coast. The Gulf Coast export terminals would compete with the New Brunswick terminal.

3.3 System Metrics

To measure the status of the system, we now measure capacity and capacity utilization, infrastructure age, and spills. We address these three areas individually. This section presents general results on these topics. Further details can be found in Appendix B.

Capacity and Spare Capacity: The GLSLR receives crude oil from all areas of the world – Texas/Oklahoma, North Dakota, Canada, and foreign countries. The infrastructure has adapted to handle each of these. Crude oil from foreign countries arrives on the Gulf Coast via crude oil tankers and is pipelined north to the GLSLR. Recently, the growth of Canadian and Bakken crude production has essentially "backed out" large volumes of foreign crude from the GLSLR. Today, few foreign tankers are received on the Gulf Coast. Further, with the influx of Canadian crude oil, many pipelines that used to carry foreign crude north to the GLSLR have been reversed. They now to carry Canadian crude to the Gulf Coast. Further, Enbridge constructed a 585mbd line connecting the Chicago area with the Gulf Coast which has increased the flow of Canadian crude oil south. One foreign crude line, Capline, remains in operation, unloading tankers and pumping their cargos to the GLSLR. With significant Canadian competition, Capline operates at very low rates and is a candidate for reversal as Canadian and Bakken production continue to increase. Table 2 below gives a high-level view of the capacities into and out of the GLSLR:

Table 2: GLSLR Pipeline Capacity

GLSLR PIPELINE CAPACITY SUMMARY		
		PIPELINE CAP'Y
		MBD
INTO GLSLR		
	from Canada	3657
	from MidCon	470
	from USGC	1200
	Total	**5327**
Refining Capacity		**4081**
OUT OF GLSLR		**878**

Note that the GLSLR has more pipeline capacity entering it than the refining capacity and pipeline capacity "OUT OF GLSLR". This is partly due to Capline (shown as the 1200mbd capacity figure above) operating at fractional capacity in response to increasing Canadian shipments. Also, Keystone, which is included in the "from Canada" designation above, can redirect its 591mbd capacity to the Gulf Coast. Also, it is worth noting that Enbridge only recently constructed its "Flanagan South" PL in 2014 with 585mbd of capacity connecting the Chicago area to the Gulf Coast. This figure is included in the "OUT OF GLSLR" designation.

Age Distribution of GLSLR Pipelines: A review was made of two of the age related issues with regard to the GLSLR pipelines. The first result, in Table 3, shows that the GLSLR underwent a significant construction boom in the 1950s, which slowly tapered off, until the 1980s, when construction resumed again due to the increase in Canadian oil production.

Table 3: Age Distribution of GLSL Region Pipelines

TOTAL MILES OF GLSLR CRUDE OIL PIPELINE BY DECADE OF CONSTRUCTION (includes all pipelines in GLSLR and only miles within GLSLR)		
	Number of Pipelines	Total Miles in GLSLR
1940s	1	80
1950s	8	2277
1960s	6	1274
1970s	3	1024
1980s	2	297
1990s	3	617
2000s	3	954
2010s	5	765

For the second result, shown in Table 4, only the major pipelines in the GLSLR were analyzed. Here, "major" pipelines are defined as those with significant exposure in the region (150 miles or more).

Table 4: Age Distribution of GLSLR Pipeline Capacity

CAPACITY OF THE MAJOR GLSLR CRUDE OIL PIPELINES BY DECADE OF CONSTRUCTION (includes pipelines in GLSLR that are more than 150 miles long)			
Construction Decade	Number of Pipelines	Total Capacity MBD	Total Miles in GLSLR
1940s	0	0	0
1950s	7	1685	2157
1960s	3	1469	920
1970s	3	790	1024
1980s	1	100	250
1990s	1	318	467
2000s	3	1892	954
2010s	5	1685	615

For the major pipelines, it is apparent that the capacity constructed in the 2000s and 2010s rivals that of the boom during the 1950s and 1960s

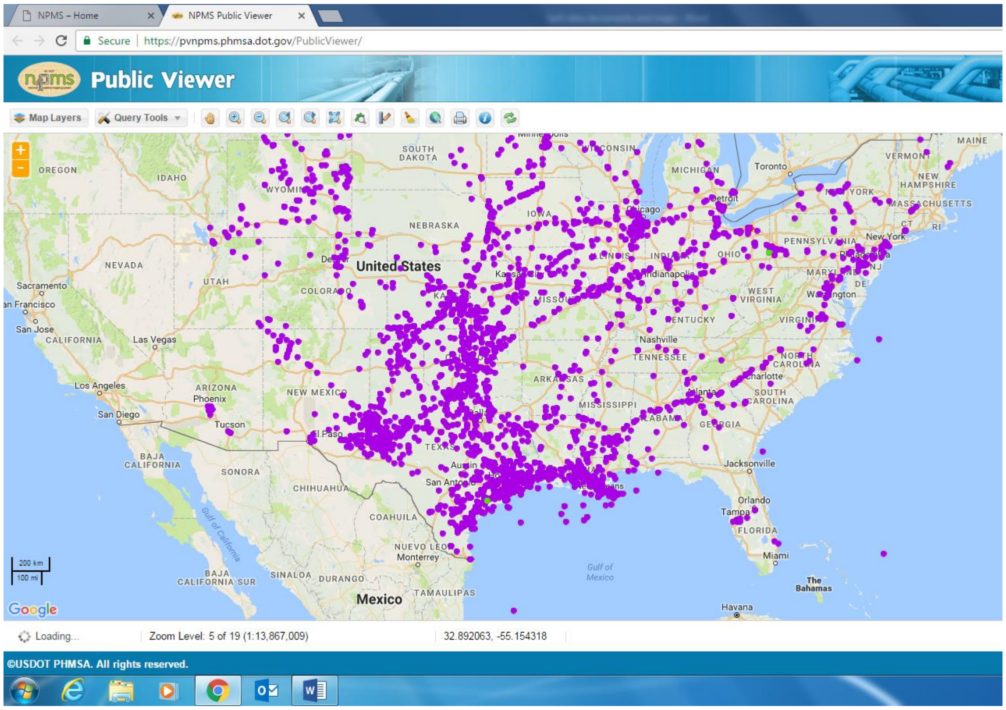
Thus, the construction boom of the 1950s and 1960s added considerable miles. The current boom has not added as many miles, but due to the use large diameter pipes, it adds an equivalent amount of capacity.

Spill history of GLSLR Pipelines: The Pipeline and Hazardous Materials Administration (PHMSA) tracks petroleum pipeline spills. PHMSA hosts a National Pipeline Mapping System where one can specify state and county. The Public Viewer then generates a map showing hazardous pipelines

To use the National Pipeline Mapping System[2], one goes to the page where one specifies state and county. The Public Viewer (see Figure 3 below) can generate a regional map with hazardous pipelines as well as regional or national maps with dots specifying all spills in their database.

[2] https://www.npms.phmsa.dot.gov/

Figure 3: Public Viewer: US hazardous pipeline spills map



Source: https://pvnpms.phmsa.dot.gov/PublicViewer/

Clicking on any one of the dots (representing spills) yields the pipeline name, year, volume released, product spilled, and cause of spill. This unique PHMSA database draws information from mandatory spill reports filed by pipeline companies. Please note that this map shows crude oil spills as well as refined product spills, as well as all other hazardous liquid spills.

3.4 Flexibility and Responsiveness to Change

The pipeline industry responds to change. The 1950s saw a boom in pipeline construction as the crude oil boom in Texas/Oklahoma shipped to the GLSLR refineries. As the Texas/Oklahoma fields began to dry up, the GLSLR replaced the Texas/Oklahoma crude with foreign crude oil arriving in the Gulf Coast in tankers. New lines were constructed from the Gulf Coast to the GLSLR, and pipelines were reversed that had previously shipped Texas/Oklahoma crude to Gulf Coast refineries. At one point, Capline, Texaco, Sun, Arco, Mobil, and Seaway, all had pipelines moving foreign crude oil north to the GLSLR. Finally, in the 1990s, Canadian crude became available to GLSLR refineries in large quantities at attractive prices. This event resulted in another construction boom as Canadian oil companies constructed lines to the GLSLR refineries.

Today, Canada produces enough oil to meet GLSLR demands and still ship additional crude to the Gulf Coast. In addition, the discovery of Bakken has added to the flow. In turn, this has resulted in additional expansions to and through the GLSLR to access the US Gulf Coast refineries.

The oil pipeline industry has a response mechanism to deal with change. The following list of actions can be taken when indicated[3]:

1. A drag reducing agent, known as DRA, can be added to a pipeline to increase its capacity.
2. Additional pump stations can be added along a pipeline to increase its capacity.
3. An existing crude oil pipeline might be reversed
4. A pipeline can be converted from natural gas service to crude oil service if it is no longer needed for gas.
5. A pipeline can be "looped." That is, a second line can be constructed parallel to the first. An advantage of looping is that the pipeline company may be able to use the right of way agreements for the first pipeline, rather than needing additional right of ways. Having two pipelines parallel to each other can reduce maintenance costs.
6. Finally, a new pipeline can be constructed using a new route after negotiating new right of way agreements.

