STRATUS CONSULTING

The Triple Bottom Line Values of Clean Water in Northeast Ohio: An Initial Scoping Study

Prepared for:

Cleveland Water Alliance
601 Erieside Avenue
Cleveland, OH 44114

and

Northeast Ohio Regional Sewer District
3900 Euclid Avenue
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July 2, 2015
SC13915

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1. Introduction

Northeast Ohio is blessed with abundant, high-quality water resources – most notably Lake Erie and its tributaries. The lake and its associated rivers and streams are natural assets that provide considerable value to those who live, work, and visit Northeast Ohio. The area's water resources are an important source of water supply, provide recreation and tourism opportunities, support world-class fisheries and other ecosystem services, and offer significant quality-of-life benefits for local residents. In addition, as Northeast Ohio continues to emphasize its manufacturing base and promote new industries, Lake Erie's abundant water resources will likely play an important role in attracting businesses and workers to the region.

Over the last several decades, however, Lake Erie and its tributaries have faced a number of water quality–related threats, including nutrient loading from nonpoint source pollution, harmful algal blooms (HABs), combined sewer overflows, and industrial discharges. Recognizing the economic and social significance of the lake, federal, state, and local agencies and organizations have made considerable investments in water quality–related restoration efforts. These efforts have resulted in significant improvements in Lake Erie and its Northeast Ohio watersheds.

Despite the considerable progress made since restoration activities began in the 1960s and 1970s, Lake Erie and its tributaries continue to show signs of distress. Monitoring indicates that water quality has declined in recent years, after having previously improved. Increases in soluble phosphorus, combined with the effects of zebra and quagga mussel invasions, have resulted in an increase in HABs and related declines in water clarity and quality. The dead zone, or area of low to zero oxygen levels, still exists in the Central Basin. Toxic chemicals released 50 years ago still persist, traveling up the food chain and contaminating fish and other aquatic species. Bacteria from stormwater runoff and combined sewer overflows often make it dangerous to swim at public beaches (Hossler, 2010).

To ensure that Ohio's Lake Erie communities are able to realize the full potential of the lake, state agencies and other partners have increased investments in key planning and restoration initiatives. For example, the Ohio Lake Erie Commission reports that since the initial publication of its *Lake Erie Protection & Restoration Plan* in 2008, Lake Erie has become even more of a national and regional priority. Since 2010, the Great Lakes Restoration Initiative has provided more than $80 million in restoration projects in Ohio, complementing state and local investments in Lake Erie stewardship (Ohio Lake Erie Commission, 2013). These activities are consistent with ongoing regional efforts, including programs initiated under the U.S. Environmental Protection Agency's (EPA's) and Environment Canada's *Lake Erie: Lakewide Management Plan* (Lake Erie LaMP Work Group, 2006).

In addition to state and federal initiatives, local agencies and organizations such as the Northeast Ohio Regional Sewer District (NEORSD) and the Cleveland Water Alliance (CWA) continue to invest in important water quality improvements in the Northeast Ohio region. To better understand and communicate the importance of these continued investments, NEORSD and CWA retained Stratus Consulting to conduct a scoping assessment to help characterize the different values associated with clean water in Northeast Ohio.

This report presents the results of this assessment:

- Section 2 describes our general study approach
- Section 3 provides an overview of the Northeast Ohio study region, including basic demographic and economic information and a description of the region's water resources
- Section 4 describes the water quality–dependent services that Lake Erie and its tributaries provide to Northeast Ohio, as well as the methods that economists use to assess the value of these services
- The next three sections describe the value of clean water in Northeast Ohio and provide order-of-magnitude estimates of value, where feasible; Section 5 addresses economic and financial values, Section 6 addresses social values, and Section 7 addresses environmental values
- Section 8 provides a summary of our key findings.

2. General Study Approach

This study is the first phase of an envisioned two-phase effort to provide useful information regarding the value of clean water in the Northeast region of Ohio. In this initial phase (Phase 1: Preliminary Screening), we have identified key benefits and values associated with clean water, provided a general reconnaissance of available data and studies, and developed some preliminary estimates to help demonstrate the range of values for clean water in the Northeast Ohio region.

As a first step in this research, we conducted an extensive review of relevant literature and data. Our review included articles from academic journals and literature, as well as published and unpublished reports from local and state organizations and research institutions. Although we focused on literature and data directly related to Northeast Ohio and Lake Erie, we also explored examples from similar regions to provide important insights. As part of our review, we worked closely with Team NEO, a local economic development organization, to obtain key economic data for the study region.

To build on findings from the literature review, we conducted several interviews with individuals who have knowledge or expertise related to water quality or clean water values in Northeast Ohio. These interviews included conversations with local businesses, water utilities, state and local agency representatives, university researchers, and other stakeholders. The various individuals we spoke with helped us understand the value of clean water within the Northeast Ohio context and identify additional reports and data sources.

As a third component of this research, we developed order-of-magnitude estimates or presented a range of potential values for some of the benefits associated with clean water in the Northeast Ohio region. In some cases, we have applied benefits-transfer techniques to develop these estimates. Benefits transfer involves the application or "transfer" of economic values estimated in one context or study to estimate economic values in a different context. There are a number of challenges and cautions to consider when using benefits transfer. However, when implemented correctly with the recognition that the estimates are not intended to be precise, benefits transfer is acceptable for estimating nonmarket values (i.e., values for goods and services that are not directly priced and traded in markets). Economists often use benefits transfer to estimate the value of nonmarket goods and services because original valuation studies can be expensive and time consuming.

The values that we describe in Sections 5 through 7 are not intended to be additive, or to provide a comprehensive "total value" estimate of the benefits of clean water. For example, in Section 6.4, we provide a measure of the benefits that clean water can provide in terms of increased property values. The idea is that people are willing to pay higher prices for properties located close to a lake or water body with good water quality, compared to a lake or water body where the water quality is severely degraded. At the same time, in Section 6.3, we describe the value that local residents derive by being able to recreate at Lake Erie beaches. We acknowledge that some of the recreational values we describe are likely also captured in the property value estimates: part of the reason people are willing to pay more for a given property may be because it is close to a lake or water body that supports recreational activities. However, under Phase 1, we are not concerned with this potential overlap. Our intention is to demonstrate a range of values, and to provide a useful framework for communicating these values to different audiences.

Finally, we have organized this assessment within a triple bottom line (TBL) framework, meaning that we have categorized the services and values associated with clean water according to three bottom lines: economic/financial, social, and environmental. We have found that the TBL framework provides an easy way to communicate the benefits of clean water in a way that resonates with stakeholders.

3. Northeast Ohio Study Region

The study area consists of seven counties in the Northeast Ohio region, including Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit. As shown in Exhibit 1, Cuyahoga, Lake, and Lorain counties border Lake Erie on the north end; Geauga, Medina, Portage, and Summit counties make up the inland portion of the study area.

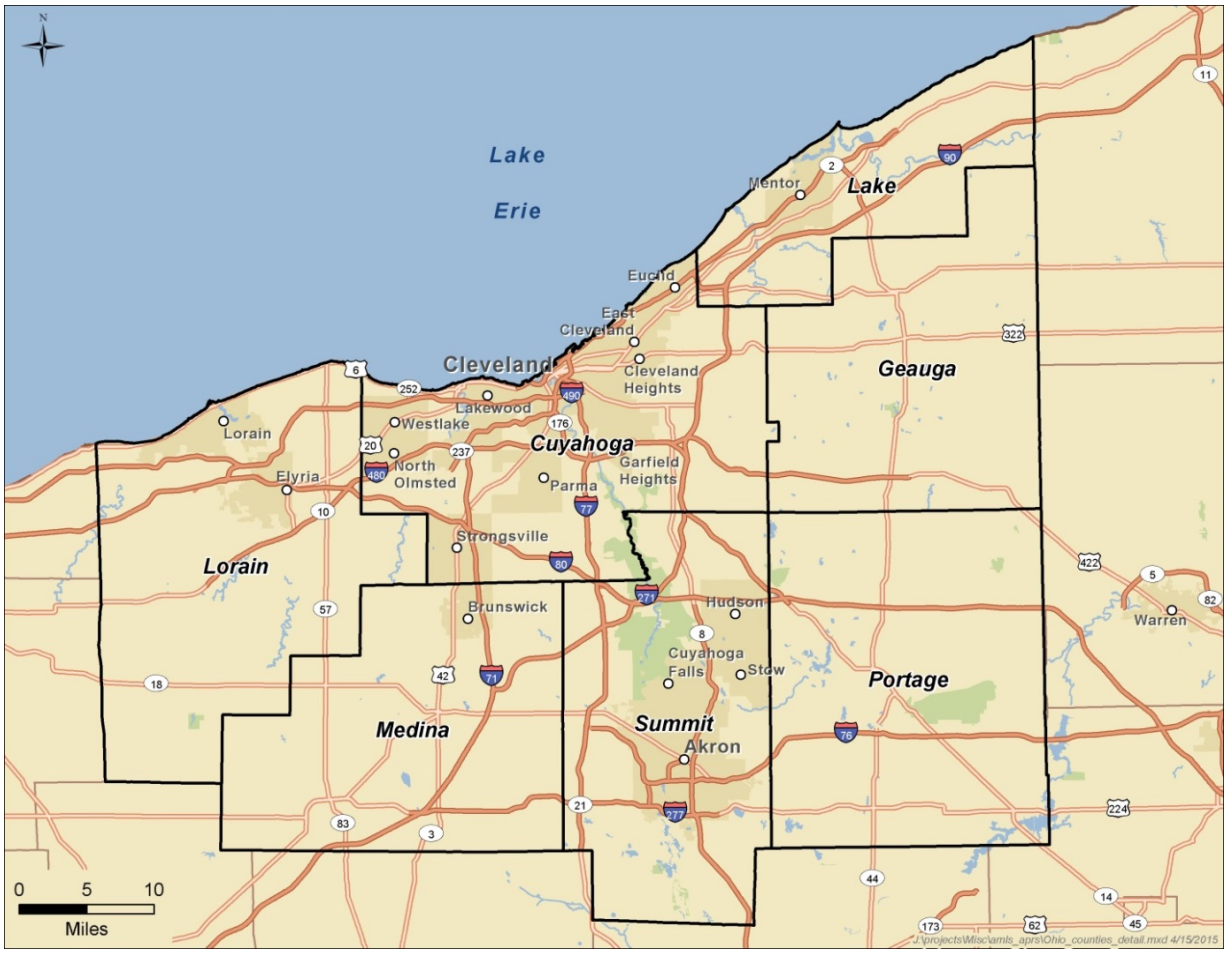

Exhibit 1. Northeast Ohio study region

There are approximately 2.8 million people living within the seven-county region. The majority of residents in the study area live in Cuyahoga (46% of residents) and Summit (19% of residents) counties, where Cleveland and Akron are located. The less-populated counties of Lorain, Lake, Medina, Portage, and Geauga account for about 34% of the study area population (ACS, 2013).

The counties within the study region fall within Lake Erie's Central Basin, which roughly extends from Sandusky, Ohio, eastward to the Ohio-Pennsylvania border. Within the study area, Cuyahoga, Lake, and Lorain counties border Lake Erie for a total of approximately 83 miles. As is shown in Exhibit 2, key watersheds within the study area include the Cuyahoga, Black, Chagrin, Grand, and Rocky river watersheds.

