Lake St Clair Flood Risk Reduction Study

For the Jefferson-Chalmers Neighborhood, Detroit, Michigan

U.S. Army Corps of Engineers (USACE) - Floodplain Management Services Program (FPMS)

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Prepared By: USACE – Detroit District

US Army Corps of Engineers
Detroit District

Contact: Garrett Ray
Plan Formulation Section
477 Michigan Ave. – 7th Floor
Detroit, MI 48073
garrett.d.ray@usace.army.mil

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1.1 FPMS Purpose and Authority

People who live in a floodplain need to know about flood hazards and the actions that they can take to reduce property damage and to prevent the loss of life caused by flooding. The Flood Plain Management Services (FPMS) Program was developed by the U.S. Army Corps of Engineers (USACE) specifically to address this need.

The program's authority stems from Section 206 of the 1960 Flood Control Act (PL 86-645), as amended. Its objective is to foster public awareness of the options for dealing with flood hazards and to promote prudent use and management of the Nation's floodplains. The program also provides guidance and assistance for meeting standards of the National Flood Insurance Program and for conducting workshops and seminars on non-structural floodplain management measures, such as flood proofing.

The FPMS Program provides the full range of technical services and planning guidance that is needed to support effective floodplain management.

General Technical Services: The program develops or interprets site-specific data on obstructions to flood flows, flood formation, and timing; flood depths or stages; floodwater velocities; and the extent, duration, and frequency of flooding. It also provides information on natural and cultural floodplain resources of note, as well as flood loss potentials, before and after use of floodplain management measures.

General Planning Assistance: On a larger scale, the program provides assistance and guidance in the form of "Special Studies" on all aspects of floodplain management planning including the possible impacts of land use changes on the physical, socio-economic, and environmental conditions of the floodplain. This can range from helping a community identify present or future floodplain areas and related problems, to a broad assessment of which of the various remedial measures may be effectively used. Some of the most common types of "Special Studies" include:

- Floodplain Delineation/Flood Hazard Evaluation Studies
- Dam Break Analysis Studies
- Flood Warning/preparedness Studies
- Regulatory Floodway Studies
- Comprehensive Floodplain Management Studies
- Flood Damage Reduction Studies
- Urbanization Impact Studies
- Stormwater Management Studies
- Flood Proofing Studies
- Inventory of Flood Prone Structures

Detroit FPMS Study Background

Water levels in the Great Lakes system have been rising substantially in the last few years. On Lake St. Clair, water levels have risen over five feet over the past seven years. The heavy precipitation in the winter and spring of 2019 has caused Lake St Clair's water level to continue its rapid increase to an elevation higher than some of the coastal, canal front, and riverine shorelines throughout the City of Detroit. This rise has increased the occurrence and magnitude of flooding in the densely-populated neighborhoods along canals connected to Lake St. Clair. In response to the 2019 flooding, the City of Detroit utilized sand bagging techniques to build up shorelines and minimize the impacts of flooding as the situation worsened rapidly. However, these efforts were not successful in mitigating all damages. In preparation for 2020 flooding, the City of Detroit employed additional temporary flood protection defenses, including HESCO barriers and Tiger Dam structures, along with sandbag structures, to provide additional protection to residences, public infrastructure, and public health in general. These measures are intended to mitigate flood damages in the short term, until a more permanent solution is developed and implemented in the Jefferson-Chalmers region.

In August of 2019, the City of Detroit requested USACE FPMS assistance for the identification of effective long-term flood mitigation measures in the Jefferson-Chalmers neighborhood in Detroit (see Figure 1, below). This was initiated by both preliminary FEMA Flood Information Rate Maps (FIRM) (now final) that put more homes in the 1% flood zone, as well as experiencing flooding due to record high Great Lakes levels in 2019. This study is intended to be the first step in evaluating mitigation measures that can be utilized for a long-term solution to reduce flood risk due to coastal influences from Lake St. Clair and the Detroit River. This study *does not* evaluate severe storm events that result in interior drainage flooding.

This FPMS study is designed to help inform the process undertaken by the City of Detroit to pursue the implementation of long-term solutions for flood mitigation efforts in the Jefferson-Chalmers area. This study looks at concept-level alternatives and does not provide a feasibility level solution, nor does it include design efforts.

1.2.1 Study Area

The efforts of this study were focused on a portion of the Jefferson-Chalmers neighborhood located on the lower east side of Detroit. The study area is bordered on the north and south by East Jefferson Ave and the Detroit River respectively, and on the east by Alter Rd. and the west by Clairepoint St. (see Figure 2). This region was one of the most impacted flood hazard areas of Detroit along the Detroit River and presents a unique challenge for the use of flood mitigation measures, due to the network of canals creating 2 "islands". The inconsistent edge conditions of this waterfront property result in multiple floodwater inundation (entry) points and, along with the proximity of homes to each other and the water, it leaves little room for the implementation of flood mitigation measures.

The Jefferson-Chalmers study area is home to approximately 8,000 residents. The area consists of more than 160 acres of waterfront parks, boat launches, fishing access points and other outdoor recreation opportunities. As part of the spring 2019 flood fighting efforts, flood barrier structures were created using sandbags and were employed to mitigate flood damages at roughly 94 of these parcels.