The above potential actions assist crude oil networks in adapting to changing supply sources. Several examples of each of these have occurred in the GLSL Region, as has been indicated in the discussion of existing pipelines above. Ozark has been expanded using DRA and additional pump stations, Enbridge Line 9 has been reversed twice since its construction in 1979. An older crude oil line (Tecumseh) in the GLSLR was converted to gas service in the 1990s. Enbridge often loops lines to add capacity. Gas conversions to crude oil service have been proposed for pipelines such as the Energy East Pipeline described earlier in this section.

[3] Hull, B. (2005)

SECTION 4: RAILROAD INFRASTRUCTURE OF THE REGION

The section below discusses the railroad infrastructure for the Great Lakes-St Lawrence Region. Railroads, as will be seen, are a highly flexible form of crude oil transportation, since they can respond quickly to market changes and can access customers who are without pipeline access. We begin with some railroading and petroleum railroading basics. Next, we discuss the existing GLSLR rail network, system metrics (such as capacity, capacity utilization, and age), and then identify flexibilities within the infrastructure.

4.1 Railroads 101

The primary railroads in North American are the seven Class 1 railroads. They include the western railroads (BNSF and UP), the eastern railroads (NS and CSX) and the Canadian Railroads (CN and CP), and KCS which operates into Mexico. The eastern and western railroads operate on opposite sides of the Mississippi River. There are also many short lines and regional railroads as well.

Railroads operate their trains on their own tracks and transport rail cars for their customers. They do not own the contents of the rail cars – the contents are owned by the shippers. They are fast, running at an average of 20-25 miles per hour. If an origin customer and a destination customer are located on different railroads, the cars must be transferred between the two railroads at an officially designated interchange point where the two railroads meet. Chicago is one of the major interchange points in the United States.

Railroads usually have multiple routes to choose among when delivering cars from any origin to any destination. The railroad (or multiple railroads if the car needs to be interchanged) selects the route. Railroads tend to route their trains along a few of their heavily travelled, dense routes. These routes accommodate the higher volume of traffic and may be double-tracked. In essence, railroads follow the well-known “80/20 Rule” in which a small percentage (20%) of the routes carry the bulk of the traffic (80%).

Railroads began in the early 1800s, competing with the early canals to attract business. As the oil industry developed in the late 1800s, railroads became the mode of choice for refineries. Railroads delivered all crude oil to the refineries and shipped all the refined products. Pipeline technology developed during WWII and pipelines quickly became the mode of choice for the refineries. Today, GLSLR refineries (almost all of which were built prior to WWII) tend to have excellent rail access. They still use railroads to move many refined products such as isobutane, propane, propylene, asphalt, and coke, while pipelines move the preponderance of crude oil and other refined products.

Crude oil moves in tank cars. The first tank cars were constructed in the GLSLR at the Standard Oil Lima refinery during the late 1800s. Crude oil tank cars travel loaded from oil field to refinery, and then return empty, since there is rarely a return load and because the crude oil residue remaining in the car would likely contaminate any return cargo. Oil companies lease the cars from companies such as GATX on a five to ten-year lease or own them outright. Railroads strictly pull them for the oil companies.

Standard tank cars can transport light crude oils. To transport highly viscous crudes such as bitumen, standard tank cars must be equipped with interior steam coils. Viscous crudes are pumped into the tank car hot. The crude cools in transit, regaining its viscosity. At destination, steam is circulated through the coils in the car to heat the crude again, so that it can be pumped into storage. A tank car hold 600-700 barrels of light crude, or 500-525 barrels of heavy crude.

Manifest trains or unit trains transport crude-oil tank cars. A manifest train carries cargos of other non-oil products destined for multiple destinations along with a string of crude-oil cars destined to a single refinery. They travel through a series of classification yards where non-oil cars are taken off and others are added on. This process can be time consuming and involves multiple handlings of the tank car. A tank train has 70-120 tank cars. Tank trains are fast, since they travel directly from a single origin oil field to a single refinery, bypassing classification yards.

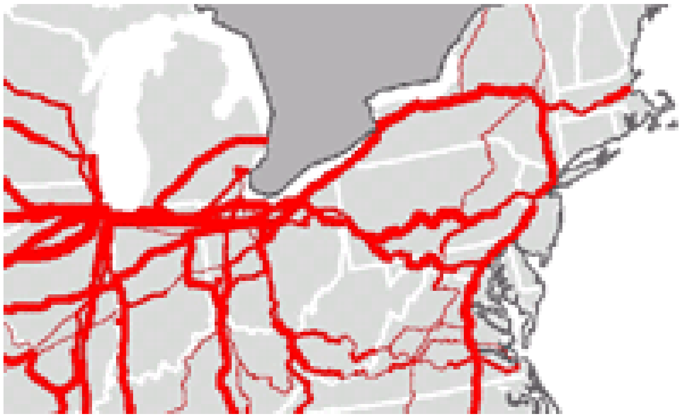
4.2 Existing Railroad Routes in GLSLR

The GLSLR has excellent rail access – perhaps better than any other region of the US and Canada – due to Chicago's status as the primary rail hub of North America. All the major western, eastern, and Canadian railroads (with the exception of KCS) interchange in Chicago. More than one fourth of all freight trains and half of all intermodal trains originate, terminate, or pass through Chicago between the East and West Coast. Chicago train traffic involves roughly 1,300 trains per day. From our perspective, the majority of trains carrying bitumen from Alberta and the Bakken crude from North Dakota pass through Chicago on their journey to GLSLR refineries. Many also pass through Chicago en route to East and Gulf Coast Refineries. The main crude oil rail routes are discussed below.

The "Chicago East Coast Corridor"[4] is a well-known set of heavily travelled tracks through the heart of the GLSLR connecting Chicago with the major US East Coast ports. The heavy lines on Figure 4 below represent routes that handled 100-200 trains per day of mixed freight during 2007. This corridor transports Bakken oil (as well as some bitumen) to US East Coast refineries. Destinations for the crude are primarily the east coast refineries, with some volume stopping off at the GLSLR refineries.

[4] Hull, Bradley, *"The Chicago-East Coast Corridor: Changing Intermodal Patterns*", Transportation Journal 51 (2), March 2013, pp. 220-237.

Figure 4: Railroad routes through the Chicago East-Coast Corridor[5]



Source: National Surface Transportation Policy and Revenue Commission, "Transportation for Tomorrow, Final Report" 2007, Chapter 3. Further Source: Association of American Railroads

The two eastern railroads, Norfolk Southern and CSX, both operate along this corridor.

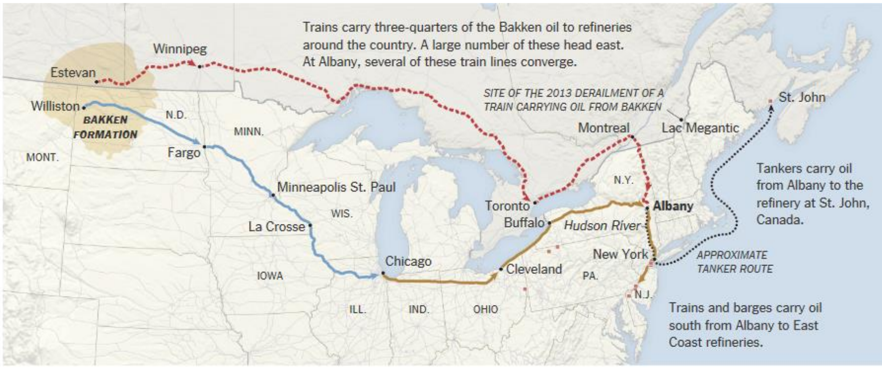
CSX Railroad: Once the CSX Railroad receives crude-oil trains from the western and Canadian railroads in Chicago, it routes them along its well-known "waterlevel route" from Chicago to New York. This route is depicted as the northernmost route on the map above. The waterlevel route is aptly named because the route from Toledo to Cleveland to Buffalo is alongside Lake Erie, the route from Buffalo to (Rochester, Syracuse, Schenectady and then to) Albany, NY follows the Erie Canal, and the route from Albany to New York follows the Hudson River. Being alongside water, the route has no tunnels and no mountains. These factors make it a quick and cost effective route for CSX. Trains can be unloaded in Albany or continue directly to New York. CSX has a secondary route from Toledo through Ohio to Yorktown, VA, where barges can be loaded to East Coast refiners. CSX is the primary railroad that moves crude oil in the GLSLR

NS Railroad: NS Railroad moves less crude oil than CSX. Its route extends from Chicago through Toledo, OH and across Pennsylvania to Philadelphia and New York and appears on Figure 4.