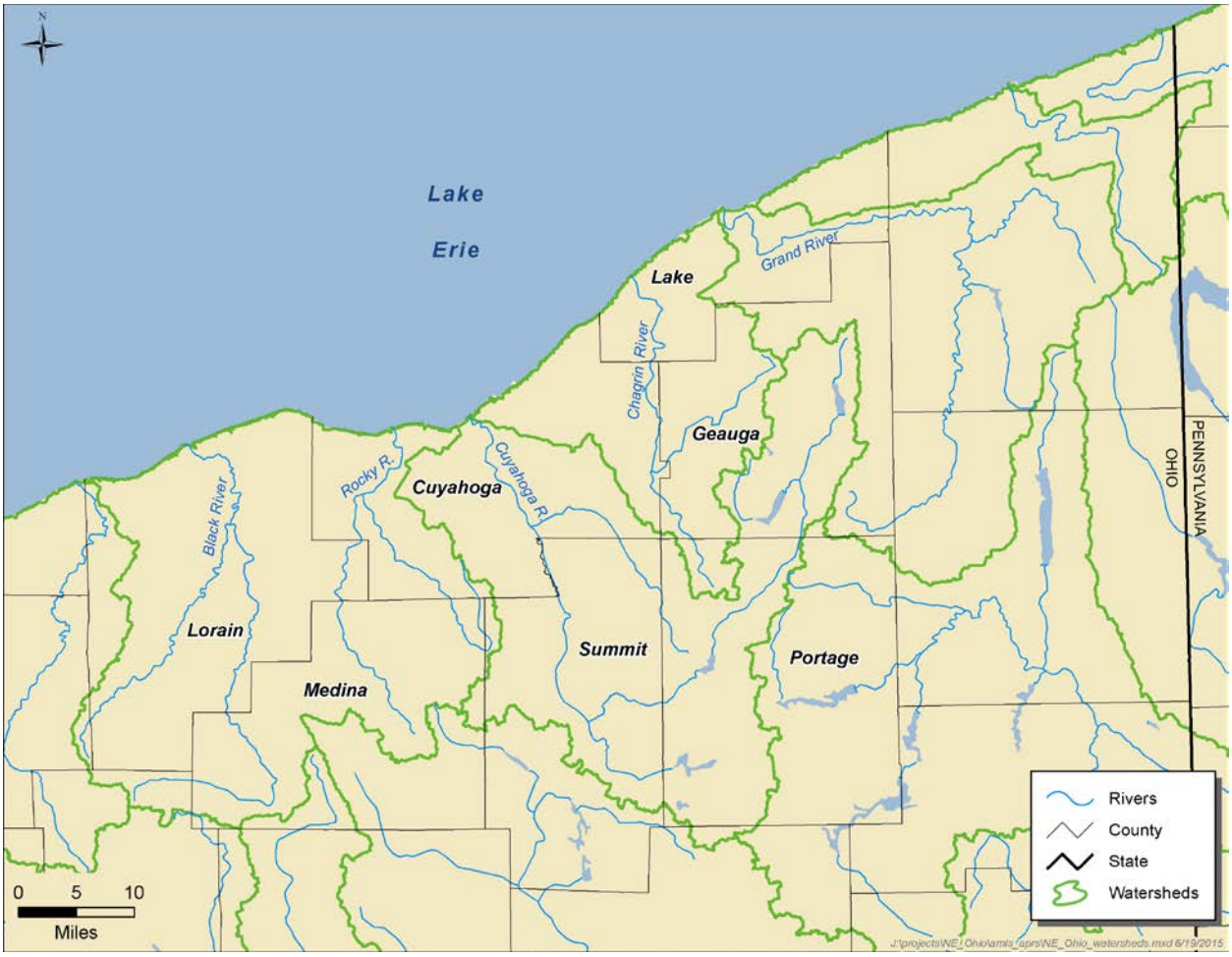

Exhibit 2. Key watersheds in the Northeast Ohio region

3.1 Water Supply

Lake Erie is the primary source of water supply within the study area. In the lakeshore counties of Cuyahoga, Lake, and Lorain, close to 100% of households are served by public water supply systems that rely on surface water supplies from Lake Erie and its tributaries. Most households in

Portage County also rely on surface water supplied by public water systems, although groundwater accounts for approximately 24% of total domestic supplies. In Geauga, Medina, and Summit counties, residents rely primarily on groundwater, which make up 75% (Summit County) to 88% (Geauga and Medina counties) of supply for municipal, industrial, commercial, and household uses. In these counties, a much higher percentage of residents also rely on self-supplied groundwater rather than public supply systems. Exhibit 3 shows the percentage of groundwater and surface water use by county, as well as the percentage of total water demand that is met through public water supply systems.

Exhibit 3. Water supply in the seven-county region

County	Total withdrawals (million gallons per day)[a]	Surface water withdrawals (% of total)	Groundwater withdrawals (% of total)	% of domestic water demand met through public systems[b]
Cuyahoga	466	100%	0%	100%
Geauga	9.87	12%	88%	22%
Lake	818[a]	100%	0%	95%
Lorain	465	100%	0%	98%
Medina	9.70	12%	88%	56%
Portage	50.5	76%	24%	73%
Summit	24.3	25%	75%	80%
Total (rounded)	1,840			

Source: USGS, 2010.

a. Total withdrawals include water used for energy production in once-through-cooling (OTC) processes. This includes 164, 786, and 388 MGD in Cuyahoga, Lake, and Lorain Counties, respectively.

b. Local water utilities indicate that as development increases, most communities will eventually become connected to a public water supply system.

Exhibit 4 shows that in the seven-county region, energy production accounts for close to 73% of total water withdrawals. This includes more than 1,300 MGD of surface water withdrawals from Lake Erie by energy companies located in Cuyahoga, Lake, and Lorain Counties. This water is used in once-through cooling processes and is then returned to the lake; it is therefore not a consumptive use of water.

Public water supply systems account for about 19.7% of total groundwater and surface water withdrawals (362 MGD), while industries and households that supply their own water make up about 5.3% (100 MGD) and 1.3% (24 MGD) of total withdrawals, respectively. Most of the industrial self-supplied water withdrawals occur in Cuyahoga and Lorain counties, which have larger populations and a greater industrial base. Overall, there is little groundwater or surface

water used for irrigation, livestock, aquaculture, or mining in the study area. Many of these uses rely heavily on precipitation instead. While not included in this phase of report, the value of agriculture in Northeast Ohio that is dependent on rainfall could be included as a topic for investigation under Phase 2.

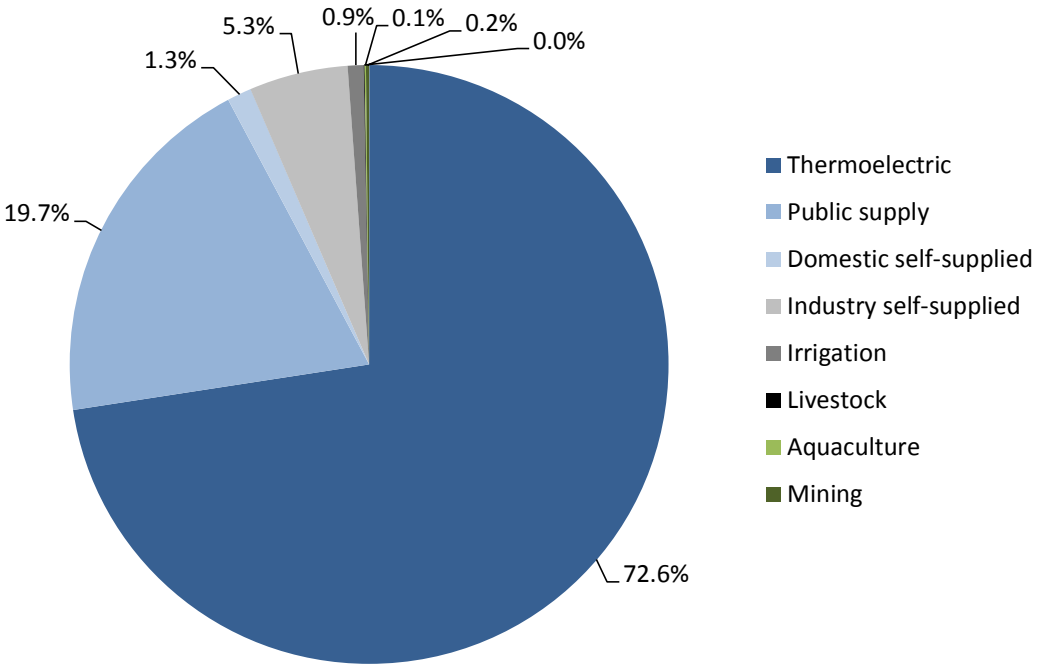

Exhibit 4. Water withdrawals in the seven-county study region, 2010

Source: USGS, 2010.

Note: Since 2010, the year this data was released, several power plants in the region have been closed. This trend is expected to continue in the near future. Thus, water used for energy production will likely make up a much lower percentage of total water use.

3.2 Water Quality

As described above, over the last several decades, Lake Erie and its tributaries have faced a number of water quality–related threats. Although point source pollution (e.g., from industrial and wastewater discharges) has largely been addressed, nutrient loading from nonpoint source pollution (e.g., agricultural runoff), and associated HABs, are on the rise. Currently, HABs are primarily an issue in the western portion of the Lake Erie Basin, yet there is concern that they

will spread further into the Central Basin (Raymond, 2013). In addition, the algae that thrives on nutrients from non-point sources often results in the formation of a hypoxic or "dead" zone in the Central Basin during late summer. The dead zone is a large area of low-oxygen water that develops as algae living in the top layer of water die and sink to the bottom of the Lake. These dead algae consume oxygen as they decompose. When the oxygen is gone, fish can no longer live in the water, hence the term dead zone. Since the mid-1990's, a dead zone has formed in the Central Basin every year.

As described in more detail in Section 6.1, toxic sediments and bacteria levels at local beaches also continue to be a problem in the Central Basin and Northeast Ohio region. Chemical pollutants associated with historical industrial discharges have been known to cause adverse health effects in animals and humans. In 2013, bacteria levels at beaches within the study region exceeded national Beach Action Value (BAV) safety thresholds in 38.5% of all samples (NRDC, 2014), representing a significant increase from previous years.

Within the Northeast Ohio region, the Black and Cuyahoga River watersheds are federally designated Areas of Concern (AOCs). AOCs are watersheds in the Great Lakes that suffer from severe environmental degradation because of current and historical pollution. Pursuant to the U.S.-Canada Great Lakes Water Quality Agreement of 1972, EPA designates AOCs based on the presence of up to 14 different types of beneficial use impairments related to fish and wildlife consumption, the ability to drink water and swim, limits on dredging activities, and aesthetic and ecological impacts. These impairments are caused by various water-quality issues including cultural eutrophication, toxic substances, bacterial contamination, habitat modification, and sedimentation.

There is concern that climate change will exacerbate water quality issues within the Northeast Ohio study region. Precipitation trends are changing, with heavy early spring rains causing winter applications of fertilizer to wash off before the ground can absorb them, thereby increasing nutrient loading into Lake Erie. Increased severity of precipitation events will also increase stormwater runoff from impervious areas, resulting in increased pollutant loading and potentially, increased sewer overflows. Warmer water lake temperatures will also serve to exacerbate water quality-related issues.

4. Assessing the Value of Clean Water

The region's waters – and more specifically, the *quality* of the region's waters – provide important economic, social, and environmental services to Northeast Ohio communities. In this way, Lake Erie and its tributaries represent a source of "natural capital" for the Northeast Ohio

region, similar to the way that physical buildings, machinery, treatment facilities, and other materials serve as a source of capital in the production of goods and services.

To estimate the values associated with natural capital assets, it is important to understand the different services they provide and how changes in the level or quality of these services would affect human welfare. Based on our research and understanding of the Northeast Ohio region, we have identified a number of water quality–dependent goods and services associated with Lake Erie and its tributaries. These include services related to the direct use of water, such as for recreation or as a source of water supply, as well as "nonuse" services, such as related to ecosystem functions or the inspiration that residents take from wildlife and the natural environment. Exhibit 5 presents the economic, social, and environmental services associated with clean water in Northeast Ohio, and describes how these services might be affected by changes in water quality.