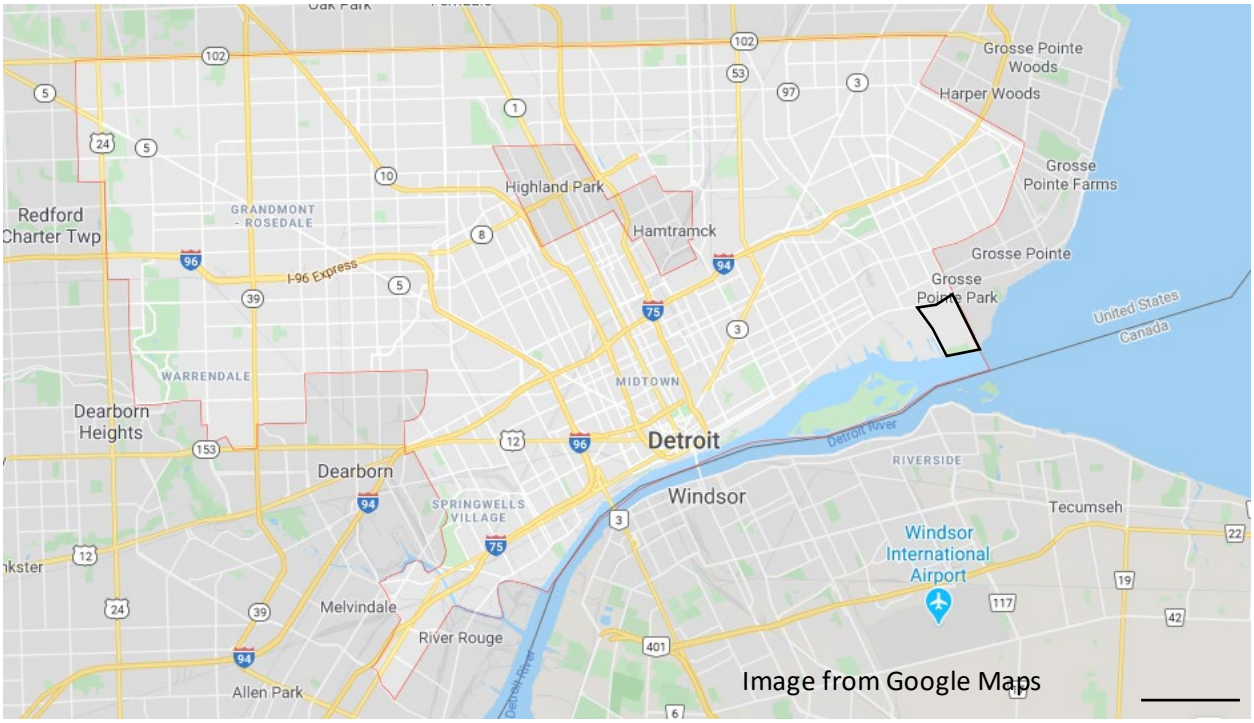

Figure 1: Study location in Detroit, MI

Figure 2: Jefferson-Chalmers area study limits.

1.2.2 Study Scope

The Detroit FPMS study is a planning document outlining feasible flood risk mitigation measures that can be combined to provide flood risk reduction in the Jefferson-Chalmers region. These include both structural and nonstructural measures. Plan formulation and analysis efforts were performed by USACE, along with collaborative multi-agency team, consisting of representatives from Detroit entities that would need to be involved, or would be impacted by installation of long-term flood risk mitigation measures. Analysis was limited to feasibility of construction, pros and cons of options, and extent to which goals are accomplished. The study does not include the development of complete design plans or specifications, cost calculations, nor the funding of construction activities. Once appropriate mitigation measures are identified, the scope of the Detroit FPMS Study will also include community outreach.

1.2.3 Study Participants and Coordination

As part of the scope of the study, a multi-agency team was organized to collaborate in the consideration and analysis of feasible flood risk management measures. Team meetings were held monthly. The following agencies and departments were represented:

- City of Detroit - Mayor's Office
- City of Detroit – Housing and Revitalization Department (HRD)
- City of Detroit - Detroit Water and Sewerage District (DWSD)
- Detroit Land Bank Authority (DLBA)
- City of Detroit – Law Department
- Great Lakes Water Authority (GLWA)
- City of Detroit - Detroit Homeland Security and Emergency Management (DHSEM)
- City of Detroit - Detroit General Services Department (GSD)
- City of Detroit - Buildings, Safety Engineering and Environmental Department (BSEED) – Environmental Affairs
- City of Detroit - Detroit Building Authority (DBA)
- City of Detroit – Department of Neighborhoods (DON)
- Environmental Protection Agency (EPA)

1.2 Prior Studies and Reports

Three prior studies were referenced that examined flooding and risk reduction issues within the study area:

1.3.1 Southeastern Michigan Water Resources Study, U.S. Army Corps of Engineers, September 1978:

High water elevations on the Great Lakes System, due to above normal amounts of precipitation during the period 1972 through 1976, caused a considerable number of water-related problems for the regions of Wayne County, MI located on the Detroit River and Lake St. Clair. The Southeastern Michigan Water Resources Study was authorized through the River and Harbor Act of 1966 and Flood Control Act of 1965, for the purpose of determining the feasibility of a flood protection project for the shoreline areas of northeast Wayne County. An initial investigation was performed by the U.S. Army Corps of Engineers to determine whether a flood protection project could be justified and be in the Federal interest. The study area extended from the shoreline of the Detroit River inland to the 500-year frequency flood elevation, for a roughly 2.4-mile reach of the river between Alter Rd. and Marquette Dr.