The CP Railroad is fortunate to have direct connections to the Bakken fields as well as direct connections to the Canadian refiners and the Albany terminal where ships and barges are loaded for East Coast and Canadian destinations. Its main Canadian competitor, CN Railroad, has few Bakken connections. CP's main Bakken competitor for East Coast markets, BNSF, does not have such one-line connections but instead needs to interchange its oil trains to either CSX or NS Railroads for final delivery. Since interchanging cars between two carriers is often quite costly, CP's direct one-line service to the Montreal refinery and the Albany terminal and New York is likely cost effective. Figure 5 below shows the CP one-line service to Albany through Montreal:

[5] http://transportationfortomorrow.com/final_report/chapter_3.htm

Figure 5: The Canadian Pacific Route through Canada



Sources: Energy Information Administration; BNSF; Canadian Pacific; CSX

GRAPHIC BY GUILBERT GATES AND JOE BURGESS

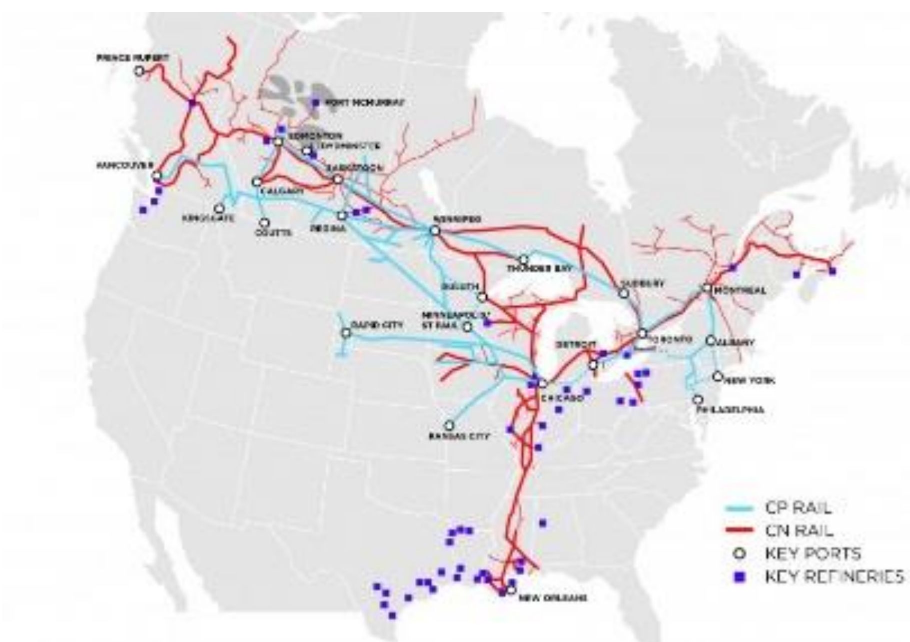
Source: New York Times, 2014[6]

The BNSF Route from North Dakota to Chicago

The BNSF Railroad, owned by Warren Buffett's Berkshire Hathaway, operates primarily west of the Mississippi River. It is the primary railroad accessing the Bakken fields in North Dakota. The BNSF route from Bakken to Chicago is depicted in Figure 5. In Chicago, BNSF interchanges primarily with CSX for delivery to Albany and New York. As can be seen, this BNSF/CSX route to the east coast transits *the entire* US portion of the GLSLR except for the state of Michigan and the Provinces.

The Canadian National Route to the US Gulf Coast

Figure 6: Canadian National and Canadian Pacific RR routes through GLSLR



[6] http://www.nytimes.com/2014/02/28/business/energy-environment/bakkan-crude-rolling-through-albany.htm

Source: Canadian Association of Petroleum Producers[7]

The Canadian National Railroad has little Bakken access but accesses multiple terminals in Alberta that ship Canadian Heavy and bitumen to the US Gulf Coast refineries. The CN route, as depicted in Figure 6, is a single-line route from Alberta, through Chicago, to New Orleans. South of Chicago, the route runs the length of Illinois. CN has expended significant effort to reroute its trains around downtown Chicago by purchasing the Elgin, Joliet, and Eastern Railroad, which circumnavigates the city, in 2009. This added Chicago "bypass" enhances the attractiveness of this route.

Ohio's growing production of Utica shale oil has resulted in short lines such as Ohio Central and regional lines such as the Wheeling and Lake Erie Railroad moving both crude oil and fracking sand[8]. The Ohio crude-oil sources load condensate to rail at the Black Run Terminal in Frazeysburg, Ohio and the Mark West Terminal in Cadiz, Ohio.

4.3 System Metrics

As further measures of the status of the system, the topics of capacity, spare capacity, infrastructure age, and spills are addressed in this section. Capacity is difficult to measure for railroads because one must consider the capacity to load tank cars, utilization of engines, scheduling limitations, track congestion, and tank car availability. No quantitative capacity and spare capacity figures are calculated in this section but the individual components are further described to arrive at a qualitative answer.

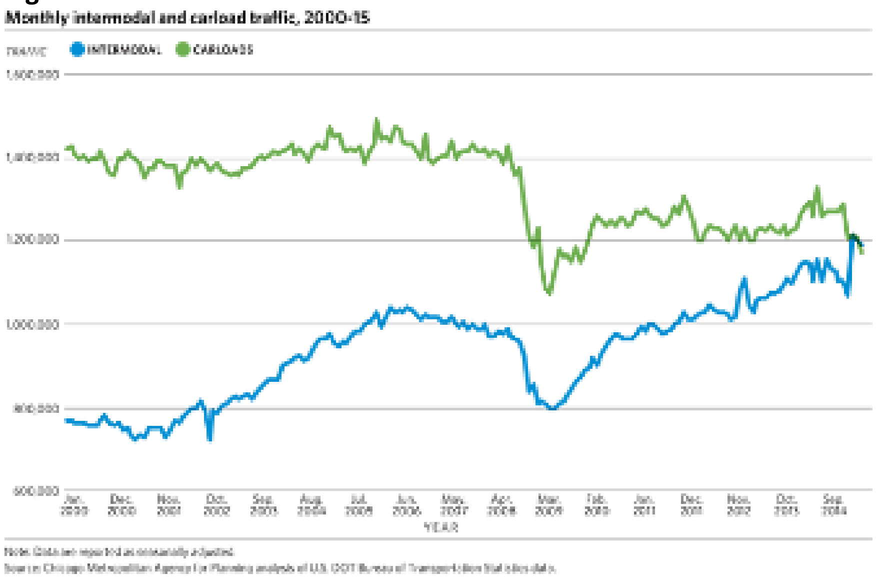
1. Loading capacity in Canada is 764mbd through 20 loading terminals in Alberta, per CAPP, compared with only 140mbd loaded to rail in 2016[9]. Loading capacity for Bakken in North Dakota is currently 1520mbd through 19 loading terminals, per the North Dakota Pipeline Authority[10]. Volumes shipped by rail in 2016 were approximately 300mbd having fallen from a maximum of 700mbd in 2014. Most of the North Dakota loading capacity was constructed during 2012-2013 to accommodate the peak shipments of 2014. Thus, additional loading capacity can be added quickly whenever needed.
2. The US has significant extra capacity to ship crude oil cars. The graph in Figure 7 shows that 2007 was the peak in total US carload shipments of all kinds. Carload traffic since then has fallen by 200,000 carloads to 1,200,000. Carloads have remained at this level ever since. Since crude oil is carload traffic, there may be spare scheduling and track capability for an additional 200,000 crude oil cars per year. Oil travels from Canada and North Dakota to Chicago in a southeastern direction, while intermodal shipments travel east-west. Thus, while the Chicago East Coast Corridor has increased intermodal movements (as suggested in Figure 7), the rail

[7] http://www.capp.ca/canadian-oil-and-natural-gas/infrastructure-and-transportation/rail

[8] http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/ohio-oil-gathering-uses-rail-to-hail-utica-light-oil-condensate-1.416171 .
[9] CAPP (2016)
[10] https://northdakotapipelines.com/

lines from Bakken and Canada may have additional crude oil capacity at least as far as Chicago and possibly eastward as well.

Figure 7: Historical carload versus intermodal traffic 2000-2015



Source: Chicago Metropolitan Agency for Planning (CMAP), data from Association of American Railroads (AAR)[11]

3. Chicago is the premier railroad hub due to its central location in North America. It is also a rail congestion chokepoint since it since it handles 1,300 trains per day. Trains can take an average of 30 hours to traverse Chicago while it only takes two days to travel from Los Angeles to Chicago. The average speed of trains in the Chicago area ranges from five to twelve miles per hour, depending on the route. Several railroads have developed methods of avoiding the downtown area altogether. CN's purchase of the Elgin, Joliet, and Eastern Railroad mentioned above is one example of circumnavigating the city. Another is the CSX intermodal hub that was recently constructed in Toledo, Ohio to avoid Chicago altogether. Congestion at a bottlenecked hub reduces the capacity of the system[12].
4. High traffic density on existing trackage may have contributed to rail delays in 2013-2014, though the evidence is not conclusive. There were two incidents during this time. First, customers experienced rail-service problems as the rail network, particularly in the Dakotas, Minnesota, and Iowa became congested. Growing crude-oil shipments competed with a large grain harvest and a surge in intermodal traffic. As a result of rail congestion, Minnesota corn, soybean, and wheat growers lost an estimated $99.3 million in revenues from March to May 2014. North Dakota spring wheat, corn, and soybean growers lost $66.6 million from January to April 2014.[13] [14] However, it is difficult to single out the contribution of crude oil trains[15] since

[11] http://www.cmap.illinois.gov/about/updates/policy/-/asset_publisher/U9jFxa68cnNA/content/update-on-freight-rail-activity
[12] http://business.financialpost.com/welcome-to-chokepoint-usa
[13] Usett, Edward (2014)
[14] Olson (2014)
[15] Personal communication May 2017

the congestion was also caused by the combination of a commodity super cycle, cold weather and bad management by the railways (i.e. CP leased out or stored about 400 locomotives to save money). Second, during this same period, the Canadian government directed the Canadian railroads to move a minimum quantity of grain due to scheduling conflicts with crude-oil trains. However, the direction of grain flows in Canada is westward to export markets while the direction of oil in Canada flows east and south to and through the GLSL Region. Thus, the contribution of oil trains to this problem is questionable.