In some cases, it is easy to assess the value of services that natural assets provide because they have an established market price. In many cases, however, the full value of these services is not reflected in their market price, or they are not bought and sold in a market at all. For example, Northeast Ohio residents do not pay an admission fee to visit and participate in stream-based recreation activities at the Cleveland Metroparks. This does not mean that they do not associate a value with these visits. Similarly, many individuals pay more than the current admission price to recreate at Lake Erie beaches, in the form of expenditures associated with traveling to the site. These expenditures are not reflected in the "market price" (i.e., the admission fee) for beach recreation.

Economists use a number of different methods to estimate the value of "nonmarket" goods and services, including stated-preference methods and revealed-preference methods. These techniques are based on the concept of willingness-to-pay (WTP) as a measure of total value. WTP is based on the notion that there is some amount of money, or other market goods, an individual would be willing to trade off so they can benefit from a nonmarket good.[1]

Stated-preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for the nonmarket good being evaluated. WTP can also be inferred from choices people make in related markets. Methods that employ this general approach are referred to as revealed-preference methods because they rely on observations of people's behavior, and their associated expenditures, as indications of their preferences for goods and services. For example, several studies have used revealed-preference methods to estimate the value that individuals place on water quality by

1. Economists also use willingness-to-accept (WTA) as a measure of value. WTA is the quantity of money, or goods, that an individual would be willing to accept to give up a good or service.

Exhibit 5. Water quality–dependent services provided by Lake Erie and its tributaries in Northeast Ohio

TBL category	Service category	Description
Economic/ financial	Economic development/activity	Clean water is an important input for many key economic sectors, including recreation and tourism, fisheries, food and beverage production, manufacturing, and others. Water quality degradation would directly affect these sectors, and would result in indirect or "ripple" economic impacts in the local region.
	Reduced water treatment costs	Poor water quality can result in increased treatment costs for drinking water utilities and local industries. The value of water quality in this context can be measured by assessing treatment costs or costs of infrastructure that water quality improvements help to avoid.
Social	Public health	Drinking water quality, fish tissue contaminant concentrations, and bacterial levels at local beaches are all aspects of water quality that affect public health.
	Recreation and tourism	Water-based recreation is an important asset for Northeast Ohio. Direct-use values portray the wellbeing and enjoyment that residents and visitors derive from water-related recreational activities, including boating, skiing, fishing, swimming, beach use, and waterfowl hunting**.** Many residents in Northeast Ohio are also willing to pay to preserve water quality so that it can be enjoyed by others (altruistic values), or by future generations (bequest values).
	Aesthetics/quality of life	Water resource amenities provide aesthetic value and passive-use opportunities for Northeast Ohio residents. This value is threatened if water quality is degraded. Aesthetic values can be measured through hedonic analysis, which examines the effect of resource amenities on residential and commercial property values.
	Water supply reliability	As seen with the Toledo algal bloom, poor water quality can result in water-supply disruptions for households and businesses. This not only results in direct financial costs, but can have important economic development implications.
Environmental	Nonuse values[a]	Lake Erie and its tributaries support riparian and aquatic ecosystems, wetlands, and other associated natural systems that provide critical habitat for fish and wildlife. Residents of the Northeast Ohio region (and elsewhere) place values on the existence and preservation of these resources, even if they do not use them.

a. The values presented here represent the full suite of services that clean water provides to the Northeast Ohio region. These are often referred to in the literature as "ecosystem services". The environmental category reflects the "nonuse" values or services that individuals derive from knowing that environmental amenities existing. This is just one component of an ecosystem services analysis.

comparing differences in residential real estate prices in areas located close to a pristine water body, to prices in areas located close to a severely degraded water body.

Another way to measure the economic value associated with clean water is to evaluate the regional economic activity that businesses and industries dependent on clean water provide to the local region. For example, economists often use regional economic models to assess the contribution of specific industries to the local economy, as well as the "ripple" effects or indirect economic impacts that these industries generate. The importance of water quality can also be examined by assessing the economic impacts associated with an industry moving to the region because of its abundant supply of high-quality water.

These different concepts are integrated into the examples of values that we describe in subsequent sections.

5. Economic and Financial Values

This section describes the economic and financial benefits associated with clean water in the Northeast Ohio region, including benefits related to economic development, as well as financial benefits associated with avoided water treatment and infrastructure costs for utilities and industries.

5.1 Economic Development

Here, we describe key sectors and economic activity in the seven-county region in terms of revenue, employment, and growth. We then discuss how water availability and quality can affect key sectors and the value provided to the local region.

5.1.1 Economic overview of the study region

As shown in Exhibit 6, manufacturing, government, and healthcare and social assistance comprise the three largest major economic sectors in the seven-county region. Together, these sectors account for approximately 37% of Northeast Ohio's gross regional product (GRP). In contrast, agriculture, retail trade, and professional services are the three smallest sectors in the region, together accounting for about 11% of GRP.

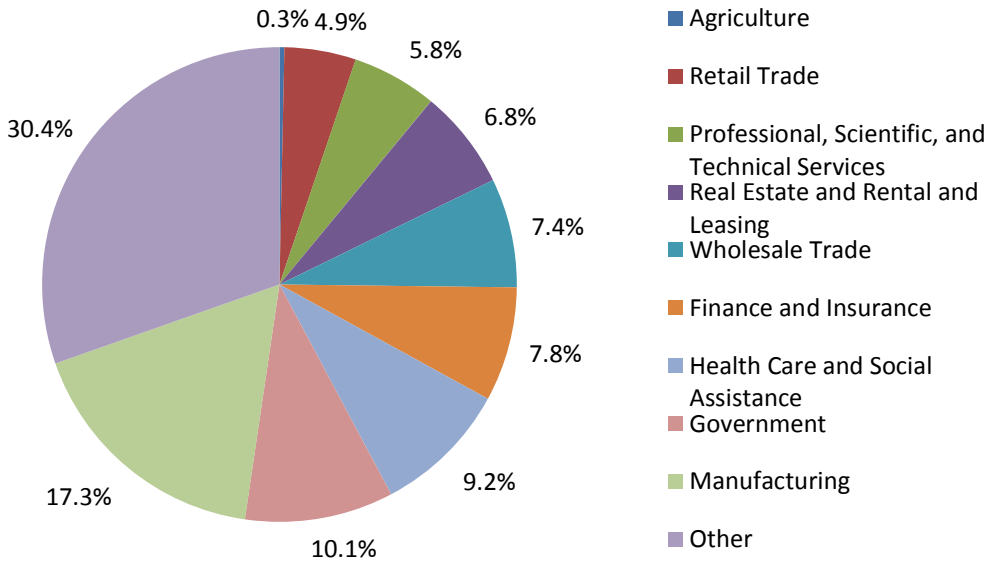

Exhibit 6. GRP by sector in the seven-county region

Source: Team NEO from Moody's Analytics.

Note: The other sector includes mining, utilities, oil and gas extraction, construction, transportation and warehousing, information, management, education, arts, entertainment, recreation, and food services and accommodation.

Although agriculture represents a small portion of the economy in terms of both GRP and employment, it makes a more significant contribution to Northeast Ohio than Exhibit 6 would suggest. Agricultural production in the Northeast Ohio region yields raw materials that serve as inputs for a variety of industries, most notably food and beverage processes that involve vineyards, farm animals and their byproducts, and specialty crops. In addition, the acreage, variety, and proximity of farmland to cities in Northeast Ohio is more suitable to regional food production rather than competitive export or large-scale usage (Team NEO, 2015). The growing demand for local and natural foods makes this relationship even more important in Northeast Ohio.

In addition to the sectors shown in Exhibit 6, there are several important subsectors in Northeast Ohio that are directly tied to the quality and quantity of the region's water resources. For example, a 2012 study identified tourism as Cuyahoga County's fourth-largest employer (Tourism Economics, 2012) [2]. The Northeast Ohio region area has many water-based recreation

2. Tourism is not considered a standard industry sector because it is supported by a number of different sectors, including food services, accommodation, recreation, and others.

and tourism opportunities, including Lake Erie beaches and boating, and water based-activities at Ohio State Parks, Cleveland Metroparks, the Cuyahoga Valley National Park (CVNP), and other local parks. We describe the value of water-based recreation and tourism for Northeast Ohio in Section 6.2.

Another industry reliant on clean water is the commercial fishing industry. According to Michigan Sea Grant 2015, there are more fish harvested from Lake Erie than all of the other Great lakes combined. However, the majority of the harvest is from Canadian waters as the US does not allow commercial fishing of walleye due to its recreational importance. USACE (2012) reports that between 2005 and 2009, the average harvest level in the US waters of Lake Erie was 4.9 million pounds, valued at $5.1 million. Yellow perch is the most common specie harvested, with other species including white bass, white perch, bigmouth buffalo, channel catfish and carp (Michigan Sea Grant, 2015).

Commercial shipping activity at the Port of Cleveland also generates significant economic activity in the Northeast Ohio area. A study using 2008 data reported that more than 10,800 jobs and $66.9 million in state and local tax receipts annually are tied to the Port of Cleveland. When private commercial terminals along the Cuyahoga River System are factored in, the numbers rise to more than 17,800 jobs in the State of Ohio and $112.3 million in state and local taxes (Martin and Associates, 2011). Shipping could potentially impact water quality in the region through releases of ballast water from ships.

In addition to existing key sectors, JobsOhio has identified 11 “target” industries that will help to drive the Ohio state economy in future years. These private-sector industries contribute to Ohio’s Gross State Product (GSP) at a faster rate than they do in other states within the Midwest region, grow at a faster rate than the rest of Ohio’s private sector, and reflect Ohio’s competitive advantage (JobsOhio, 2015).

Data provided by Team NEO show that the largest target industry sub-sectors for the state are also important sectors in the seven-county region. Exhibit 7 shows how Ohio’s target industries contribute to the GRP of the study region. As shown, financial services, biohealth, shale and petrochemicals, headquarters and consulting, and advanced manufacturing are all important sectors in the seven-county region. The biohealth cluster in particular is a major target industry for Northeast Ohio, as the region is home to local, specialized biomedical manufacturing and world-class institutions such as the Cleveland Clinic and the Global Center for Health Innovation.

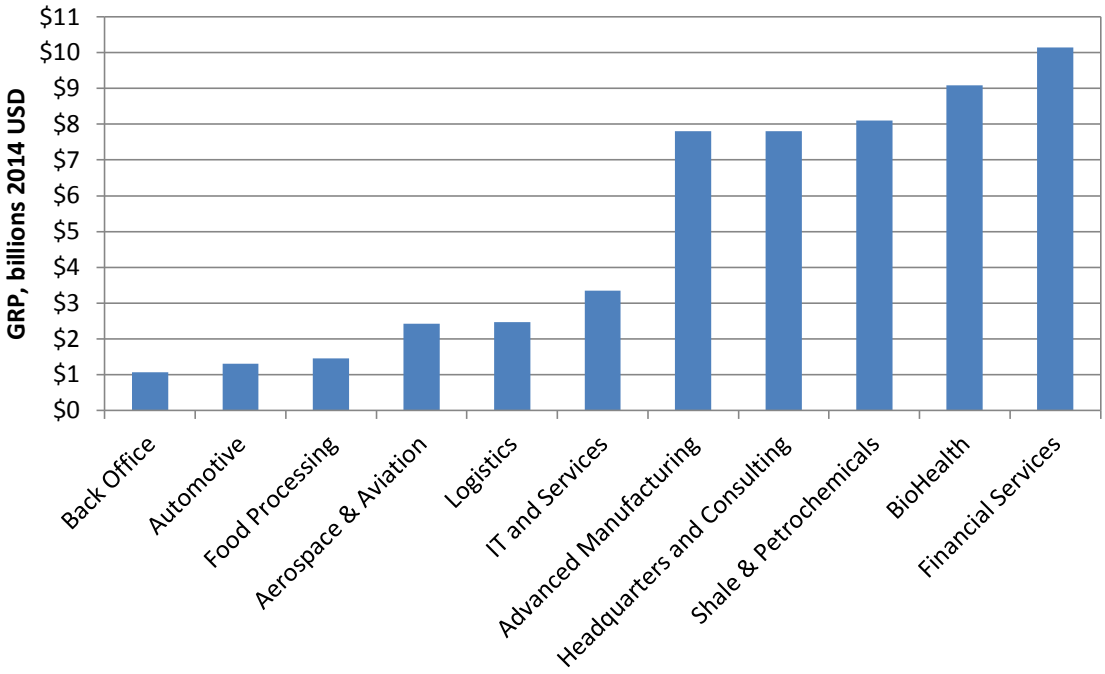

Exhibit 7. GRP in seven-county target industries
Source: Team NEO from Moody's Analytics

Note: For reference, total GRP in the study region amounts to close to $148 billion. Thus, the biohealth and financial services industries currently account for about 6% and 7% of total GRP, respectively.