Both structural and non-structural flood risk reduction measures were developed to form alternative solutions that were evaluated based on cost, benefit, and environmental and socioeconomic effects. Comments and preferences were provided by residents of study area and were taken into consideration. The overall benefit-cost ratio was determined to be 4.16 for the measures recommended for implementation. However, the project was not selected for federal funding to initiate design and implementation.

1.3.2 Detroit Far East Side Flood Control Study, NTH Consultants, July 2005

In 2005, NTH Consultants, Ltd. was retained by the City of Detroit Planning & Development Department, to develop a flood control study to evaluate the Federal Emergency Management Agency's (FEMA) proposed changes to floodplain elevations, and their effect on the City's Far East Side Area. Alternatives proposed varied from filling all canals, lining the banks of all canals with SSP, and installing levees along the entire Detroit River shoreline in the project area. Other alternatives considered were the occasional closure of canals with levees or closure structures or allowing controlled passage with the installation of floodgates and boat locks. The recommended plan (i.e., 'Stillwater Protection Plan') included installing three stop log structures, each 30 feet wide, with a top elevation of 580 at Fox Creek, Philip Canal and Lakewood Canal.

1.3.3 Detroit Floodplain Study, Giffels-Webster, dated July 2019

In 2019, Giffels-Webster was contracted by the City of Detroit to evaluate the preliminary FEMA Flood Insurance Rate Maps (FIRMs) released in December 2018. The study included an assessment of the potential for the City of Detroit to challenge the preliminary FIRM updates, the location of floodwater inundation points, and proposal of flood mitigation techniques to reduce the number of properties located in the regulated floodplain. Two study areas were included in this project: Jefferson-Chalmers and Jefferson Village, which is bounded by East Jefferson Ave. to the north, St. Jean St. to the east, Freud St. to the south and Marquette Dr. to the west.

Giffels-Webster surveyed the two regions and did not find a technical basis for the City of Detroit to challenge the preliminary FIRM panels. Jefferson Village was found to have one inundation point at the Harding Canal. Inundation points in Jefferson-Chalmers were located along the inconsistent edge conditions of Fox Creek and the canal located north of Harbor Island.

In the areas of inundation, possible mitigation measures considered for the floodwater inundation areas in Jefferson-Chalmers included an earthen levee, seawall improvements and floodgates. These measures would be built to an elevation of 580 feet and would reduce flooding impacts but would remain insufficient for mitigation of impacts from a 100-year storm event, shown on FEMA FIRMs.

2. Problem and Needs

2.1 Flooding Background

Water levels in the Great Lakes depend upon precipitation and the watershed drainage surrounding them. In normal years, the evaporation from the lakes is almost equal to the precipitation and runoff that enters them, resulting in a consistent water level. However, the hydrologic characteristics of the outlets and connecting channels of the Great Lakes are such that they do not provide sufficient capacity to discharge above normal amounts of precipitation, nor do they produce sufficient control to hold back water when below normal precipitation occurs. The result is that lake levels rise or fall depending on whether or not surpluses or deficiencies of rain and snow occur. The flooding experienced in recent years in the Jefferson-Chalmers area is primarily a result of extreme precipitation events in the Great Lakes Basin. Precipitation rankings in Michigan show that the last five years have been the wettest 5-

year timeframe in the entire period of record of precipitation data, spanning 1895 to 2020[1]. This increasing precipitation trend, combined specifically with the weather in winter 2018-19 and heavy precipitation in spring 2019, has caused the water levels in the Great Lakes System to significantly rise. This rise has increased the occurrence and magnitude of flooding in the densely-populated neighborhoods along canals connected to Lake St. Clair. This region is especially prone to flooding impacts due to its location on the western shore of Lake St. Clair. Wind compounds the problem already created by high water levels, as easterly winds cause the water to "run-up" on the western shore of the lakes. The combination of high-water levels and wind generated waves cause a considerable amount of damage.

Figure 3, below, shows 100 years of water level data for each of the Great Lakes, as well as Lake St. Clair, which connects Lake Huron and Lake Erie. Water levels in Lake Superior and Lake Ontario are less variable due to the regulation they experience from the Soo Locks and compensating works, and associated hydroelectric plants and Niagara Falls respectively. In the other three lakes, water level peaks have been experienced in the spring seasons of 1929, 1952, 1973 and 1974, 1986, 1997, and most recently in 2019. The 2019 peak set records for water levels in each of the lakes except Lake Michigan-Huron, which just missed setting a record. Throughout the last 100 years, flooding impacts have been experienced in the low-lying regions on the western shores of Lake Huron, Lake St, Clair, and the Detroit River and this region is experiencing another period of above average water levels, causing more damage.

High water elevations create water and related land resource problems in the study area. The effects of high water range from nuisance conditions to major destruction of property. Temporary flood protection measures have been employed but a solution providing long-term protection is needed during this period of above average water levels, and for the periods to come.