5. The final component of the capacity issue is tank car availability. Changes in government specifications for constructing and operating tank cars can restrict the delivery capacity of the fleet. Further, with an expected increase in the need for coiled and insulated cars to move bitumen, supplies may become tight (coiled and insulated cars are a niche market). As of February 2017, it is estimated that 28 percent of the 400,000 crude-oil tank car fleet is idle,which implies that rail car supply is not a binding constraint. Idle tank cars are used for storage[16] and lease rates have fallen from $2000/month in 2012 to $399-375/month. [17] Thus, tank car supply is not a constraining factor.

Estimating the capacity or spare capacity for railroads is difficult due to the number of factors that must be considered. However, an examination of the main factors indicates a significant amount of spare capacity.

The US and Canadian railroads are quite old, having been in service since 1825, and forced to compete with the Erie Canal. Railroads constantly inspect and replace their tracks so age does not limit their capabilities. Since the U.S. freight rail system is privately owned and operated, the major railroads have no obligation to report the routes their trains take or freight track conditions to government agencies. Track status reports are unavailable. The Federal Railroad Administration (FRA) regulations require railroads to maintain track inspection records and make them available to FRA or state inspectors on request. However, there is currently no regular program to collect and analyze the many inspection reports performed by the industry.

Regarding oil spills by rail, Propublica[18] gives a list of rail spills of crude oil. Also, Earth Justice provides a list and map of rail incidents.

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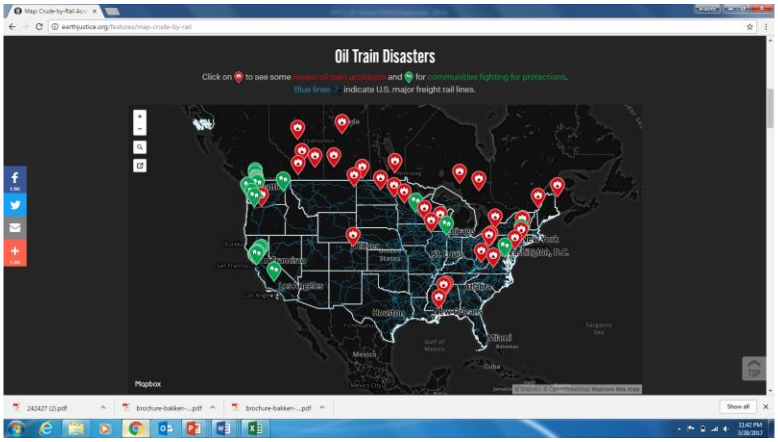
[16] https://www.wsj.com/articles/the-new-oil-storageace-railcars-1456655405

[17] http://blogs.platts.com/2016/11/11/energy-railway-crude-rail-went-bust/

[18] https://projects.propublica.org/graphics/oil-trains

Figure 8: Crude by Rail spills



Source: Earthjustice[19]

As can be seen from the map of oil spills above, the spills trace out the primary crude by rail routes across the GLSLR.

4.4 Flexibility and Responsiveness to Change

Railroads have a distinct advantage in that they can access all refineries, even those that do not have pipeline access. East and West Coast refiners all have water access, giving them excellent access to foreign crude oil. However, the Rocky Mountains and the Appalachian Mountains are formidable barriers to pipeline construction. Thus, East and West Coast access to Midwestern petroleum (such as Bakken and Bitumen) is limited to either rail or occasionally waterborne shipments from the US Gulf Coast.

Thus, geography has played a role in increasing volumes of crude by rail. In addition, environmental objections to pipelines have resulted in increased crude by rail. As crude oil wells begin producing, rail becomes an expensive but feasible option in the case that pipelines are not available. Rail has allowed oil fields to come on stream and has further allowed them to access East and West Coast refineries for which there is no pipeline access and Gulf Coast refineries to which access has been limited.

[19] http://earthjustice.org/features/map-crude-by-rail

SECTION 5: WATERBORNE INFRASTRUCTURE OF THE REGION

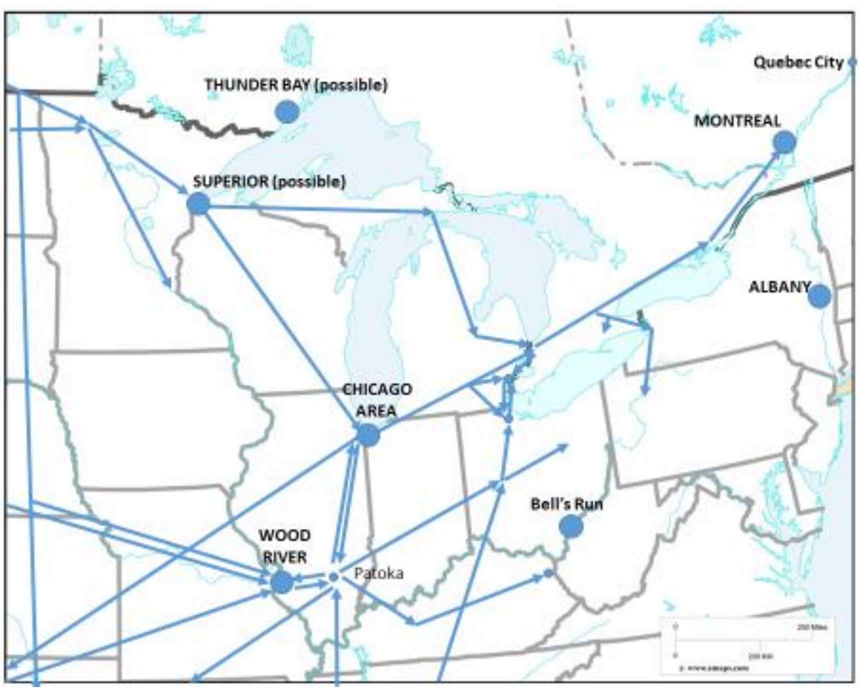
5.1 Waterways 101

The GLSL Region is blessed with an amazing natural resource – fresh water. This resource flows through our States and Provinces via the Great Lakes, the St Lawrence Seaway, the Mississippi River, the Ohio River, and the Illinois River. The water surrounding the GLSL Region was important to our historical development because of the connections it provided us to the other markets of North America and Europe making us a North American commercial hub. Cargos of all kinds originate and terminate at the hub, or pass through on their way to other parts of North America. This section discusses water transportation of crude oil, discussing first the existing system, system metrics, and finally a discussion of flexibility.

5.2 Existing and Potential Waterway Routes in GLSLR

Figure 9 below outlines the existing pipeline network. The dots on the map below highlight the main areas in the GLSL Region where crude oil barges/ships are loaded. Note that most of the waterborne loading facilities receive oil by pipeline. For the existing projects, the barges/ships can access not only GLSLR refineries but also refineries on the US Gulf and East Coasts. The two cities of Superior, WI and Thunder Bay, ON are also included as dots where waterway projects have been proposed.

Figure 9: Existing and potential crude routes by water loading terminals



Source: see Appendix C

Pipelines and railroads both have direct access to the oil fields of North America. The waterways, unfortunately, do not. Instead, they rely on pipelines and railroads to provide them oil, making them the "second leg" of an extensive, long-distance intermodal system. We will discuss the activities at each of these terminal regions. Unfortunately, current information on barging is not readily available[20]; current information on each one tends to be anecdotal. A table of several of the specific terminals is included in the Appendix C. A general discussion follows:

1. **Chicago Area**: Chicago receives oil through the Enbridge Mainline System from Canada and Bakken as well as oil from the US Midcontinent and US Gulf Coast. Some of the terminals receive crude oil by tank train and others by manifest train only. Barges move down the Illinois River to destination via the Mississippi River. There are two potential problems. The first is that the Illinois River can freeze during winter, making the transport seasonally dependent at times. The second is delays at the six Illinois River locks. The advanced age of some locks creates delays, reducing reliability and increasing transit time. However, with at least five barge terminals, barging remains a viable mode of transport.
2. **Wood River IL (St. Louis) Area**: Wood River is home to at least five barge terminals, fed by either pipe, rail or both. Wood River is a natural crossroads for multiple pipelines, as seen in the pipeline section, and many major refiners have tankage in the Patoka Wood River area. As such, several of them have added barge access over the years. Wood River is also home to the Gateway Terminal that offers heated storage and can receive unit trains from Canada as well as North Dakota.
3. **Albany NY Area**: Albany hosts two important waterborne crude oil terminals. The first, Buckeye, has had a longstanding contract with Irving Oil to load ships for their refinery in New Brunswick. This 135mbd facility can also load barges for East Coast Refineries. The second, Global Partners, can load 160mbd of crude oil to barges for delivery to East Coast Refineries. East Coast refineries have been highly reliant on foreign crude oil supplied by crude oil tankers since they have no pipeline access from the midcontinent. With the availability of Bakken and Canadian crude by rail, they have found it more cost effective to receive it by barge from Albany rather than develop rail access of their own. One of the East coast refiners has considered constructing a pipeline from the Albany area to receive crude from these terminals. It is unlikely that either of the two Albany terminals have received crude since last September when the price of foreign crude oil has become increasingly competitive.
4. **Montreal[21]:** The Enbridge Line 9 reversal in 2015 opened an opportunity for Valero's refinery in Quebec City. Their 265mbd refinery had been 100 percent dependent on foreign oil with no access to Canadian oil by pipe and limited access by rail. With the Line 9 reversal, Valero now light loads Panamax crude oil tankers in Montreal at the eastern terminus of Line 9 and transports the oil to Quebec City. This tanker movement gives Valero a measure of energy independence by directly connecting it with Canadian oil for the first time. Montreal, being an "ice free" port, can load tankers year round.
5. **Lake Superior**: The Lake Superior region is home to two potential crude oil projects. The first of these is the Thunder Bay Terminal on the north shore of Lake Superior. Thunder Bay is Canada's gateway between the oil fields of Alberta and the Great Lakes-St. Lawrence cities and has