Employment data provided by Team NEO show that financial services, headquarters/consulting, and advanced manufacturing also drive employment in Northeast Ohio. Despite long-term downward trends in overall manufacturing employment, advanced manufacturing ranks second in terms of jobs in target industries in the seven-county region. The biohealth sector employs the greatest number of people.

5.1.2 The importance of water availability to the Northeast Ohio economy

Many of the sectors identified above as being important to the Northeast Ohio region are dependent on having an abundant supply of water. Cleveland State University (CSU) has identified agriculture, power-generation, and several manufacturing subsectors, including textiles and garments, meat production, beverages, and automobile manufacturing, as the most water-intensive industries in Northeast Ohio (Alexander et al., 2014).

Other important, water-dependent subsectors include chemical and petrochemical manufacturing and biohealth, which, as noted above, is one of the fastest growing industries in the Northeast

Ohio region. Chemical and energy manufacturing use water primarily for cooling and steam production purposes. However, chemical manufacturers employ water for additional needs, such as vacuum creation, steam production, solvent and reaction media preparation, reagents, product rinsing, and distillation (Alexander et al., 2014). Important water uses in the biohealth sector include pharmaceutical and medical device production, and process water used at numerous testing laboratories, offices, and institutions, including the Cleveland Clinic.

Exhibit 8 shows examples of several specific "water-enabled industries" in the State of Ohio that are also important to the Northeast Ohio economy. Water-enabled industries are industries that use water as a key input, have significant water discharges, or both. As shown, "advanced manufacturing" and "polymers and chemicals," one of the two major subsectors of the shale and petrochemicals sector, are two of the more important water-enabled industries in the state, respectively providing 32.6% and 10.2% of the total jobs in water-enabled industries. Due to time and resource constraints, Exhibit 8 only shows four examples of water enabled industries. In Phase 2, we propose to show a more complete list of water enabled industries for Ohio, and to provide context on the relationship of water enabled industry jobs and revenue to overall jobs and revenue for Ohio.

Exhibit 8. Percent of total Ohio water-enabled industry jobs, for selected industries

Target water-enabled industry	Number of Ohio jobs	Percent of total Ohio water-enabled industry jobs
Advanced manufacturing	56,561	32.6%
Polymers and chemicals	17,737	10.2%
Food processing	8,235	4.7%
Automotive	12,192	7.0%

Source: Team NEO from Moody's Analytics.

Food processing is also a water-enabled industry. This subsector requires water for transportation, cleaning, processing, and product formulation. While food processing comprises a nominal portion of GRP, it saw a significant employment growth of 18.7% between 2004 and 2014, a period which saw an average negative employment growth for the country as a whole. As noted above, the Northeast Ohio region offers competitive advantages for the food processing industry associated with access to raw materials, overall favorable conditions of the Northeast Ohio economy, and growing emphasis on locally produced food (Team NEO, 2015).

Another growing economic development cluster in the Northeast Ohio region is the water technology industry. This business sector provides technologies and services essential to providing high-quality water, and it is becoming an important economic driver for the region (Nortech Water Technologies, 2012). Nortech, an economic development organization that has now merged with TeamNEO, identified eight main categories of industrial water technology in

the Northeast Ohio market. These categories cover various types of water treatment or stormwater control technologies, including manufacture of various types of membranes for high-pressure water filtration or other techniques for filtration to remove contaminants from water, technologies to separate solids from liquids using centrifuges or vacuum technology, use of biological treatment agents to remove biological contaminants, manufacture of disinfection technologies for killing or controlling pathogenic contaminants, and stormwater reduction or control technologies to store stormwater and release it when the system is no longer overloaded by stormwater inflows. For these core industrial water technologies (not including laboratory or design services), Northeast Ohio has 84 different organizations that generate $135 million in revenue and funding, and employ 685 full-time-equivalent workers. Nortech projects growth in this sector to be substantial over the remainder of the decade, with 3,510 additional jobs projected to be added to the economy in the three most promising technology segments alone. Economic activity related to the water technology cluster also includes the sale of materials dredged from Lake Erie (see Exhibit 9).

Exhibit 9. The value of "clean dirt"

Another water quality–related market segment includes the management and disposal of material dredged from shipping lanes to maintain sufficient depth for ship traffic. This ship traffic delivers goods and materials to and from important industries upstream on the Cuyahoga River. The dredged material contains pollutants from urban areas that were flushed into the river via storm runoff. The Army Corps of Engineers has been disposing of sediment from the Cuyahoga River shipping lanes by pumping it into Combined Disposal Facilities (CDFs) built into Lake Erie. CDF capacity is expected to be exhausted in 2015, and constructing additional capacity would be very expensive. USACE has concluded from sampling results that sediments in the CDFs are now clean enough to dump directly into the open waters of Lake Erie. However, Ohio EPA does not agree with the assessment that disposal in Lake Erie would be safe.

The Port of Cleveland (Port) has developed a multi-tier plan to help control and dispose of dredged material safely. Key elements of this plan involve selling the sediment for beneficial uses that have been determined to be appropriate and safe for the type of sediment material. Part of the plan is for the Port to intercept sediment before it can be contaminated by downstream pollutants in the ship channel, making it clean enough to be sold for unrestricted uses. The bedload interceptor project is paid for in part thru state of Ohio's Healthy Lake Erie Fund. The project is designed to be self-sustaining because commodities produced will cover operating costs, thus limiting impact on taxpayers. Another aspect of the plan is to sell dredged material from the shipping channel for use in the appropriate purposes, including covering over brownfields, for road construction, to fill basements of demolished houses, and to restore aquatic habitat areas. The Port believes this practice will establish Cleveland as national model for innovative methods for managing the dredged material (White, 2014).

5.1.3 The significance of water quality to the Northeast Ohio economy

CSU, among other Ohio institutions, recognizes the danger in assuming that an abundant supply of water is all that is necessary to sustain and promote thriving water-dependent industries and

their diverse water needs. Specifically, CSU states that industrial processes found in numerous manufacturing processes are essential to key sectors of the seven-county region and "are often complicated and sensitive to water quality" (Alexander et al., 2014, p. 48).

Whereas cooling water use in energy production does not necessarily have intake quality considerations – instead, having outflow temperature requirements – cooling water for manufacturing is often used for contact cooling. As a result, intake water quality is a consideration along with the usual factors such as equipment, techniques, and efficiency. CSU recognizes the importance of this extra factor for iron and steel manufacturing, which is a large part of the state's manufacturing core, and which in turn affects other key manufacturing-related sectors such as automotive and aviation (Alexander et al., 2014). Many advanced manufacturing firms are also affected by water-quality considerations associated with producing specialized metal components. In addition, much of the water use in technological chemical production, such as for producing medicinal, pharmaceutical, or energy-related products, takes place at high temperatures and pressure and therefore requires demineralized, high-quality water (Alexander et al., 2014).

As noted above, the food and beverage industry, including food processing, is a growing contributor to the Northeast Ohio economy. We selected this sector for further investigation because of the relatively high importance of high-quality water to food and beverage production processes. Breweries have thrived in Northeast Ohio because of abundant, high-quality raw materials such as water and agricultural products. Statistics compiled by the Brewer's Association for 2011 to 2013 show an increase in the number of craft breweries from 42 to 76 in Ohio, with over one million barrels of craft beer produced in 2013. Considering that quality water is the primary ingredient by volume, an abundant source of high-quality water is a key growth concern for producers. Recently, California-based breweries have had to confront supply constraints, in terms of both maintaining current production as well as planning for business growth. Sierra Nevada, a brewer based in Chico, California, recently opened a new production facility in North Carolina, in part because growth in drought-inflicted California, where the Governor has recently imposed mandatory water-use restrictions, is potentially limited by water quality and supply considerations (Olson, 2015). Although Sierra Nevada has not moved baseline production to North Carolina yet, a spokeswoman for the company has mentioned that it is a possibility in the future. In the meantime, Sierra Nevada has set a new water efficiency target of 4 gallons of water as input for every gallon of beer produced for current production. Bear Republic, another California brewer, has also increased their water efficiency by reducing the ratio of water to beer produced from 6:1 to 3:1.[3] Struggles with water-quality availability in California underscore the comparative advantage that water abundant regions such as Northeast

3. In an interview conducted with the Great Lakes Brewing Company (GLB), the company's representative said by contrast that they typically use six gallons of water for every gallon of beer produced, which is roughly the industry standard.

Ohio have in supporting water-dependent industries. Exhibit10 provides additional insights on the importance of water quality and quantity for brewers in the Northeast Ohio region, based on an interview with the Great Lakes Brewing Company (GLBC).

Exhibit 10. An interview with Saul Kliorys and Pat Conway of GLBC

GLBC is the 23rd largest craft brewery out of roughly 3,400 breweries in the United States. The brewery is growing by adding incremental capacity of 5% to 10% at a time. However, the brewery concentrates on serving its home region, an area within 500 miles from brewery.

GLBC is a socially conscious business concerned with sustainability. During our interview, GLBC expressed familiarity with water-quality and quantity issues affecting the Northeast Ohio region. GLBC was concerned about the possibility that dredge materials from the Cuyahoga River could potentially be dumped into Lake Erie. GLBC's concern was not only potentially for water quality for its business, but also generally about the effect of heavy metals on fish and recreation. GLBC organizes the Great Lakes Burning River Fest® to recognize efforts to clean up the Cuyahoga River since the 1969 fire and to promote awareness of the importance of water quality to the region. GLB also recognized combined sewer overflow problems in the region; large rain events have resulted in beach closures and loss of swimming recreation.

GLBC operates in the Central Basin of Lake Erie. GLBC noted the problems with algal blooms that have happened in the Western Basin of Lake Erie because that basin is shallower and closer to agricultural producers that are sources of nutrients that lead to algal blooms. Although algal blooms do not currently affect the Central Basin, GLBC was concerned about the possibility that the Central Basin could experience algal blooms like those that have affected the Western Basin and the nearby City of Toledo. GLBC did not know to what extent algal blooms would affect water production from Cleveland Water, which provides water to GLBC. However, GLBC anticipated that if the brewery were forced to close down for more than a few days (perhaps a week), the company would suffer not only from production and sales declines, but also long-term effects on the reputation of their product in the market.