[1] https://www.ncdc.noaa.gov/cag/statewide/rankings/20/pcp/202002

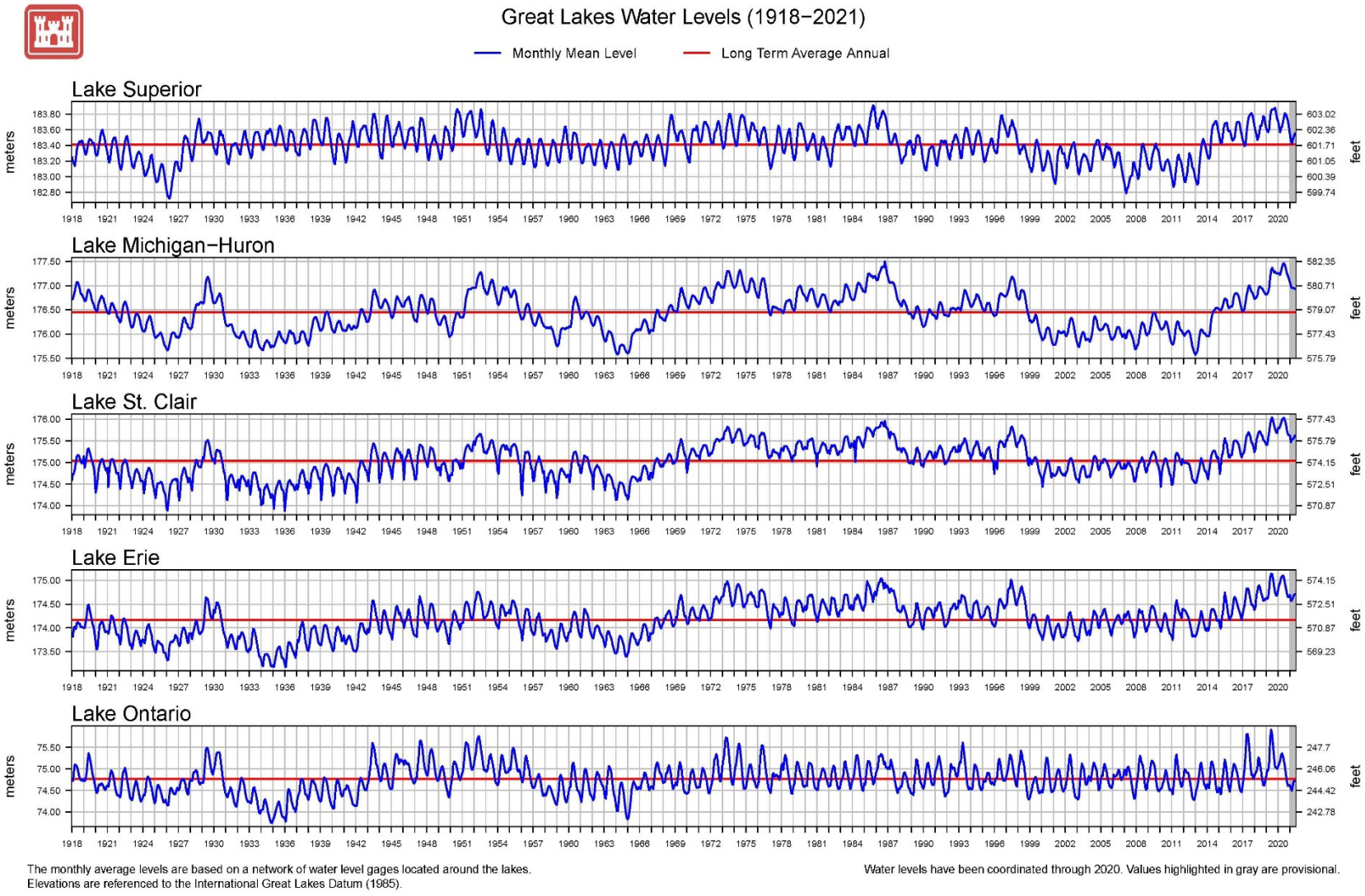

Figure 3: Great Lakes Historic Water Levels

2.2 Forecasting Conditions

Due to their direct correlation with weather events, water levels are challenging to forecast for long periods in advance. However, USACE maintains a six-month Great Lakes water levels forecast that is updated monthly based on the recently experienced and expected weather conditions. The most recent output is pictured below in Figure 4. The five lakes analyzed all began 2021 having lower water levels than the same time in 2020. This is an indication that spring 2022 water levels can be expected to be similar to, but slightly lower than 2021 levels, but still above average, as depicted in Figure 5 below for Lake St. Clair.