[20] Petroleum waterborne traffic is published in arrears by the US Army Corps of Engineers, "Waterborne Commerce of the United States" at http://www.navigationdatacenter.us/wcsc/wcsc.htm
[21] CPCS (2003)

considerable traffic. The Energy East Pipeline, if constructed, will run through Thunder Bay. Thunder Bay has the potential to load ships from this pipeline. Thunder Bay could also load ships from tank cars loaded in Alberta and Saskatchewan. The second potential project is at the Calumet Refinery in Superior WI. Calumet has access to the Enbridge Mainline, which has a tank farm in Superior WI. From there they could load ships. This project was cancelled due to lack of customers. However, there is historical precedent for ship loading. Crude oil travelled by tanker from Superior WI to Great Lakes refiners beginning in 1950 shortly after the discovery of oil in Canada. It ended in 1964 due to year-round competition with the pipelines constructed in the 1950s and 1960s.

6. **Bell's Run, Ohio**: Ohio is in the midst of the Utica shale formation and because of this loads Utica condensate into rail cars and barges. Bell's Run, located on the Ohio River near Marietta, OH is a barge loading facility. A 200-mile pipeline in Ohio delivers oil to Bell's Run. This 50mbd pipeline can also load rail cars at the Black Run Terminal in Frazeysburg, OH.

5.3 System Metrics

The capacity of the Montreal ship-loading operation is easy to estimate. Enbridge Line 9 has a 300mbd capacity (using DRA), which limits the capacity of the ship movements from Montreal to Quebec City or to export. However, estimating the capacity to load barges on the River system is not easy. Little crude oil moves by barge and the capacity and locations of barge docks are not widely published (see Footnote 15). One contributing reason for the limited applicability of waterways is that many of the rivers close during the winter months due to ice conditions. The Seaway locks close, which further prohibits transport on the Great Lakes. Since refineries process crude oil year-round, this restricts the use of waterways. Montreal is the exception to this rule since it is navigable year-round.

Age-related issues are also an issue with waterways as it is with pipeline and rail. The average age of locks on the river system is 50 years and the Seaway celebrated its 50th anniversary in 2009. Thus, reliability and maintenance are an issue as it is with the other modes of transport.

5.4 Flexibility and Responsiveness to Change

Two factors limit the waterways. First, they are often affected by seasonal factors such as winter ice conditions. Since refineries operate year round, alternate supply modes are necessary for the winter operations. Also, since North American oil fields are not located on the waterways, waterborne cargos must be delivered to the barge/ship by pipe or rail. Adding a mode reduces the economic viability of the waterways.

On the other hand, since many barge terminals exist, any need for water transport can be met quickly and remain viable until a new pipeline or railroad route can be developed. Further, the water mode excels at long-haul, low-cost transportation, especially when it has direct access to customers. This is the case with the barge terminals of Albany, Wood River, and Chicago. In these cases, the low-cost economics of barging – even if other modes are necessary -- can provide a cost-effective solution for these niche markets.

SECTION 6: PROJECTS EXTERNAL TO THE REGION AND THEIR IMPACT ON THE REGION

As Canadian and Bakken oil fields have expanded, many projects to move the new oil by pipeline have been proposed. Some have been approved/rejected by the Trudeau Administration, the Trump Administration has approved some, and still others are under review and development. This section reviews these projects from a specific point of view – their impact on the GLSL Region. The following discussion groups the potential pipeline projects into three categories. The first category includes the pipelines that would/will divert oil flows away from the GLSL Region. The second category includes pipelines that would/will move increasing quantities of oil into and through the region. The third category includes pipelines that would increase flows into and through the Region. These projects vary considerably in their impact on GLSLR, even within each category. A table detailing each of these pipelines is included in Appendix D.

Lines that would divert oil flows from GLSLR: Two proposed Canadian pipelines would divert oil flows away from the GLSLR. These are the Enbridge's Northern Gateway project and Kinder Morgan's Trans Mountain Pipeline expansion. In both cases, Canadian crude oil from Alberta would flow to Western Canada. There it would be processed by West Coast refineries and/or loaded onto crude oil tankers for export. Both would divert flow away from the GLSLR, the US and Canadian East Coast and the US Gulf Coast.

Of the two projects, the Trudeau Administration has approved the Trans Mountain Expansion project, while rejecting the Northern Gateway.

Trans Mountain Pipeline is an existing line, originally constructed in 1953. It moves Canadian crude oil from Edmonton to the refineries of Vancouver and Washington and to the Westridge terminal in Burnaby, British Columbia for export by crude-oil tanker. The line capacity is 300mbd. The Trudeau Administration recently approved an expansion of this existing line by an additional 590mbd. Since Canada has limited physical access to world markets, it is likely that the Trans Mountain capacity will be fully utilized. This would divert flows away from the GLSLR.

In approving the Trans Mountain Expansion, the Trudeau Administration also rejected the second project, Enbridge's Northern Gateway, which would have been a newly constructed line from Alberta to Kitimat, British Columbia (near Prince Rupert). Northern Gateway would have added 525mbd of additional capacity.

Lines that would likely divert oil flows from GLSLR: Two additional proposed lines are planned to move Canadian and Bakken crude oil to the USGC. However, along their route, they pass through the GLSLR at Patoka IL. Once at Patoka they both access the GLSLR pipeline network which connects to GLSLR refineries. Thus, while the intent of the pipelines is to access the US Gulf (and thus divert crude oil away from the GLSLR), they will have access to the GLSLR. These are the Keystone XL Pipeline and the Bakken Pipeline System.

The Obama Administration rejected the Keystone XL Pipeline, but the Trump Administration has allowed it to reapply for permits. Keystone XL would add 830mbd of capacity from Canada to the US Gulf Coast.

The original Keystone XL plans included a pipeline that would allow it to receive 100mbd of Bakken crude oil (as part of the 830mbd total). Keystone XL would also have access to the Wood River/Patoka area through a connection with the existing Keystone Pipeline (Keystone XL is an expansion of the original Keystone Pipeline). Thus, the crude in Keystone XL could access the GLSLR pipeline network.

The second system is the Bakken Pipeline System. This system is a pair of pipelines under consideration: the Dakota Access Pipeline (DAPL) and the Energy Transfer Crude Oil Pipeline (ETCOP). DAPL will move Bakken crude from North Dakota to Patoka, IL. ETCOP will move it from Patoka to Texas for refining and export. Both pipelines will have initial capacity of 470mbd, expandable to 570mbd. Since DAPL reaches Patoka, it will have access to the GLSLR pipeline network. Thus, though most of its volume should pass through Patoka en route to the Gulf Coast, it is possible that some of it will access GLSLR refineries.

Further, DAPL will most likely reduce the rail deliveries from North Dakota since it opens a new, less expensive transport route to markets. This, if true, will divert rail moves (many of which transit GLSLR) toward the US Gulf Coast. As one example of this dynamic, Phillips 66 of Bayway, NJ recently suspended its crude by rail shipments (which transited the GLSLR). Finally, DAPL is planning rail loading facilities in Patoka, IL. Rail movements from Patoka would likely not transit the Chicago East Coast Corridor and might avoid much of the GLSLR.

Lines that would increase oil flow into and through GLSLR: Three final projects would increase the flow of crude oil from Canada into and through the GLSLR. These projects are the Enbridge Line 3 Replacement Project, TransCanada's Energy East Project, and Enbridge's Sandpiper Project. All of these projects would make Canadian and/or Bakken crude more accessible to GLSLR refiners.

The Trudeau Administration has approved the Enbridge Line 3 Replacement Project. This project would replace the existing 34" diameter Line 3 with a 36" diameter line, raising its capacity from 390mbd to 760mbd. Since the line runs from Alberta to Superior, WI, the US Gateway to the GLSLR, it will provide the capacity for increasing volumes of Canadian crude oil.