GLBC recognized the importance of abundant, high-quality water for the beverage industry. The brewery believes that the Great Lakes Region and Northeast Ohio specifically has a competitive advantage compared to areas of the country such as California that are facing drought pressures. GLBC noted specific cases of water availability pressures on craft brewers in California, where brewers needed to significantly reduce their water consumption ratio of water to beer produced, compared to industry standards, to adapt to reduced water availability. Alternatively, California breweries have considered expanding into other areas of the country, such as North Carolina, to pursue abundant, high-quality water.

In addition to a local comparative advantage for brewers, GLBC representatives also noted the comparative advantage that the Northeast Ohio area has in terms of affordability of living compared to high-cost areas such as California and Seattle. GLBC believed that affordable living and abundant water provide an incentive for companies and their workers to migrate to upper-midwest cities such as Cleveland.

GLBC also noted the importance of agriculture, and the greenhouse industry specifically, in Northeast Ohio. This industry has grown near abundant water; it is an important supplier to GLBC and to restaurants and food providers in the Northeast Ohio region.

In our interview with GLBC, company representatives stated that they believe the region's abundant supply of high quality water provides a comparative advantage relative to other areas of the country facing water supply constraints. Belief in this comparative advantage appears to be commonly held. However, there are no hard data available at this point in time to back up this belief. There is some anecdotal evidence in the United States that water availability can influence a business' decision on where to locate, depending on the type of industry, but evidence on the impact of water quality on business location decisions is even more rare.

Data on the importance of water quality to specific industries are difficult to obtain. This is partially because industry use of water in manufacturing processes is often unique, and also because there can be confidentiality concerns about revealing trade secrets around water use. Interviewing local businesses is the most direct way to gather additional data on the importance of water quality to the local economy. We requested three interviews with businesses for this phase of the investigation and were granted one of those requests.

For Phase 2 of the investigation, we propose that it would be very valuable for us to conduct more interviews with a wider range of local business types to assess the importance of water quality and the comparative advantage it provides for the region. We will need assistance from the Cleveland Water Alliance and its partners to help arrange for these interviews.

5.1.4 Multiplier effects of water dependent industries and investments

Water dependent industries and businesses add value to the Northeast Ohio region based on the direct sales and employment that they generate. They also create multiplier effects in the local economy by supporting other businesses (e.g., businesses they purchase supplies from) and households, which in turn, spend money in the local region. Multiplier effects are classified as direct, indirect, and induced economic impacts:

- ***Direct impact***s represent local expenditures made by a business or industry, including expenditures related to inventory, utilities, equipment and pay to employees.

- ***Indirect impacts*** happen as dollars that the local business spends at other area businesses re-circulate in the economy.

- ***Induced impact*** refers to the additional consumer spending that happens as employees, business owners, and others spend the income they earn as a result of direct and indirect economic activity in the local economy.

To assess the direct, indirect, and induced economic impacts associated with clean water, it is important to first be able to identify a change in the economy resulting from water-related economic activity. This could include for example, the economic impact of a new business being

attracted to the region largely because of its water resources (e.g., what economic impact would the business have in the local region?), or the impact associated with a business leaving the region because of concerns over water quality or quantity. This would help to provide a picture of the importance of water resources within the local region. One could also assess the economic impacts associated with a large investment from outside of the local region (e.g., from the federal government or a foundation) to improve water quality. When assessing economic impacts associated with water dependent industries or investments, it is important to keep in mind that there must be a change in expenditures from outside the local region that would not otherwise be made.

Under Phase 2, we will work with CWA to explore different scenarios that we can develop to estimate the direct, indirect, and induced effects associated with water-dependent industries.

5.2 Avoided Water Treatment Costs

Water quality directly affects the level of treatment required for drinking water and water used for industrial purposes. Thus, high levels of water quality can result in reduced or avoided costs for water treatment processes and associated infrastructure.

In terms of water treatment, municipal water suppliers are typically most concerned with salinity and total suspended solids (TSS; Koteen et al., 2002). High levels of salt in municipal source water can damage the equipment used in retrieving, treating, and transporting water to households, resulting in increased maintenance and replacement costs. TSS levels in source water directly affect the treatment processes that municipal water suppliers must use to ensure drinking water safety. For example, water with low TSS levels can be treated by filtration, while high levels of TSS require more advanced and expensive treatment processes, such as sedimentation. Low TSS levels also simplify the disinfection process, making it less costly (Koteen et al., 2002).

In a recent report on the economic benefits of healthy watersheds, EPA (U.S. EPA, 2012) presented the results of a study of 27 U.S. water suppliers, which found that water treatment costs vary significantly depending on source water quality. Specifically, the study found that protecting forested watersheds to improve water quality can reduce capital, operational, and maintenance costs for drinking water treatment by more than 200%. Exhibit 11 presents the results of this study.

Exhibit 11. Municipal water treatment costs

Share of forested watershed	Treatment cost ($ per 3,000 m^3)	Average annual treatment costs (2012 USD)	Cost increase compared to cost for 60% forest cover
60%	29	297,110	NA
50%	36	369,380	24%
40%	46	465,740	57%
30%	58	586,190	97%
20%	74	746,790	151%
10%	91	923,450	211%

Source: U.S. EPA, 2012.

Using data from over 400 of the largest U.S. utilities, Holmes (1988) estimated that a 1% increase in sediment loading leads to a 0.05% increase in water treatment costs. Austin et al. (2007) used this estimate to assess the benefits associated with a 40% reduction in sedimentation in the Great Lakes – the target reduction identified in the 2005 *Great Lakes Regional Collaboration Strategy (GLRC) to Restore and Protect the Great Lakes* (Great Lakes Regional Collaboration Strategy, 2005).

First, the authors estimated that operating costs for water supply facilities that draw on water from the Great Lakes total about $600 million (2006 USD). Thus the GLRC goal of achieving a 40% reduction in sedimentation would reduce drinking water treatment costs by $12 million per year. In addition, water suppliers would also likely benefit from reduced capital costs associated with water treatment infrastructure (Austin et al., 2007).

In the Northeast Ohio study region, salinity and TSS do not present a significant issue for most municipal water suppliers. Municipal suppliers and their customers have therefore benefited from lower costs associated with water treatment in relation to these constituents. However, water quality treatment issues associated with the hypoxic dead zone remain a concern for water suppliers that rely on Lake Erie as a primary source of water supply. For example, Cleveland Water reports that under the right weather conditions, dead zone water can reach one of the utility's four intakes on Lake Erie. Although Cleveland Water is vigilant in watching for dead zone water, it can be extremely difficult (and costly) to treat, and the final treated water may be impacted by elevated levels of manganese from the dead zone. Dead zone water does not have health issues associated with it, but it can result in an unpleasant color and odor.

Treatment issues associated with HABs also remain a pressing concern in the region, and many Ohio communities have made significant HAB-related investments. For example, the Columbus Dispatch (Hunt, 2014) reported that in 2014, the City of Columbus spent more than $700,000 to address the unpleasant taste and smell in drinking water caused by toxic algae at Hoover Reservoir. In 2013, Toledo spent $3 million to keep Lake Erie's toxic algae out of the city's drinking water. Exhibit 12 provides several additional examples from Ohio EPA (Raymond, 2013) of treatment costs associated with HABS in different Ohio communities.

Exhibit 12. Example of HAB-treatment costs in Ohio communities

- Toledo. Population 450,000. Spends up to $200,000/month on carbon to address algae and HABs. Many Lake Erie water systems routinely add carbon to address HABs.
- Clermont County. Population 117,000. In response to increasing trihalomethane (THM) and algae levels, spent approximately $6 million in capital costs for the new granular-activated carbon (GAC) facility, and anticipates spending $660,000/year on GAC filter media.
- Akron. Population 333,000. Spent more than $200,000 in one month on carbon to treat an algae bloom that was affecting taste and odor.
- Columbus. Population > 1,150,000. Spent an extra $10,000/day for powdered activated carbon (PAC) in response to an algae-related taste and odor event.
- Carroll Township. Population 2,288. Installing upgraded $125,000 ozone treatment in response to water microcystin detections.
- Celina. Population 11,700. Spent $7.2 million in capital costs for new GAC facility and spends ~ $500,000/year on GAC filter media and ozone annual expenses to address disinfection byproducts and HAB concerns.

Source: Raymond, 2013.

Although HABs are not yet widespread within the Central Basin, conversations with water utility representatives in the study region indicate that they do continually monitor for HAB-related constituents, as well as other water quality parameters. In addition, some utilities are planning to develop infrastructure to mitigate any potential effects of HABs. For example, a representative from Avon Lake Regional Water reported that the utility plans to spend $35 million dollars over the next several years to develop additional storage that they can draw upon in the event of a HAB or other water quality-related event[4]. Other utilties in the region, such as Cleveland Water, have benefitted from not having to expend large amounts of money to treat water that has been contaminated by HABs.

Under Phase 1, we were not able to obtain specific data from local water utilities related to treatment costs. However, we were able to discuss general water quality issues, and the benefits that utilities associate with being able to access high quality and abundant water resources. In Phase 2, we propose to survey water utilities within the region to explore the costs and benefits

[4] This includes water shortages that may occur due to frazil ice blocking the utility's water intake in Lake Erie.

associated with water quality issues, including frazil ice (a potential problem for Avon Lake Regional Water District) and the hypoxic dead zone.

In addition to water utilities, industries that supply their own water also benefit from water-quality improvements. Similar to municipal water suppliers, industrial users of water are typically concerned with salinity and TSS levels; however, treatment requirements vary significantly depending on the industrial use. As reported by Koteen et al. (2002), studies estimate that industries in the United States experience total annual damages associated with salinity and TSS levels of between $1.3 billion and $2.6 billion.[5] In the Northeast Ohio region, self-supplied industrial water accounts for close to 20% of total water withdrawals. Thus, the region's abundant supplies of high-quality water potentially provide a substantial benefit in terms of avoided treatment costs for local industries. However, there is little information on the benefits of reduced water-quality treatment requirements for industrial users.

Households can also benefit from avoided water-quality treatment costs. For households connected to municipal water systems, these benefits are usually limited. However, in some areas, many households purchase point-of-use treatment systems to reduce taste and odor issues. Households may also face additional treatment-related costs in extreme situations, such as quality-related water supply disruptions (see Section 6.5). Clean water reduces these costs, or allows households to avoid them altogether.

6. Social Values

In this section, we describe the social benefits associated with clean water, including benefits related to public health, tourism and recreation, property values, and water supply reliability.

6.1 Public Health

Over the past several decades, investments in improving Lake Erie's water quality have resulted in significant benefits, particularly in relation to reducing public health risks. However, elevated bacterial levels at local beaches, algal toxin exposure, and fish contaminant concentration issues continue to pose potential health risks for residents and visitors in the Northeast Ohio region. In this section, we describe the public health implications and values associated with water quality in the study region, as they relate to recreational contact, drinking water, and fish consumption.

5. Updated from 1998 USD to 2014 USD.

6.1.1 Bacteria levels at local beaches

Discharges of polluted urban runoff, untreated sewage spills, and combined sewer overflows (CSOs) continue to result in elevated levels of bacteria and other pathogens at Lake Erie beaches. This in turn can cause a number of water-borne illnesses, including stomach flu, respiratory infection, and ear and skin infections. Although most of these illnesses last only a few days to several weeks, "in some cases pathogens may cause severe, long-term illness or even death. Sensitive populations such as children, the elderly, or those with a weakened immune system are particularly at risk for long-term effects" (NRDC, 2014, Health and Economic Impacts section, p. 1).

In 2013, Ohio monitored 22 of the 25 coastal beaches within the study area for bacteria levels and other pathogens. Of the reported beach monitoring samples, 39% exceeded the Beach Action Value (BAV) safety threshold for *E. coli* bacteria[6]. Beaches with the highest BAV exceedence rates included: Lakeview Beach in Lorain County (76% exceedence rate), Edgecliff Beach in Cuyahoga County (62%), Clarkwood Beach in Cuyahoga County (61%), and Sims Beach in Cuyahoga County (61%).