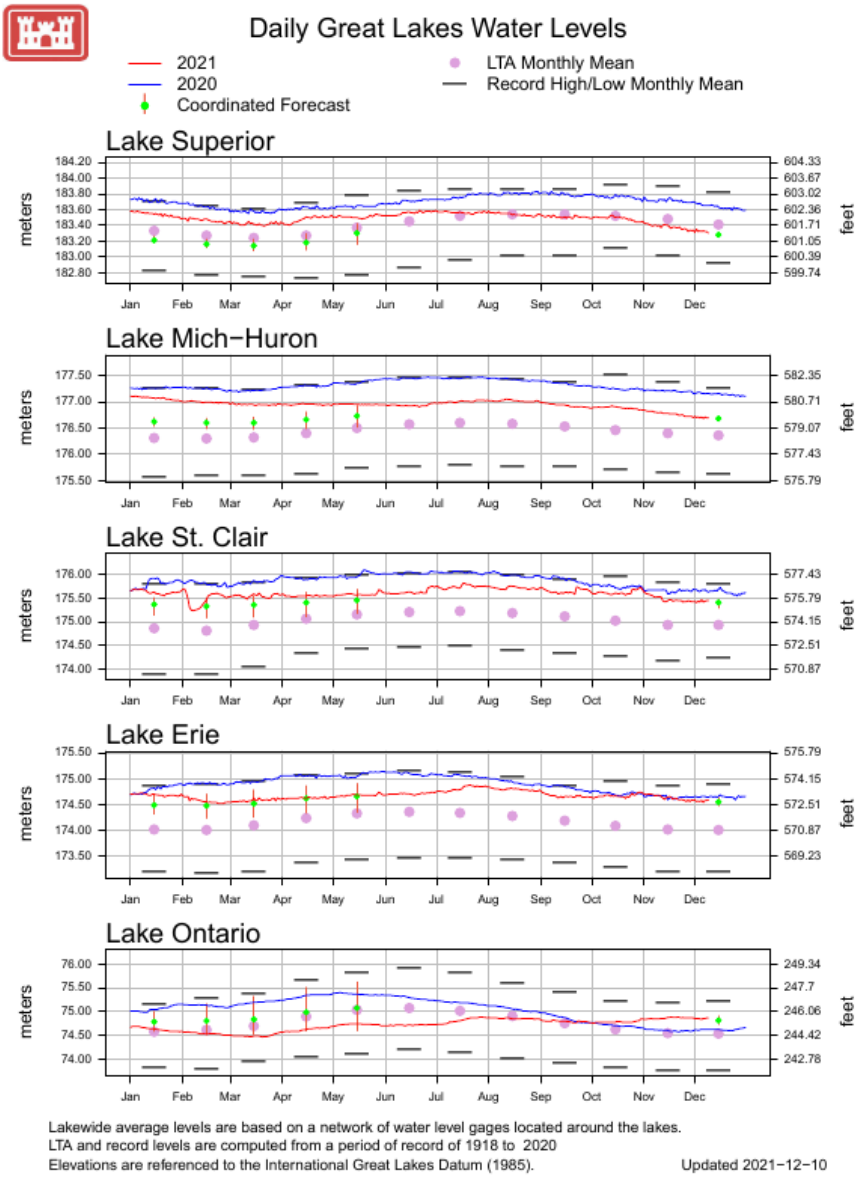

Figure 4: Great Lakes Forecasted Water Levels 2020-2021[2]

[2] https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Information-2/Water-Level-Data/

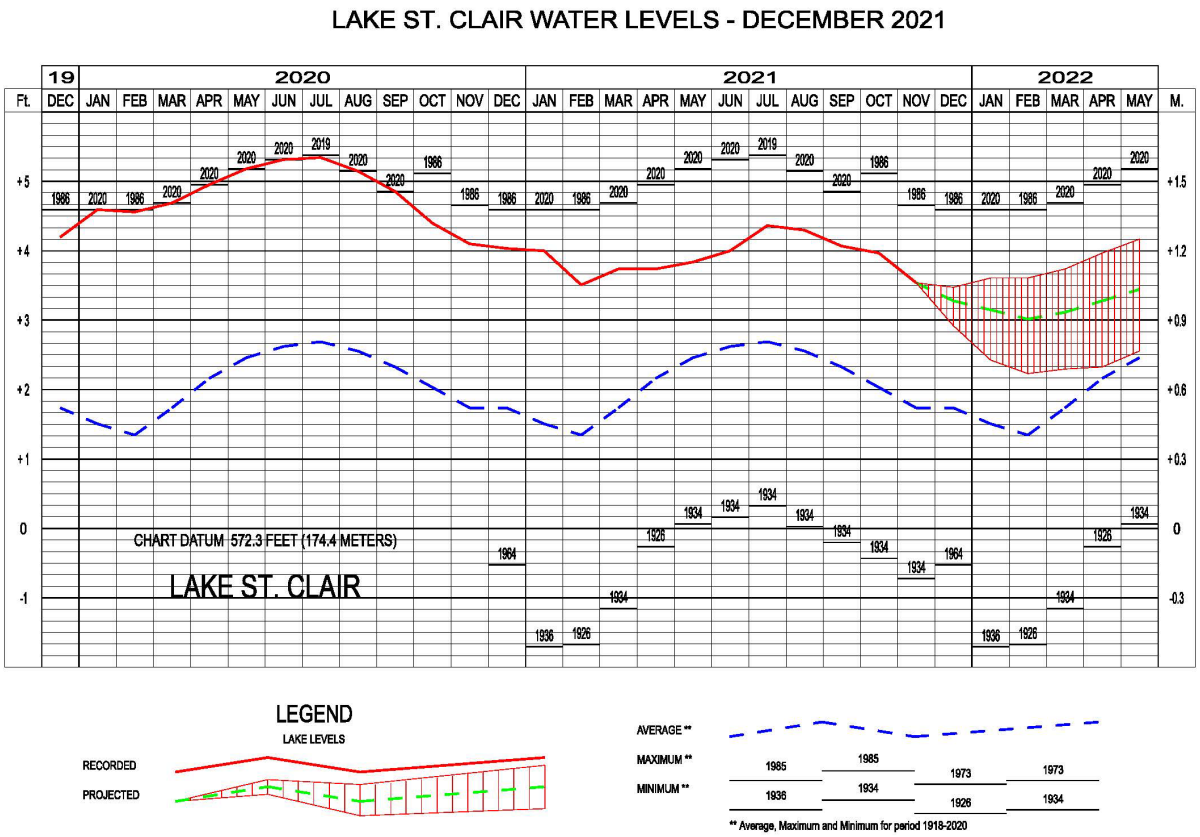

Figure 5: Lake St. Clair 6 Month Forecasted Water Levels 2021-2022[3]

2.3 Flooding in Jefferson-Chalmers

The project area sits at the southwest border of Lake St. Clair, at the headwaters of the Detroit River. The cause of the flooding in the project area is from a combination of high lake levels and wave action/run-up from Lake St. Clair.