The second project is the TransCanada Energy East Project. It was discussed in a previous section and is mentioned here only for completeness. This project would ship Canadian crude from Alberta through six provinces ultimately following the Albany River and the Ottawa River en route to Montreal and Quebec and then New Brunswick. With a capacity of 1100mbd, the line would deliver to Suncor at Montreal, Valero in Quebec City, Irving Oil in New Brunswick, and an export terminal in New Brunswick. It would provide these eastern Canadian refineries with access (or improved access) to Alberta crude and allow Canada an export location. Several refineries in Europe and India are capable of refining Canadian heavy crude oil. The Trudeau Administration has not approved this project at this point. However, the Canadian National Energy Board reopened hearings on the project in January 2017. Thus, it is under consideration.

The Sandpiper Pipeline is the final project that would have increased oil flow into the GLSLR. Sponsored by Enbridge, this project would have opened 225mbd of additional capacity to move Bakken crude from North Dakota to the Enbridge Mainline System in Superior, WI. Enbridge cancelled the project after lengthy review.

SECTION 7: CRUDE OIL FORECASTS AND IMPACT ON THE REGION

Crude oil enters the GLSL Region primarily from Canada, the Bakken Region of North Dakota, the US Midcontinent, and foreign sources (by crude oil tanker from the US Gulf Coast). Foreign crude however, has been replaced largely by domestic and Canadian sources. As mentioned in Section 3, most of the pipeline capacity that originally moved foreign crude oil north into the GLSLR reversed to move growing Canadian crude supplies south into the US Gulf Coast. This section reviews forecasts for Canadian crude oil and Bakken and addresses the impact of these forecasts on the GLSLR. For both, sufficient pipeline capacity is being planned to handle the increased production and reduce or eliminate crude transport by rail. However, the unpredictability of crude-oil prices allows for significant volume shifts that could result in higher rail movements. No forecast of foreign movements is provided since the volumes are limited.

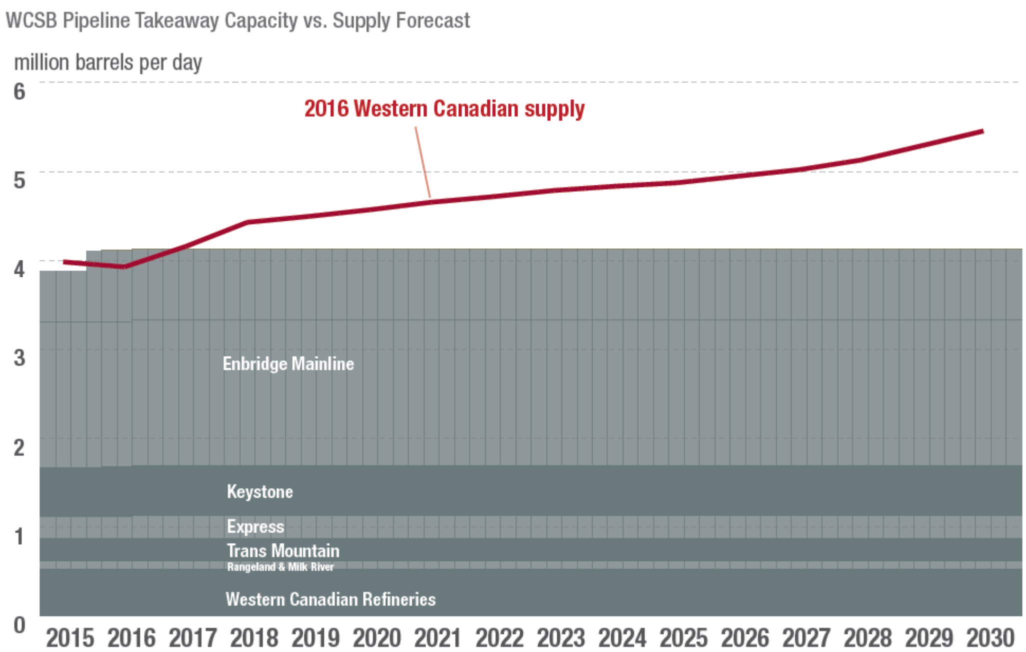
7.1 Canadian Crude Oil Forecast

The Canadian Association of Petroleum Producers (CAPP) publishes the primary forecast every June. Below is a summary of results from their Crude Oil Forecast, Markets & Transportation report of June 2016. Their updated report will be available on their website in June 2017. The main points from their 2016 forecast are that:

a. Oil supplies continue to expand, primarily in the oil sands region
b. While there is uncertainty for new oil-sands projects, the projects already underway continue to increase production.
c. Oil production in Western Canada is expected to grow by 1500mbd between now and 2030. Additional pipeline or rail capacity is needed to move this quantity

Expected growth in Western Canadian production, versus available pipeline capacity is depicted below:

Figure 10: Western Canadian supply versus existing pipeline capacity



Source: CAPP 2016 Canadian Crude Oil Forecast, Markets, and Transportation

Please note that the existing Canadian pipeline network becomes inadequate to move the entire supply in 2016/2017. This factor explains the growth in rail shipments of up to 140mbd in 2015, particularly to the United States Gulf Coast.

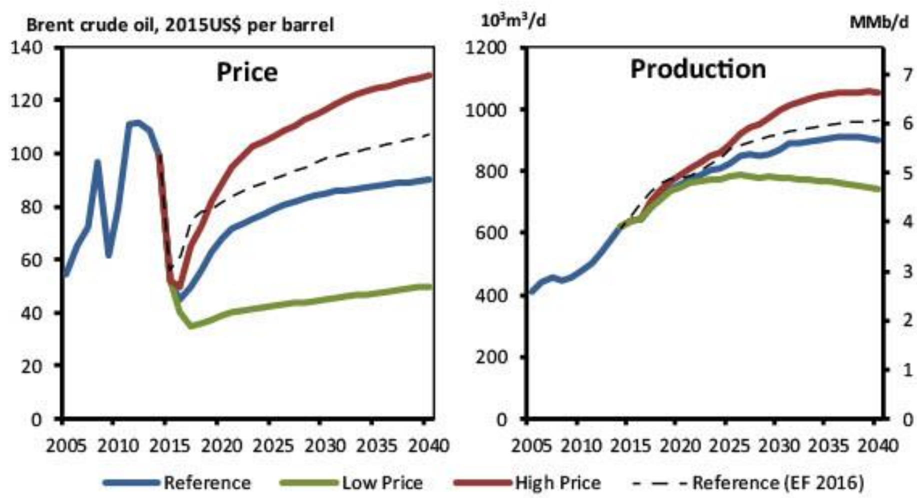
Keeping pace with growing supplies requires additional pipeline capacity. Potential pipeline projects were detailed in Section 6 and Appendix D. Below is a summary of their capacity additions:

Table 5: Proposed New Canadian Pipeline Capacity

NEW CANADIAN PIPELINE CAPACITY	
Proposed Pipeline	Added Capacity (MBD)
TMPL Expansion	590
Line 3 Replacement	370
Keystone XL	830
Subtotal	**1790**
Energy East	1100
Total	**2890**
versus	
Forecasted production increase by 2030	**1500mbd**

The capacity of the new projects greatly exceeds the forecasted supply increases, raising the likelihood of cancellation for some of them. Rail shipment estimates were not included in Table 5 since none appear to be needed 1) unless sufficient pipeline capacity is not built, 2) unless refineries start to receive pure bitumen by rail (it is too viscous for pipelines), or 3) except to access markets that are not pipeline available. Price changes can drastically change the outlook for crude production. The National Energy Board (NEB) report "Canada's Energy Future 2016: Update - Energy Supply and Demand Projections to 2040" of October 2016 addressed issues of price change[22]. As seen in Figure 11, high and low price scenarios alter Canadian oil production by +/- 1000mbd by 2030. These swings could require more rail and/or pipeline alternatives, or could result in idle capacity. Crude-oil prices used in the reference, low and high price cases, are not three single prices. For each case, the crude oil price changes with time.

Figure 11: Impact of Crude Oil Price Changes on Production Levels of Canadian Oil



Source: NEB, "Canada's Energy Future 2016: Update - Energy Supply and Demand Projections to 2040" 2016

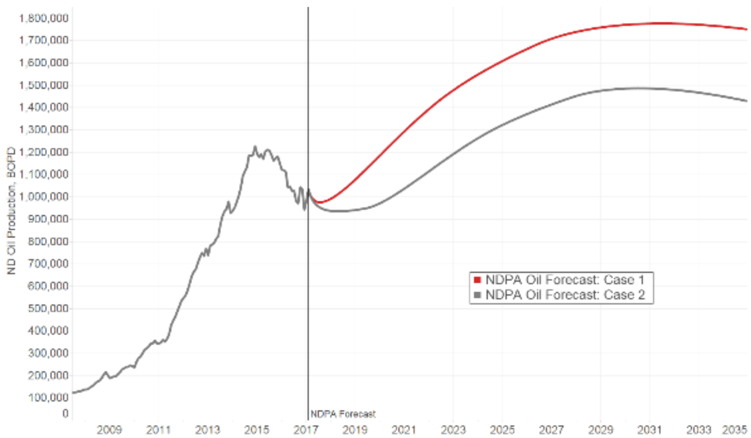
As proposed pipelines are built, crude by rail will likely be reduced except to markets with no pipeline access – specifically US East Coast refineries. However, US East Coast refineries process little bitumen. As explained in the last section, expanding the Trans Mountain Pipeline from Alberta to the West Coast will likely divert oil from GLSLR while greatly expanding an export market for Canada. Building Energy East Pipeline to the East Coast of Canada will also divert oil from the US portion of the GLSLR while providing energy independence for the Quebec refiners and opening an export market to Canada.