When water quality samples exceed established thresholds, Ohio EPA issues water-quality advisories. In 2012, of the 61 coastal beaches that Ohio monitored, 57 of them had at least one water-quality advisory/notification action. For the majority of these actions, water quality returned to normal and beaches were deemed safe for swimming within one or two days. However, EPA reports that of 6,510 beach days associated with Ohio's 61 monitored beaches, Ohio EPA issued notification actions on 1,278 of those days in 2012. This means that beaches were closed and deemed unsafe for swimming approximately 20% of the time. As discussed in Section 6.2, in addition to public health concerns, beach closures can have significant economic effects.

The public health effects that result from recreational contact with polluted waters are difficult to quantify. Many cases go unreported, and there can be a delay of several days to two weeks between contact with contaminated water and expression of symptoms; many people who get sick from swimming are not aware of the link. In addition, beachgoers can become ill without even going into the water, making the connection even more difficult.

In addition, issues associated with bacterial contamination will continue to improve. Over the past several decades, NEORSD has invested nearly $900 million in projects that have

[6] The U.S. Environmental Protection Agency provides the BAV to states as a conservative, precautionary value for making beach notification decisions in order to provide an early alert to beachgoers, including families with children.

significantly reduced CSOs, and associated bacteria contamination at local beaches. In addition, in 2011, NEORSD entered into a Consent Decree with the U.S. Department of Justice, U.S. Environmental Protection Agency, and Ohio Environmental Protection Agency to achieve 98% capture of CSOs and reduce total CSOs by $4 billion gallons annually. The District estimates that their plan to reach this goal through a mix of green and gray infrastructure projects will cost $3 billion and will be completed within 25 years.

6.1.2 Contamination of drinking water supplies

Microbial contamination of drinking water can also pose a potential public health risk in terms of acute disease outbreaks. Illnesses associated with contaminated drinking water are mainly of a gastrointestinal nature, including diarrhea, nausea, stomach cramps, and other symptoms; some pathogens are capable of causing severe and life-threatening illness (Lake Erie LaMP Work Group, 2006).

Microbial and other sources of contamination have largely been eliminated by municipal water suppliers through the treatment of drinking water before distribution (e.g., contaminants are removed and disinfectants such as chlorine are added to prevent waterborne disease). However, serious incidences of contamination have occurred in recent history within the Great Lakes region. For example, in May 2000, bacteria entered the drinking water supply of Walkerton, Ontario; 7 people died and more than 2,000 people became ill (Lake Erie LaMP Work Group, 2006). In 1993, a major cryptosporidiosis outbreak in Milwaukee killed 54 people and sickened more than 400,000 people after stormwater compromised the performance of a drinking water treatment plant (NRDC, 2014).

6.1.3 Public health implications of HABs

The toxins that develop as a result of algal blooms in the Lake Erie region can make people ill if they are exposed to contaminated water. HABs can cause serious and potentially life-threatening symptoms in humans, including diarrhea, nausea, vomiting, abdominal cramping, chills, diminished temperature sensation, muscle aches, dizziness, anxiety, sweating, seizures, numbness and tingling of the mouth and digits, paralysis, and cardiovascular and respiratory ailments. According to the Ohio Department of Health, there were 48 probable and suspected human illnesses related to recreational algal toxin exposure in 2010, including 8 in Grand Lake St. Marys, 9 in the Western Lake Erie Basin, 6 at Burr Oak State Park, 3 at Deer Creek, 2 at Lake Alma, 1 at Lake Hope, and 19 at Lake Mac-O-Chee (YMCA Camp Wilson). There were also five reported dog deaths related to HABs in that year (Raymond, 2011). These are considered low estimates because water-borne illnesses are likely underreported, misdiagnosed, and possibly

increasing. We were unable to find similar data for later years, when HABs were even more prevalent in Lake Erie.

6.1.4 Chemical and industrial pollutants

The critical chemical pollutants of concern in Lake Erie include organochlorines and metals that are known to cause adverse health effects in animals and humans. These chemicals do not break down easily; persist in the environment; and bioaccumulate in aquatic biota, animal, and human tissue. They are called persistent bioaccumulative and toxic (PBT) chemicals. Organochlorines tend to accumulate in fat, such as in adipose tissue and breast milk; and metals tend to accumulate in organs, muscle, and flesh. These chemicals are found in greater concentrations in the Cuyahoga, Portage, and Grand river sediments, and there is concern that without proper precautions, continued dredging for commercial transportation will increase exposure of fish populations to these contaminants.

Exhibit 13. Ohio EPA sport fish consumption advisory information

Ohio EPA offers the following general advice in relation to limiting fish consumption:

- Two meals per week for yellow perch, sunfish (e.g., bluegill, green, longear, redear)[a]
- One meal per week: all fish not specified
- One meal per month: Flathead catfish 23" and over, northern pike 23" and over, steelhead trout from Lake Erie and its tributaries.

a. Consumption of these species should be limited to one meal per week from Ashtabula River, Cuyahoga River, Mahoning River, Nesmith Lake, Ohio Canal, Ohio River and West Branch Reservoir.

Source: Ohio EPA, 2015.

Consumption of fish is the primary route of human exposure to PBT chemicals in Lake Erie. To limit adverse health effects associated with fish consumption, Ohio EPA issues fish consumption advisories for Lake Erie and its tributaries. Exhibit 13 shows the current general fish consumption advisory information for Lake Erie (Ohio EPA, 2015). Conversations with an Ohio Department of Natural Resources (ODNR) representative indicated that if dredged materials in the region are not disposed of properly, fish consumption advisories will become much more stringent (e.g., recommendations may go from one meal per week to one meal per month).

The Lake Erie Lakewide Management Plan reports that "demonstrating health effects in humans from chronic, low-level exposure to persistent organic pollutants such as typically encountered in the Great Lakes region is a challenge for researchers" (Lake Erie LaMP Work Group, 2006, p. 132 in PDF). Exposure to contaminants from Great Lakes fish is dependent upon the amount eaten and species consumed; overall, there is limited information available on exposure levels and health effects for people who consume Lake Erie fish (Lake Erie LaMP Work Group, 2006).

Between June 2001 and June 2002, Imm et al. (2005) conducted a population-based, random-digit-dial telephone survey of adults residing in Great Lakes states to assess consumption of commercial and sport-caught fish and awareness of state-issued consumption advisories. Findings from this survey indicate that exposure to persistent contaminants found in Great Lakes fish is likely limited to a relatively small subpopulation of avid sport-fish consumers. Results also underscore the public health importance of advisories for commercial fish because an estimated 2.9 million adults living in these states consume more than 104 fish meals per year and may be at risk of exceeding the reference doses for methylmercury, polychlorinated biphenyls, and other bioaccumulative contaminants.

Research has also shown that some populations have a higher risk of experiencing adverse health effects associated with exposure to contaminants from fish consumption. These populations include Native Americans, minorities, sport anglers, the elderly, pregnant women, and fetuses and infants of mothers consuming contaminated Great Lakes fish. These communities may consume more fish than the general populations or have physiologic attributes, such as physical and genetic susceptibilities, which may cause them to be at a greater risk (Lake Erie LaMP Work Group, 2006).

6.1.5 The value of clean water within the context of public health

As noted throughout this section, water quality–related health effects are difficult to quantify. However, individuals that contract waterborne illnesses, or experience long-term health effects from water-quality contamination, incur real and often significant costs associated with medical bills, pain and suffering, restricted activity days, and lost work days. Contamination of drinking water supplies can also result in devastating effects in local communities, including illnesses and death. Within this context, the value associated with clean water to public health cannot be overstated.

6.2 Water-Based Recreation and Tourism

Lake Erie and inland water bodies provide a popular tourist attraction for Ohio residents, as well as visitors from other states. There are two types of values associated with recreation and tourism. The first reflects the value that individuals derive from participating in recreational activities (and is measured based on their willingness-to-pay to participate in them). Economists refer to these values as recreational-use values. The second relates to the direct and indirect economic impacts associated with tourism-related expenditures (i.e., the economic stimulus provided by recreational spending). In this section, we present an overview of water-based recreation in Northeast Ohio, provide estimates of the recreational-use values associated with

water-based recreational activities, and assess the impact of tourism-based expenditures on the local economy.

6.2.1 Overview of water-based recreational activities

The Northeast Ohio study region contains approximately 83 miles of coast along Lake Erie (ODNR, 2014), including 16.5 miles of public beach access. Lake Erie and its beaches serve as the primary recreational attraction within the region, supporting countless beach recreation activities, including swimming, fishing, and boating.

In addition to Lake Erie, the region's extensive network of rivers, streams, and inland lakes also serve as important recreational assets. Water-based recreation attractions within the study area include the Ohio State Parks, Cleveland Metroparks, and CVNP. As described below, residents and visitors to the Northeast Ohio region make more than seven million visits to these attractions each year. This estimate does not include visits to the many other local parks in the region that provide water-based recreation activities.

Exhibit 14 presents the number of visits to Ohio State Parks within the Northeast Ohio region in 2010, and the different water-related activities available at each park.[7] As shown, all seven State Parks within the region have one or more lakes. Although we are unable to provide data on the number of visits specifically related to water-based recreational activities, it seems reasonable to assume that water quality has a significant effect on recreation at these parks.

In addition to Ohio State Parks, Cleveland Metroparks support more than 15.5 million visitors per year at its 18 parks within the greater Cleveland region (Trust for Public Land, 2013). Cleveland Metroparks is the largest stream-side landowner in Ohio, and conversations with park staff indicate that recreation at the parks is largely stream-based (Jennifer Grieser, Cleveland Metroparks, Senior Natural Resource Manager – Urban Watersheds, personal communication, Jennifer Grieser, March 26, 2015). Key water-related park activities include birding, boating, fishing, exploring nature, hiking, picnicking, swimming, wildlife viewing, and more.

7. The State Parks do not report visitation by activity (Douglas Lyons, Ohio State Parks, Northeast District Manager, personal communication, May 13, 2015); however, the individual park websites include activities available at the park.

Exhibit 14. 2010 visitation to Ohio State Parks within the study area

Park name	County	Water attraction[a]	Water-related activities[a]	2010 total visitation[b]
Findley State Park	Lorain	93-acre lake	Boating, fishing, swimming	543,362
Headlands Beach	Lake	Lake Erie	Fishing, swimming	4,367,619
Portage Lakes	Summit	2,034 acres over 8 lakes	Boating, fishing, swimming	1,076,044
Punderson	Geauga	150-acre lake	Boating, fishing, swimming	631,558
West Branch	Portage	2,650-acre lake	Boating, fishing, swimming	472,930
Wingfoot Lake	Portage	444-acre lake	Boating, fishing	83,762
Total				7,175,275

a. Source: ODNR, 2015.
b. Source: ODNR, 2010.

Similar to Cleveland Metroparks, CVNP also supports many stream-based recreational activities including streamside hiking, fishing, birdwatching, canoeing, and kayaking. CVNP is contained in Cuyahoga and Summit Counties, and located a short distance from the urban areas of Cleveland and Akron. The park attracts over 2.16 million visits each year. Spending by these park visitors supports 530 jobs earning $14.9 million in labor income (Trust for Public Land, 2013).

Although not all visits to local recreational sites involve water-based activities, it is clear that clean water plays a large role in recreational use and associated contributions to the local economy. This is particularly true for angling, boating, swimming, beach use, and coastal recreation. For example, angling is directly affected by fish contamination (and associated fish consumption advisories), as well as fish abundancy (which is often a problem in the Lake Erie dead zone). Beach closures associated with bacterial contamination also significantly impact recreational enjoyment. As described in Section 6.1, Ohio's Lake Erie beaches were closed to water-based recreation 20% of the time in 2012.