Several flood risk reduction studies have occurred over the last several decades, but no significant long-term solutions have been implemented.

The low, flat terrain along the shoreline of the study area makes this land more susceptible to flooding. Primary inundation points in Jefferson-Chalmers are along residential properties that have varying heights of seawalls.

[3] https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Information-2/Water-Level-Data/

The most recent significant flood events in 2019 were due to record high Great Lakes levels that inundated back yards and roads through low points along the canal systems. The City used sandbags for flood protection during record high great lake levels and is seeking a more permanent solution for flood risk reduction. In Figure 1, parcels shown in blue indicate locations where sandbags were used for flood mitigation in 2019.

Figure 6: 2019 Sandbag locations

2.3.1 Flooding Impacts

In spring 2019, constant flow from Lake St. Clair and the Detroit River entered low areas and resulted in continuous, uncontrolled flooding, which entered the storm sewer system for weeks at a time. This additional load on Detroit's Combined Sewer Outflow (CSO) system resulted in increased discharges of untreated water into the Detroit River, violating water quality requirements. It also increased the load on the pump stations and the wastewater treatment plant.

Flooding has caused significant economic impact to the Jefferson-Chalmers residents, due primarily to basement flooding. Significant property damage also occurred in 2019 in this area. Residents

along the canals are subject to inundation due to the inconsistent heights of seawalls along the canals. Residents along the west shore of Lake St Clair are susceptible to flooding during easterly wind events.

Table 1: Study area demographics

Census Tract	Population	Age >65	Age <19	Unemployed	Poverty Status	Persons with a Disability	Median Household Income	Per Capita Income
5132	1,756	11.2%	29.1%	13.7%	40.7%	21.9%	$33,828	$16,556
5133	2,433	19.3%	22.4%	7.3%	21.6%	15%	$42,670	$28,897
5137	3,598	16%	36.1%	13.1%	36.1%	18%	$23,162	$17,364
Michigan	9,925,568	15.8%	25.1%	7.4%	15.6%	14.3%	%52,668	$28,938
USA	321,004,407	14.9%	24.7%	6.6%	14.6%	12.6%	$57,562	$31,177

Additionally, there are historic properties located in Jefferson-Chalmers that could be impacted by future flooding. The Vanity Ballroom and the Jefferson-Chalmers Historic Business District are both listed on the National Register of Historic Places. Other properties including the Fox Creek Historic District, Lighthouse Subdivision Historic District, Marlborough Chalmers Historic District, Riverside Historic District, and Guyton School are eligible to be listed on the National Register of Historic Places. The historic value of these venues and properties would be greatly impacted by flooding.

2.3.2 FEMA Map Revisions

FEMA incorporates flood hazards and risks into flood maps known as Flood Insurance Rate Maps (FIRMs). These maps support the National Flood Insurance Program (NFIP), detailing the requirements for flood insurance and community floodplain management. In December of 2018, FEMA published draft (preliminary revised) FIRM maps for Wayne County that would greatly increase the number of homes located within the 1% annual chance (100-year) event floodplain for the Jefferson-Chalmers neighborhood.

Figure 7 shows the changes to the FEMA FIRM for the study area. The FIRM panels include contour lines representing the base flood elevation, calculated for the 100-year (1% annual chance) and 500-year (0.2% annual chance) flood events. The preliminary map identifies the entire study area, minus some elevated park spaces, as having a *1% Annual Chance Flood Hazard*.