[22] https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016updt/index-eng.html

7.2 Bakken Crude Oil Forecast

The North Dakota Pipeline Authority forecasts production rates in the Bakken Region and publishes a report that is updated frequently. The most recent version from April 2017 is below[23]:

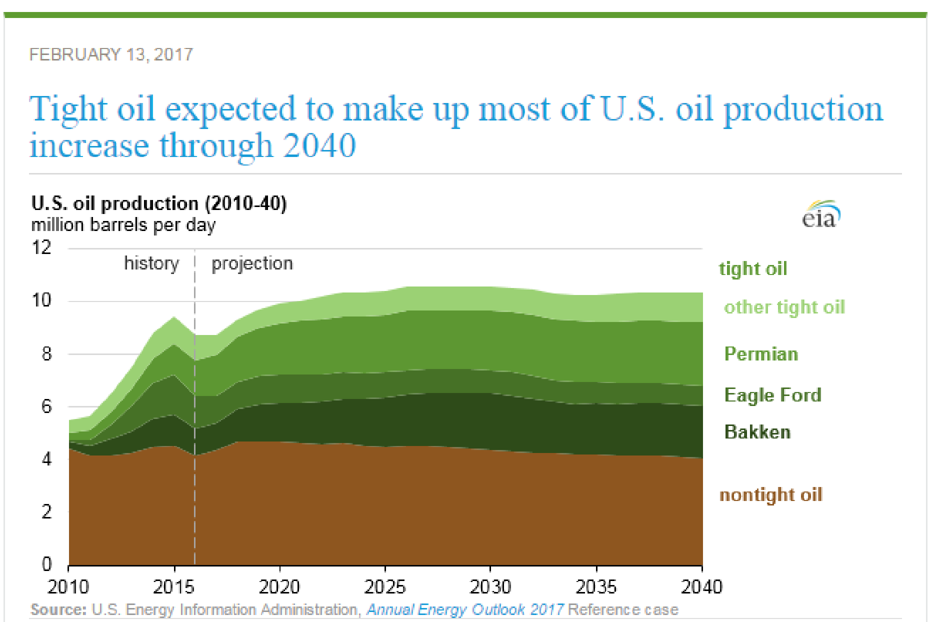
Figure 12: Bakken Crude Oil Production Forecast (North Dakota Pipeline Authority)



Source: North Dakota Pipeline Authority

In the chart, Bakken production rises from its current 1000mbd production rate to 1500-1750mbd by 2030 depending on the price of crude oil. This figure is congruent with the forecast of the US Energy Information Agency[24]:

Figure 13: Bakken Crude Oil Production Forecast (Energy Information Agency)



[23] https://ndpipelines.files.wordpress.com/2012/04/kringstad-jan-6-2017-house-energy-and-natural-resources.pdf
[24] https://www.eia.gov/todayinenergy/detail.php?id=29932

Source: EIA, Today in Energy, February 13, 2017

Not all forecasts are from the same school of thought though. Some analysts feel that the Bakken field has peaked and the well-production rates show that decline has begun[25]. Both Figures 12 and 13 above show that Bakken production fell by 200mbd in 2015/2016 and is beginning to recover. The Bakken infrastructure, especially with the inclusion of the Dakota Access Pipeline, appears capable of handling the increased production.

Table 6:

Bakken Transport Capacity	MBD
Existing pipelines	763mbd
Dakota Access Pipeline	470mbd (expandable to 570mbd)
Local refineries	88mbd
Total PL and refining	1321-1421mbd
versus	
Recent Bakken Production Rates	1000-1200mbd
Future Max Bakken Production Rates	1500-1750mbd

Table 6 above does not include Bakken rail loading capacity, which is 1500mbd[26] presently.

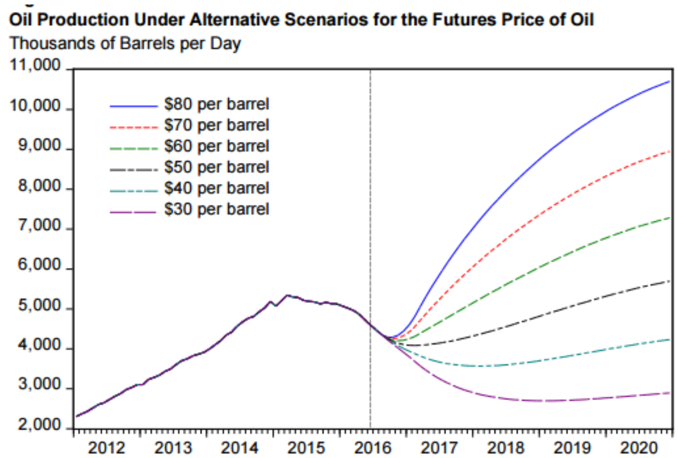
Comparing existing and future capacities in Table 6 shows that the addition of the Dakota Access Pipeline adds enough capacity to move all Bakken crude by pipeline. This implies that once the Dakota Access Pipeline goes into service in mid-May 2017, it is likely that crude oil transport by rail will be minimal with little Bakken railed to the East Coast. (One of the major Bakken consumers, Phillips 66 recently announced they are suspending Bakken rail receipts at their Bayway, NJ refinery for the present time.) The Bakken forecast, though, is highly dependent on crude oil prices. To evaluate this factor, the Congressional Budget Office commissioned a study[27].

[25] https://www.forbes.com/sites/arthurberman/2017/03/01/the-beginning-of-the-end-for-the-bakken-shale-play/#2d6b83ac1487

[26] https://ndpipelines.files.wordpress.com/2012/04/williston-basin-transportation-table-nov-2016.jpg

[27] https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/workingpaper/51599-workingpaper_2016-01.pdf

Figure 14: Variability in Shale Oil Production with Crude Oil Price



Source: Lasky, *"The Outlook for U.S. Production of Shale Oil,"* Congressional Budget Office, May 2016

The study considered all sources of tight oil, including Bakken, and the results show significant variability depending on the crude-oil price. Thus, while the Dakota Access Pipeline may substantially eliminate crude by rail at present, crude oil prices may result in additional production that would require rail in the future.

The GLSL Region is greatly impacted by this forecast especially considering the imminent Dakota Access startup. For with the startup, sufficient pipeline capacity is added to substantially eliminate Bakken by rail except to certain refineries that have no pipeline access otherwise. East Coast rail deliveries through GLSLR should slow down drastically or stop.

SECTION 8: SUMMARY

The GLSLR crude-oil delivery system is quite intricate. Most oil moves into the system by pipeline from North Dakota and Canada through the Chicago area or by pipeline from the south through the St Louis area (Wood River/Patoka) or by pipeline from Texas through Cincinnati, OH. Having arrived, the oil moves to GLSLR refineries or exits the Region to the US Gulf Coast. The pass-through capacity is significant -- nearly 900mbd. Much of the pass-through capacity is due to newer pipe constructed since 2000.

Complementing the pipeline network is a well-established rail infrastructure. Rail is a more expensive option. Based on this cost disadvantage, rail serves a much smaller and unique niche market – oil fields and refineries that have limited pipeline access. Rail, however, also has significant benefits. It can respond quickly to the development of new oil fields as seen with the rapid growth of Bakken oil production. It can also transport viscous crude oil types such as bitumen, which are difficult to pump.

Railroads tend to move crude-oil trains on their well maintained mainlines. The GLSLR mainlines pass through major population centers such as Chicago, Cleveland, Buffalo, Rochester, Syracuse, Albany, and Montreal. One primary route, the Chicago-East Coast Rail Corridor, serves East Coast refineries that have limited pipeline access and passes through all these cities (except Montreal).

While rail and pipeline provide direct access to crude oil fields, barge transportation does not. As such, barges rely on pipelines or rail for their supply of crude, essentially "extending the reach" of these modes. Pipeline/barge transshipment points are located in the Chicago and St Louis areas near major pipelines. A rail/barge transshipment point is located in Albany, NY to help serve US and Canadian East Coast refineries. In fact, a rail/ship transshipment is located in Montreal where Panamax crude oil tankers are loaded to a refinery in Quebec City – further "extending the reach" of the Enbridge pipeline system.

With an already extensive system, the prospect of still further supplies of Canadian and Bakken crude oil have given rise to multiple potential additional pipeline projects. Each, if implemented, would have a unique impact on the GLSL Region. Each would also have unexpected consequences. As example, the Dakota Access Pipeline, expected to start in June, will likely divert significant Bakken quantities to the Gulf Coast, and in the process, substantially reduce or eliminate rail shipments across the GLSLR to the East Coast.

With the price of crude oil ever fluctuating, crude oil production rates in Canada and North Dakota can change significantly. Thus, the volume of crude entering and exiting the GLSLR can change as well. Without direct pipeline access to markets, additional volumes of crude moves initially by rail and barge. As new pipeline capacity becomes available to move the additional volume, pipeline tends to supplant rail and barge movements. In the interim, barge and rail movements demonstrate a great ability to respond quickly to existing markets and to open new markets.