6.2.2 Recreational-use values

As stated above, the value of recreation includes values that individuals derive from participating in recreational activities (i.e., recreational-use values). In the Recreation Use Values Database for North America, Rosenberger (2011) reports per-day recreational use values for several activities and regions. Exhibit 15 presents these values for recreational activities in Ohio that are linked to water quality (beach use, swimming, boating, fishing).

Exhibit 15. Recreational-use values (per visitor-day) reported in the Recreation Use Values Database for North America (Rosenberger, 2011) for water-related activities in Ohio

Activity	Number of studies	Average value per day[a] (2015 USD)	Range (2015 USD)
Beach	2	$14.13	$1.08 to $39.07
Swimming[a]	1	$21.70	n/a
Motorboating[b]	1	$16.53	n/a
Freshwater fishing[c]	7	$16.52	$0.56 to $59.87

a. a visitor day is defined as one visit by one person on one day

b. Study area includes IN, MI, NH, OH, WI, and WV.

c. Study area includes IL, IN, KY, MI, OH, PA, TN, WI, and WV.

Beach use and swimming: Lake Erie and Ohio's inland lakes provide popular swimming and beach-use sites. Song et al. (2010) note that there is little economic literature regarding the value of beach access along the Great Lakes, and that Sohngen et al. (1999) and Murray et al. (1999) are two of the few previous studies that estimate recreational values associated with Great Lakes beaches. As reported in these studies, in the summer of 1998 the Ohio Sea Grant Program conducted surveys on 15 beaches in Lake Erie, 7 of which are located within the Northeast Ohio study region. Based on these surveys, Sohngen et al. (1999) estimated that there were approximately 224,000 beach user days at Headlands State Park during the summer of 1998, and that each day provided users with $21.03 in recreational-use value. Thus, total recreational-use value for beach use at the park amounted to $4.75 million. As noted above, in 2012, Ohio closed Lake Erie beaches on about approximately 20% of days during the summer swimming season. If we assume that beach use would have been 20% higher at Headlands State Park in the absence of these closures, total recreational use value would have been $5.7 million (an additional $950,000).

Recent studies indicate that recreational-use values associated with Lake Erie beaches may be much higher. For example, Song et al. (2010) used travel cost expenditures to estimate the value that individuals place on trips to Great Lakes beaches in Michigan. The authors found that the value of a trip to a specific Great Lakes beach site in Michigan averaged $51.01, and ranged from $40.24 to $62.72 (2015 USD).These estimates are significantly higher than those reported by Sohngen et al. (1999) and Rosenberger (2011).

Boating and angling: Boating and fishing are also popular recreational activities in Northeast Ohio, especially on Lake Erie.[8] Although an accurate count of boating days within the study

8. According to the Great Lakes Commission (2007), approximately 50% of angling in Ohio is boat-based. For the purposes of this study, we do not attempt to disaggregate the economic values between boating and fishing.

region was unavailable, several studies have estimated boating days and the corresponding economic impacts for the Great Lakes. The Great Lakes Commission (2007) report indicated that there are 4.3 million boats registered in the 8 Great Lakes states, with an estimated 911,000 operating on the Great Lakes themselves. Of the 4.3 million registered boats in the Great Lakes states, 413,048 are registered in Ohio.[9] In a survey conducted by Ohio Sea Grant, the average respondent took 15.6 trips to Ohio boating sites, of which 4.3 were to Lake Erie sites, 1.3 were to Ohio River sites, 8.7 to inland lakes and reservoirs, and 1.3 to inland rivers and streams (Hushak, Undated). As shown in Exhibit 15, Rosenberger (2011) reports that the value of these trips averages $16.53 per day.

In a benefit-cost analysis of a comprehensive program to protect and restore the Great Lakes, Austin et al. (2007) reported a range of recreational-use values per Great Lakes angler day from multiple studies. Based on these studies, the authors estimate that Great Lakes anglers value each 1% increase in catch rates for both cold water species (e.g., trout and salmon) and warm water species (e.g., walleye, perch, bass, pike) at $0.06 per fishing day, with a range of between $0.02 and $0.11 per day. In addition, the authors report that according to one study, Green Bay anglers value each 1% increase in *all* species at roughly $0.15–$0.30 per fishing day (this is roughly consistent with summing the estimates for major individual species). Austin et al. (2007) extrapolated these findings to the Great Lakes region to estimate that benefits associated with water-quality improvements associated with the GLRC. Specifically, the authors estimated that based on 23.1 million Great Lakes fishing days per year, avoiding an immediate 25% decrease in fish abundance would be worth roughly $87–$170 million annually (2007 USD).[10]

6.2.3 Economic impacts of tourism

As stated above, the second component of economic value associated with recreation and tourism includes the direct and indirect economic impacts associated with the expenditures from tourism. Tourism Economics (2012) estimated that in 2012, the total economic impact associated with tourism in Ohio counties adjacent to Lake Erie included $11.8 billion in sales, $3.2 billion in wages, and 117,513 jobs. Sohngen et al. (1999) reported that visitors to Headlands State Park

9. One caveat of note, however, is that although boat registration is a proxy for boating activity, it does not provide an accurate indication of where boating trips occur (Melinda Huntley, Ohio Travel Association, Director, personal communication, May 5, 2015).

10. The authors also report recreational-use values per Great Lakes angler day from a 1988 study (Hushak et al., 1988) that focused on the Central Basin of Lake Erie. This study estimated recreational use values for boat-based anglers fishing for walleye and yellow perch of $1.12 per angling day. However, this study is based on a survey conducted in 1981, and thus may not provide an accurate estimate of current valuation.

spend about $28 per single-day trip, generating approximately $4.5 million in local economic impacts.

Boating is one of the primary drivers of recreation-related economic activity. In a 2007 study, the Great Lakes Commission (2007) estimated that spending on boating and related activities in Great Lakes states amounts to $18 billion per year. They further estimated that this spending directly and indirectly supports 244,000 jobs and contributes $21 billion in direct and indirect sales, $7.2 billion in personal income, and $10.4 billion in value added.

Based on this study, Exhibit 16 reports the total average annual economic impact of registered boats for the State of Ohio.

Exhibit 16. Total average annual economic impact of registered boats on Ohio's economy

	Sales (millions)	Jobs	Personal income (millions)	Value added (millions)
Trip spending	$1,312	16,645	$430	$525
Annual craft spending	$892	9,503	$308	$532
Total spending	**$2,204**	**26,148**	**$738**	**$1,056**

Note: Totals may not sum due to rounding.

Source: Great Lakes Commission, 2007.

The Great Lakes Commission (2007, p. 9) reported that, "direct spending in Great Lakes coastal communities by charter fishing customers in 2003 was estimated to be $23.1 million, not including charter fees…resulting in direct economic impacts of $18.8 million in sales, $7.8 million in wages and salaries, and $10.3 million in value added to local economies, sustaining 331 jobs."

Local parks and CVNP also contribute substantially to tourism-related economic activity. The Trust for Public Land (2013) estimated that visitors to the outdoors in Cuyahoga County spend $743 million annually and generate $51.2 million in state and local sales taxes. In addition, non-local visitors to CVNP spend about $37.7 million per year.

As noted above, a number of water-quality issues can affect recreational and tourism-related spending. For example, Grand Lake St. Marys State Park, while not within the Northeast Ohio region, can be used as a proxy for the lost economic impacts associated with HABs in inland lakes. The Lake Improvement Association (Undated) estimated local businesses have lost 35–40% annually in revenue in 2011 and 2012 due to slow tourism seasons since the algal bloom occurred, and property values have declined 6% because of conditions in Grand Lake in

St. Marys State Park. HABs and decreased fish abundance in the Lake Erie dead zone may also affect sales in the Lake Erie charter boat fishing industry.

6.3 Property Values

Economists often estimate the value of environmental goods and services based on how they affect the value of nearby properties. A primary advantage of using property values to assess environmental attributes is that "they reflect what people are *actually willing to pay*, rather than what they might *say* they are willing to pay" (Austin et al., 2007, p. 41). In addition, property values can serve as a measure of the *aggregate* value of environmental goods and services. In the current context, this includes values associated with direct uses of clean water, such as for drinking or recreation, as well as values associated with the existence of clean water for environmental and ecosystem purposes, or for the benefit of future generations.

Several studies have examined the relationship between water quality and residential property values. Results of these studies vary considerably depending on the water-quality parameters being examined, baseline water-quality levels at the study site, and the study location. For example, Ara (2007) estimated that a 1% reduction in fecal content at the nearest Lake Erie public beach would increase residential property values in four Ohio counties adjacent to the Lake by about $7.40 per property (2014 USD). This amounts to an increase of 0.004% for every 1% decrease in fecal content. Comparatively, in a study of waterfront properties on Chesapeake Bay, Leggett and Bocksteal (2000) estimated that a 1% reduction in water fecal content would increase property values by about 0.0002%.

Studies evaluating the effects of water clarity have generally found more significant effects. In the study mentioned above, Ara (2007) estimated that a 1% increase in water clarity would increase residential property values in four Ohio counties adjacent to Lake by about $67, or 0.04%. Clapper and Caudill (2014) found that buyers in Near North, Ontario, are willing to pay 6.5% more for lakefront property for every one-meter increase in water clarity. In a study of lakefront property values in New Hampshire, Gibbs et al. (2002) also found water clarity to be an important consideration for property owners. Specifically, the authors found that a one-meter decrease in Secchi depth water clarity led to decreases in property values ranging from 0.9% to over 6%, on average. In a more recent study, Herak (2014) estimated that a one-meter increase in Secchi depth water clarity in Hoover Reservoir (located in the Upper Big Walnut Creek watershed in Franklin and Delaware counties in Ohio) could increase a home's value by up to 30%. The author also found that the marginal damage of a 1 mg/L increase in nitrogen and phosphorus loadings ranged from 0.2% to 2.4% of a home's value, respectively.

As reported by Walsh et al. (2011), water quality can affect the value of both waterfront properties and properties located close, but not directly adjacent to the shore. These findings are

confirmed in a series of hedonic studies by Patunru et al. (Undated) and Braden et al. (2006), which estimated the economic impacts associated with AOCs in three Great Lakes watersheds: Sheboygan River in Wisconsin, Buffalo River in New York, and Waukegan Harbor in Illinois. Results of these studies suggest that homes within five miles of an AOC likely suffer a 5% decline in property values (or greater) because of the presence of the AOC.

Building on this research, Patunru et al. (Undated) and Braden et al. (2006) also conducted stated-preference studies in these locations to analyze the potential increases in residential real estate values that would occur if the AOCs were cleaned up. These studies indicated that residential property values closest to cleanup sites would increase by 15% to 20% (or conversely, real estate prices, in the absence of cleanup, are depressed by 15% to 20%). Again, the authors found that price increases tapered off with distance, usually disappearing within five miles (Austin et al., 2007).

Austin et al. (2007) used the results of the Patunru et al. (Undated) and Braden et al. (2006) studies to develop order-of-magnitude estimates of the benefits and costs of a comprehensive program to protect and restore the Great Lakes (based on the 2005 report, *Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes)*. Specifically, the authors assumed that the program would result in a 10% increase in value at properties located in Census tracts adjacent to the Great Lakes. For properties located in Census tracts within Metropolitan Statistical Areas (MSAs) beyond the coastal Census tracts, but within the "zone of possible impacts," the authors assumed a 1% to 2% increase in value. These potential increases were intended to serve as conservative, lower-range estimates for the average price increases associated with restoration activities, based on findings from the Patunru et al. (Undated) and Braden et al. (2006) studies. As described below, we followed this basic method to develop order-of-magnitude estimates for how property values might increase if water-quality improvements similar to those described in the GLRC Strategy restoration plan were implemented in the seven-county region.