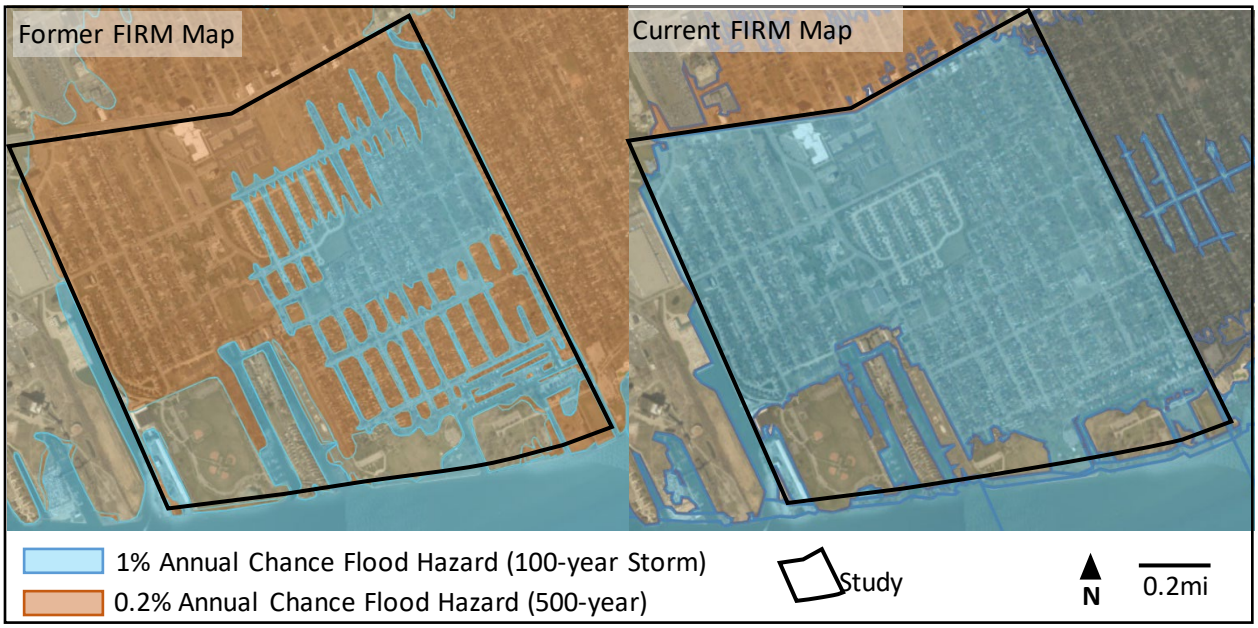

Figure 7: FEMA Flood Insurance Rate Map Update in the Study Area

https://hazards-fema.maps.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd

2.3.3 FEMA Freeboard Requirements

The purpose of 'freeboard' is to account for the uncertainties associated with the Hydraulic and Hydrology (H&H) analysis and to minimize damages and threat to life and property. The freeboard requirements vary if the levee system lies within a riverine area or a coastal area. Since the flood source is Lake St. Clair, coastal freeboard requirements apply.

The coastal freeboard requirements are stated in 44 CFR 65.10(b)(1)(iii), which states the following:

"For coastal levees, the freeboard must be established at one foot above the height of the one percent wave or the maximum wave runup (whichever is greater) associated with the 100-year still water surge elevation at the site. To show that a levee system provides base flood hazard reduction in a coastal area, the top of the levee must be equal or greater than the highest value of the following:

1. Two (2) feet above the base flood total stillwater storm surge elevation including wave setup;

2. One (1) foot above the base flood wave crest elevation; or

3. One (1) foot above the maximum base flood wave runup elevation.

The stillwater surge elevation shall be considered the water level in the absence of waves, but with all other processes present. This includes the stillwater elevation of the base flood event plus a wave setup component. The wave setup is defined as the increase in mean water level above the stillwater level due to momentum transfer to the water column by waves that are breaking or otherwise dissipating their energy."

The levee/ floodwall elevations required in the project area are shown in the following table:

Table 2: Required levee/ floodwall elevations

Transect	1% Annual Chance Stillwater Elevations	Required levee elevation for Stillwater (inland) inundation areas (including 2' freeboard)	1% Max runup elevation	Required levee elevation for runup-influenced areas (including 1' freeboard)
WAY-12	578	580	579	580
WAY-13	578	580	582	583
WAY-14	578	580	581	582
WAY-16	578	580	580	581

Elevations taken from Preliminary FEMA FIRM Maps for Wayne County, Michigan as well as the *Coastal Flood Hazard Study Result Summary, Wayne County, Michigan* published by greatlakescoast.org.

3. Plan Formulation

Plan formulation is undertaken to develop a comprehensive water management plan which provides the best uses, or combination of uses, of water and related land resources to meet the identified needs of the Detroit Shoreline study area. The formulation process therefore involves identification of project limitations and objectives that inform the creation and evaluation of flood risk mitigation measures.

3.1 Project Limitations

Both structural and nonstructural flood risk mitigation measures for use in the Jefferson-Chalmers area are limited by cost, recreational and environmental constraints. These are aspects that limit the feasibility of a flood risk reduction project, and then there are additional constraints that limit the acceptability of a flood risk reduction project by the City and the study area residents.

There have been flood reduction studies conducted for this region since prior to 1978, but limited action has been taken to mitigate damage from flooding in this area. This is primarily due to the high costs associated with the construction of a project having the scale to mitigate flood impacts to hundreds of acres of residential property, combined with the City's limited ability to finance or provide cost-share funding for projects due to, in part, low property values. Additionally, there is not much available space throughout the impacted area for structural improvements along the associated canals. Much of the land along the canals is private property and any construction in these regions would involve the challenge of obtaining private property easements.

Since high water levels and an increase in strong storm events are a current problem, without a foreseeable resolution, the time constraints to get a long-term project in place also create additional

challenges for project implementation. Permanent projects to provide flood risk mitigation take a long time to plan and design. When water levels start to decline, as they have in 2021, the desire to pursue flood mitigation solutions also decreases, and both the administration and the public can start to lose interest in the development of a flood risk mitigation project.

Limitations on the acceptability of any given proposed flood risk reduction project largely stem from residents' desires for water views and direct water access to the canals, Lake St. Clair and the Detroit River. Public engagement, while not initially part of this study, will be crucial in the ultimate development of a constructible project that mitigates flood risks within the Jefferson-Chalmers area.

3.2 Planning Objectives and Constraints

The primary Planning Objectives identified from an analysis of the problems, needs, limitations, and opportunities within the study area is as follows:

- Reduce the risk of flooding due to high water levels and wave run-up of Lake St. Clair in the Jefferson-Chalmers neighborhood;
- Develop a plan that is considerate of the desires and needs of the residents and is acceptable to the City of Detroit.
- Remove the properties located in the Jefferson-Chalmers study area from the high risk floodplain (1%, 100 year event) in order to alleviate flood insurance costs.

Planning Constraints and considerations used in the plan formulation analysis include:

- Avoid measures that would displace existing homeowners;
- Minimize impacts to private property;
- Preserve the 'viewscape' of residents, wherever possible;
- Avoid measures that block boater access to the canals, the Detroit River and Lake St. Clair.