SECTION 9: LITERATURE CITED

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APPENDIX A: REFINING

Subtotal MBD	Capacity MBD	GREAT LAKES ST LAWRENCE RIVER REGION REFINERY CAPACITIES
1,371		**Illinois**
	176	Citgo Lemont
	239	ExxonMobil Joliet
	430	BP Whiting
	314	Phillips 66 Wood River
	212	Marathon Robinson
448		**Indiana**
	420	BP Whiting
	28	Countrymark Mt. Vernon
132		**Michigan**
	132	Marathon Detroit
437		**Minnesota**
	339	Koch Pine Bend
	98	Western Ref St Paul Park
585		**Ohio**
	93	Marathon Canton
	152	BP/Husky Toledo
	180	PBF Toledo
	160	Husky Lima
76		**Pennsylvania**
	11	Bradford Refinery
	65	United Refining Warren
45		**Wisconsin**
	45	Calumet Superior
392		**Ontario**
	119	Imperial Sarnia
	75	Shell Sarnia
	85	Suncor Sarnia
	113	Imperial Nanticoke
367		**Quebec**
	137	Suncor Montreal
	230	Valero Levis
3,853	**TOTAL CAPACITY GREAT LAKES REGION**	

Various sources, including Energy Information Administration, Oil and Gas Worldwide Refining Report 2016, CAPP 2016 Crude Oil Forecast, Markets, and Transportation, and US Department of Energy.

APPENDIX B: PIPELINES

CRUDE OIL PIPELINES OF THE GREAT LAKES ST LAWRENCE REGION

Non Enbridge

Lines	Status	Capacity	Construction	Diameter	Mileage	Route	Owners	Notes
		mbd	year	inches	miles			
Capline	low volumes	1200	1966	40	635	Louisiana/Patoka	Plains, MPLX, BP	possible reversal
Chicap	120mbd flow in 2015	360	1968	26	203	Patoka/Chicago	48% Unocal, 29% BP, 23% Enbridge	
Keystone	operating	591	2011	30	2147	Canada to Wood River, Patoka and Port Arthur TX	TransCanada	591MBD to Wood River or to Port Arthur
MidValley PL	nearly full	240	1950	20/22	1053	Longview TX to Lima, Toledo, and Detroit	91% Sunoco Logistics	
Minnesota PL (4 pipes)	278mbd flow in 2015	465	1954, 1970s, 1980s, 2008			Clearbrook/ Minneapolis	Koch Pipeline	expanding the newest pipe by 185mbd in 2017
Mustang	nearly full	100	<1957	18	200	Lockport IL/Patoka	Enbridge/Exxon	
Ozark PL	nearly full	230	1949	22	433	Cushing/Wood River	Marathon PL	expand by 115mbd in 2018
Pegasus	nearly full	100	1947-1954	20		Nederland TX/Patoka IL	reversed in 2006	
Platte PL	operating	145	1952	20	1036	Casper WY/Wood River	Enbridge	
Sun 16"	nearly full	190	>1967,<1971	16	123	Marysville/Detroit, Toledo	Sunoco Logistics	

ENBRIDGE								
LINES		**Capacity**	**Age**	**Diameter**	**Mileage**	**Route**	**Products**	**Notes**
To SuperiorWI								
Line 1		237	1950	18	1098	Edmonton/Superior WI	NGL, Prods, Syn light	
Line 2A,B		442	1967	24/26	1098	Edmonton/Superior WI	Light	
Line 3		390	1967	34	1098	Edmonton/Superior WI	Light, medium, heavy	Line 3 replacemen would restore to 760mbd
Line 4		796	2002	36/48	1098	Edmonton/Superior WI	Light, medium, heavy	
Line 67		800	2010, 2014, 2015	36	999	Hardesty/Superior WI	Heavy	Alberta Clipper
Line 65		186	2010	20	313	Cromer/Clearbrook MN	Light, medium	
From Superior WI								
Line 5		540	1953	36/48	645	Sarnia	NGL, light	2-20" lines cross Straits of Mackinac
Line 6A		667	1969	34	467	Griffith, Hartsdale	Light, medium, heavy	
Line 6B		600	1969	30	293	Line 6A/Detroit, Toledo, Sarnia	Light, medium, heavy	
Line 14/64		318	1998	24	467 (L14)	Mokena, then on L64 to Griffith, Hartsdale	Light, medium	
Line 61		931	2009	42	454	Flanagan	Light, medium, heavy	Southern Access
		1916						
From Flanagan IL								
Line 62		235	2013	22	75	Griffith, Hartsdale	Heavy	Spearhead North
Line 78		570	2015	36	75	Griffith, Hartsdale	Heavy	Spearhead North Twin
Line 55	CTC	193	1957, opened 200	22 24	575	Cushing	Light, medium, heavy	Spearhead South, Cushing to Chicago PL
Line 59		585	2014	36	593	Cushing	Light, heavy	Flanagan South
Line 63		300	2016	24	165	Patoka	Light, medium, heavy	Southern Access Extension
From Sarnia ON								
Line 7		180	1957	20	120	Nanticoke, Warren PA	Light, medium, heavy	
Line 9		300	1976	30	524	Montreal, and then Quebec City by ship	Light	
Line 17		100	1990s	16	88	Line 6B at Stockbridge/Toledo	Heavy	
Line 79		90	1990s	16 20	62	Line 6B at Stockbridge/Detroit	Heavy	
Line 10		74	1962 or 1970s	20	91	Line 7/Kiantone (United Refining)	Light, medium, heavy	
Line 11		117	>1978	16 20	47	to Imperial Nanticoke	Light, medium, heavy	

APPENDIX C: WATERBORNE

WATERBORNE AND INTERMODAL TRANSPORTATION IN THE GLSL REGION					
	Company	Location	Initial Date	Description	Capacity
Chicago Area					
pipe/unit train	Buckeye	Hartsdale, Hammond	2113	Pipe/unit trains to east coa:	NA
pipe/barge	Ducere/Shell	Lockport IL	approved 2116		NA
rail/barge	Cogent	Lockport IL	approved 2113	unit train to barge	40mbd
rail/barge	Hoffman Transptn	Lorenzo IL	NA	manifest trains	NA
rail/barge	MV Purchasing	Lorenzo IL	NA	manifest trains	NA
rail/barge	Marquis	Hennepin IL	2012	Bakken/Canadian unit train	35mbd
Wood River/Patoka					
pipe/barge	Marathon	Wood River IL	older	NA	NA
pipe&rail/barge	Valero	Hartford IL	older	NA	75mbd
rail/barge	Gateway	Sauget IL	2014	unit train to barge	65mbd
rail/barge	Omega	Sauget IL	in development	unit train to barge	40mbd
Albany					
rail/barge&ship	Buckeye	Port of Albany	2012	unit train to barge&ship	135mbd
rail/barge	Global Partners	Port of Albany	2011	unit train to barge	160mbd
rail/pipe	Global Partners	Port of Albany	planning stage	Albany/pipe/Linden NJ	200mbd
Montreal					
pipe/ship	Valero Terminal	Montreal	2015	pipe/Mont/ship/QCity	<300mbd
Lake Superior					
pipe/ship	Calumet	Superior WI	cancelled	Enbridge to Superior WI	NA
rail or pipe/ship	Thunder Bay	Thunder Bay ON	concept stage	Energy East access?	NA

APPENDIX D: PROPOSED PROJECTS

PROPOSED PIPELINES WHICH IMPACT GLSLR

Name	Status	Capacity	Comment	Diameter	Mileage	Route	Access to:	Owners
Enbridge Line 3	Trudeau approved	390mbd to	Planning Stage	36" replaces	1098mi	Hardesty/Superior	GLSL	Enbridge
Replacement		760mbd		34"			Refineries	
							Quebec & NB	
Energy East	NEB hearings	1100mbd	Planning Stage	gas	2860mi	transits	refineries	TransCanada
	reopened Jan 30, 2017		est 2020 (OGJ)	conversion	65mi gas line)	6 Provinces	& export	
Dakota Access Pipeline	2Q2017 start	470mbd,	>90%	30"	1172mi	ND to	Chicago, MW	Phillips, Sunoco
(DAPL)	paired with	expandable	complete			Patoka IL	Cushing &	Enbridge, Marathon
	ETCOP	to 570mbd					ETCOP	Energy Transfer
Energy Transfer	paired with	470mbd,	1950s	30"	1100mi	Patoka to	USGC	same as
Crude Oil Pipeline	DAPL	expandable	gas line			Texas	refiners	DAPL
(ETCOP)		to 570mbd					& export	
Keystone XL Pipeline	application	830mbd	Planning Stage	36"	1179mi	Hardesty/	MW & USGC	TransCanada
	resubmitted					Wood River &	refiners &	
	Trudeau approved					Texas	export	
Northern Gateway	Trudeau rejected	525mb	NA	36"	735mi	Bruderheim AB to	export	Enbridge
						Kitimat	terminal	
Sandpiper Pipeline	Cancelled	225mbd	NA	24"	616mi	ND to	Enbridge	Enbridge
	newbuild					Clearbrook MN		Marathon