Following Austin et al. (2007), we used data from the 2013 American Community Survey (ACS) to determine the aggregate value of owner- and renter-occupied households for Census tracts located directly adjacent to Lake Erie (i.e., coastal Census tracts), as well as for non-coastal Census tracts located within the Cleveland MSA. As shown in Exhibit 17, the results of our analysis indicate that a 10% increase in residential property values in Census tracts located directly adjacent to Lake Erie would result in $1.24 billion in property value benefits for the local region. Applying an additional 1% to 2% in value to residential properties in non-coastal Census tracts would add another $1.04–2.08 billion in value. Combining the two estimates yields an estimated range of $2.28 billion to $3.32 billion in increased property value, and thus economic benefit, associated with the water-quality improvements described in the GLRC Strategy restoration plan.

Exhibit 17. Potential property value benefits of water quality improvements

	Number of households	Average value	Aggregate value (millions)	Value of improved water quality (millions)
Coastal Census tracts				
Owner-occupied households	54,185	$174,727	$9,468	$947
Renter-occupied households	33,756	$85,562	$2,888	$289
Non-coastal Census tracts				
Owner-occupied households	507,299	$168,240	$85,348	$188–377
Renter-occupied households	250,109	$75,294	$18,832	$854–1,707

Although these results serve as a proxy for the value that local residents place on clean water, the results are sensitive to baseline water-quality levels and the extent of expected improvements. These estimates also do not capture what local residents would be willing to pay to avoid further water-quality degradation. In addition, the aggregate benefits reported in Exhibit 17 are likely conservative, they do not take into account any potential increases in commercial properties, and they do not include properties located in Portage and Summit counties, within the Akron MSA. Although not located adjacent to Lake Erie, many of these properties are located near rivers and streams within the Lake Erie watersheds – watersheds that would likely benefit from large-scale restoration efforts. As discussed elsewhere in this report, these rivers and streams serve as an important asset for Northeast Ohio residents.

6.4 Water Supply Reliability

Water utilities in Northeast Ohio provide reliable supplies of high-quality water to households and businesses within the seven-county region. The importance of water supply reliability for businesses is described in Section 5.1. This section focuses on the impacts of water quality-related supply disruptions for households.

Water utilities in the three counties that rely primarily on Lake Erie for its water supplies (Cuyahoga, Lake and Lorain counties) supply water to 1.8 million residents. As described in Section 3.1, many water utilities and residents also rely on the region's groundwater as a primary source of supply.

Water quality can affect the reliable delivery of these supplies. For example, in 2014 a toxic algal bloom in Lake Erie interrupted water delivery by the City of Toledo for three days. After workers at the city water treatment plant started to see high readings of microcystin, they posted

"Do Not Drink" warnings and pumped carbon into the water to eliminate the toxin. Groundwater quality and supply can be threatened by chemical pollutants and nutrients, as well as overuse.

The economic impacts of water supply disruptions are demonstrated by the effects of the 2014 algal bloom (see Exhibit 18). Toledo's mayor estimated total the economic impact at $2.2 million to $2.5 million, and other estimates were higher, at $3 to $4 million. Effects from the event also lingered, as residents had to conserve water for the rest of the summer to reduce stress on the treatment plant.

Exhibit 18. Effects of Toledo's 2014 HAB

- Approximately 500,000 people affected
- No-swim advisories in Lake Erie
- Schools and businesses, including restaurants, shut down, and sports events disrupted
- Increase in emergency room visits
- Residents drove to Michigan and Indiana to find bottled water when supplies became scarce locally
- Cleanup costs of $200,000

Sources: Dungjen and Patch (2014), NBC News.com (2014).

In addition to these estimates of direct and indirect economic impacts, the effects of water-quality related supply disruptions can also be measured by the amount that residents are willing to pay to avoid these types of events. Customer WTP varies based the frequency of the event – if events happen more often, customers become more accustomed to them and they are not willing to pay as much to avoid them. Based on existing literature, WTP to avoid multiple day interruptions when they happen up to twice per year ranges from $18 to $71 per household per year when updated to 2014 USD (MacDonald et al., 2003; Hensher et al., 2005). With approximately 220,000 households affected in the City of Toledo, this results in a WTP to avoid the 2014 event ranging from approximately $4 million to $15.6 million.

These values can also be applied to households in the study region as a measure of the costs they avoid because they have not been affected by similar supply disruptions. For example, almost all households in the lakeside counties of Lake, Lorain, and Cuyahoga receive drinking water from public water systems that rely on Lake Erie as their source of water supply. Based on the stated range of WTP to avoid water quality-related supply disruptions, the value of clean water to households in these three counties amounts to between $13.4 and $52.8 million per year.

7. Environmental Values

As demonstrated in previous sections, ecosystems in the upper Great Lakes perform a wide range of important ecological services.These services include fish production to support commercial fisheries and recreational sport fisheries, waterfowl production, natural resource–based tourism, and the provision of abundant clean water supplies for municipal and industrial uses. In previous sections, we have described these ecosystem services and provided examples of the value that they provide to the Northeast Ohio region.

In addition to the values that individuals derive from direct and indirect uses and activities, clean water also provides some level of "nonuse" benefits. These benefits stem from the inherent value that individuals place on environmental goods and services. In environmental economics, nonuse values include[11]:

- ***Existence values*** reflect the benefit that people receive from knowing that a resource exists even if no use of the resource is anticipated
- ***Bequest values*** represent the value that individuals gain from the preservation of a resource for use by future generations
- ***Option values*** are values that individuals place on an asset or resource because of the possibility that it may someday be used.

Nonuse values can only be estimated using stated-preference methods that elicit individual or household WTP to maintain or improve an environmental asset or amenity. To some extent, analyses that estimate property value increases associated with environmental amenities also capture nonuse values. However, these types of analyses typically only apply to households located relatively close to the amenity, and therefore do not provide an estimate of total value (e.g., individuals that do not live next to Lake Erie or one of its tributaries still likely derive nonuse values from them). In addition, these studies cannot determine the percentage of value attributable to use versus nonuse benefits.

In a recent study, Ge et al. (2013) used a meta-analysis to value water-quality improvements. The authors reviewed more than 100 studies and constructed a dataset of 332 valuations from 38 distinct studies, with quality indicators converted to a standardized metric. The meta-analysis included studies that used both revealed-preference and stated-preference methods to estimate WTP, capturing both use and nonuse values.

The study indicated that households in the Lake Erie region are willing to pay substantial amounts of money for water-quality improvements in the Great Lakes. The annual WTP estimates for various water-quality improvements in the Great Lakes appear in Exhibit 19, where the change in water quality index is a scale from 1 to 100. As the table indicates, households are willing to pay more for greater water quality improvements, but the increase is not linear. For example, households are willing to pay $812 for a 5 point improvement (40 to 45) and $837 for a 10 point improvement (40 to 50). The table also indicates that households are willing to pay more for improvements to poorer water quality; households are willing to pay more for

11. The term "nonuse value" is typically used in a more general manner to encompass all three of the constructs we describe in the bullets (Harpman et al., 1994).

improvements for a 10 point improvement from 40-50 than they are for a 10 point improvement from 70-80.

Exhibit 19. WTP estimates for water-quality improvements in the Great Lakes

Change in water quality index[a]	40 to 45	40 to 50	70 to 75	70 to 80
Annual household WTP	$812	$837	$726	$750

Source: Ge et al., 2013.
a. The Water Quality Index (WQI) is a unitless measure of water quality ranging from 1 to 100; a higher number is indicative of better water quality. Scores are determined based on nine water quality constituents: temperature, pH, fecal coliform bacteria, dissolved oxygen, total suspended sediment, turbidity, total phosphorus, and total nitrogen..

Again, the values shown in Exhibit 19 reflect both use and nonuse values. Based on existing research (e.g., Van Houtven, 2007; Stratus Consulting, 2009), we estimate that within the context of water quality, non-use values account for approximately 35% of the total values (including use and non-use values) that individuals place on water resources. Applying this percentage to the average WTP estimate for water-quality improvements in the Great Lakes ($781 per year), would yield a nonuse value of $275 per year per household within the seven-county study region. Across all households in the study region, this would amount to a total nonuse value of more than $291 million per year.

8. Summary

As evidenced throughout this report, residents and visitors benefit in a number of ways from the high quality, abundant water resources within the Northeast Ohio region. Lake Erie, its associated rivers and streams, and other inland water bodies support economic development within the region and will underpin economic growth in future years. In addition, Lake Erie and its tributaries serve as a reliable source of water supply for residents and businesses, and provides important benefits in terms of public health, recreation and tourism, quality of life, and ecosystem services.

Exhibit 20 provides a summary of some of the key findings from this research, including order-of-magnitude estimates for many of the clean water values that we describe above. Again, these values are not additive, but help to provide insight into the different ways that people value clean water. In Phase 2 of this research, we will conduct a more in-depth assessment of many of these values.

Exhibit 20. Summary of key findings and examples of clean water values

TBL category	Service category	Key findings/examples of value
Economic/ financial	Economic development/activity	▸ Key water-dependent sectors in Northeast Ohio region include manufacturing, agriculture, tourism, and commercial fisheries. Many target sector industries also depend on clean water, including advanced manufacturing, food and beverage manufacturing, and biohealth. ▸ There is a belief that the region's water resources have the potential to provide a competitive advantage in attracting businesses and employees.
	Reduced water treatment costs	▸ Capital, operation, and maintenance costs for water treatment can vary by more than 200% depending on source water quality. ▸ Ohio communities have spent $125,000 to $3 million per investment to protect drinking water from HABs (sometimes these expenditures are necessary each year). ▸ Municipal water suppliers in Northeast Ohio region avoid significant costs associated with water treatment because they have access to a reliable, high-quality source of supply.
Social	Public health	▸ In 2012, Ohio Lake Erie Beaches were closed 20% of the time during the swimming season due to bacterial contamination. ▸ Drinking water contamination and contact with HABs or bacteria at local beaches can result in severe illness. ▸ Individuals that contract waterborne illnesses, or experience long-term health effects, incur real and often significant costs associated with medical bills, pain and suffering, restricted activity days, and lost work days. ▸ Fish contamination can adversely affect "at-risk" populations.
	Recreation and tourism	▸ Residents and visitors to Northeast Ohio are willing to pay $14.13 to $62.72 per day to participate in various water-based recreation activities. ▸ Closures at just one popular beach due to bacterial contamination may have resulted in close to $1 million in lost recreational value during the 2012 swimming season. ▸ In the Great Lakes region as a whole, a decrease of 25% in fish abundance would result in $87 to $170 million in lost recreational value. ▸ Tourism is an important, water-quality dependent sector. In 2012, the total economic impact of tourism in Ohio counties adjacent to Lake Erie included $11.8 billion in sales, $3.2 billion in wages, and 117,513 jobs.

Exhibit 20. Summary of key findings and examples of clean water values (cont.)

TBL category	Service category	Key findings/examples of value
Social (cont.)	Aesthetics/quality of life	▸ People are willing to pay 1% to 10% more for their homes in areas with better water quality. Water-quality improvements associated with the 2005 GLRC Restoration Strategy would result in property values benefits in coastal counties in the study region ranging from $2.28 to $3.32 billion.
	Water supply reliability	▸ Household WTP to avoid multiple-day, water quality–related supply disruptions may range between $13.4 to $52.8 million per year in the three coastal counties that rely on Lake Erie for drinking water.
Environmental	Nonuse values	▸ Households in the study region might be willing to pay $291 million per year to maintain important "nonuse" ecosystem services that Lake Erie and its tributaries provide.

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