3.3 Additional Considerations

- Enhance the social well-being of the study area's population.

The Detroit River is listed on the Environmental Protection Agency's (EPA) Area of Concern (AOC) list. The EPA Guidance Plan details 14 specifically chosen habitat restoration projects to remove the 14 fish and wildlife related Beneficial Use Impairments (BUIs) in this AOC. One of these projects is the Detroit Upper Riverfront Parks Restoration project. Initial design of the project began in 2017 and, as of July 2018, the project plan involves wetland creation and riparian enhancements on the riverfront and canal shorelines, and plantings including a pollinator garden in Alfred Brush (AB) Ford Park and Riverfront Lakewood East Park. However, after the FEMA FIRM map revisions and City of Detroit's decision to pursue a long-term flood reduction project in these areas, design and construction of the EPA park project was halted. The current design may not be feasible to implement alongside many of the potential flood risk management measures, but the City of Detroit will continue to coordinate with EPA in the attempt to also allow for future habitat restoration in these areas. GSD expects the EPA project to begin construction in 2023 and continues to hope that the detailed design of flood mitigation measures will be in consideration of the habitat project to maintain its original intent where possible.

An additional consideration for the design of a flood risk mitigation project will involve accommodating internal drainage requirements for the Jefferson-Chalmers neighborhood, which would require a separate stormwater risk reduction study.

While 'residential' is the primary land type in the Jefferson-Chalmers neighborhood, it is important to consider the additional entities and specific groups of people that would also be affected by any plans to drastically alter the shoreline or canal-front environments in the formulation of potential flood risk mitigation projects. Potential stakeholders were identified through collaborative efforts and are listed below:

i. Residents - specifically seniors on fixed income
ii. Businesses
    - Jefferson Ave. businesses
    - Fiat Chrysler Automobiles
    - Nearby marina (impacted by canal use changes)
iii. Development Activity
    - Guyton Elementary Redevelopment (former public school – adding mixed use development that provides significant portion of homeowner assistance programs – paid for with HUD money that cannot be applied to development within a floodplain)
iv. Detroit Water and Sewage Department (DWSD)
    - Combined storm/sanitary sewer and treatment system impacts
v. Great Lakes Water Authority (GLWA)
vi. Buildings, Safety Engineering and Environmental Department (BSEED)
vii. Land bank properties (quasi-city agency, technically public property, EDC/DEGC)
    - Detroit Economic Growth Corporation (DEGC)
    - The Economic Development Corporation (EDC)
    - Detroit Land Bank Authority
viii. Planning and Development Department (PDD)
ix. Housing Revitalization Department (HRD)
x. General Services Department (GSD)
    - city parks and improvement projects – river front
xi. Real estate projects that depend on federal funds
xii. Emergency Management/Homeland Security
xiii. Recreational Users
    - Fishing
    - Kayaking
    - Boating
xiv. Marina – associated businesses within the canal closures

3.4 Flood Risk Mitigation Measures Considered

Flood risk mitigation measures are the building blocks of flood risk mitigation solutions and are categorized as either 'structural' or 'nonstructural'. Structural measures include constructing physical barriers to reduce flood risk, such as levees and floodwalls. Non-structural measures include flood-warning systems, removing property that can be damaged from a flood-prone area, elevating homes and other actions. Equal consideration must be given to these two categories of measures during the planning process.

3.4.1 Nonstructural Flood Risk Measures

As mentioned above, nonstructural measures consist of flood risk reduction actions other than the construction of physical barriers along the river to contain floods. Non-structural measures could also be used in combination with structural measures to reduce the potential for flood damages in the study area. Nonstructural measures considered in the creation of flood risk mitigation plans generally include permanent relocation/removal of buildings and property from the floodplain, floodproofing of houses, and filling basements to reduce flood impacts to structures. None of the nonstructural measures listed below will protect the combined sewerages system. Basic descriptions of these measures are included in the following sections.

- *Permanent Relocation from the Floodplain*

Relocation would require moving residents and removal of all floodplain structures, roadways, and utilities from the design level floodplain. Evacuated land would thus become available for appropriate uses such as parks, sports fields, wetlands, marshlands, etc.

- *Floodproofing*

Floodproofing typically consists of structure modifications to buildings such that floodwaters cannot penetrate and damage the contents. Buildings in the study area would be best floodproofed by the placement of a series of aluminum panels immediately adjacent to the unit.

- *Additional Nonstructural Measures*

    - Elevating homes
    - Filling in home basements

3.4.2 Structural Measures

Structural measures that were considered which reduce flooding impacts include levees, floodwalls, seawalls, floodgates, lock systems, and canal fill.

4. Canal Environments

Throughout the Jefferson-Chalmers study area, the presence of canals allows water to flow inland from the Detroit River and Lake St. Clair, creating larger numbers of waterfront residences. While these canals are enjoyed by many residents desiring open-water access, during periods of high water they can create major flooding problems for residents and public infrastructure as they provide a path for inundation.

In the study area there are approximately 6 canals that have the potential to allow inundation into the low-lying Jefferson-Chalmers region: Connor Creek, Grayhaven East and West, Lakewood, Phillip St, and Fox Creek Canals. The latter three canals surround two land areas in the study area, creating Harbor and Klenk Islands. The location of these islands and canals are shown in Figure 8 below. Each of these canals are characterized by different features and different flooding impacts. Brief descriptions of each canal are included in the sections below.

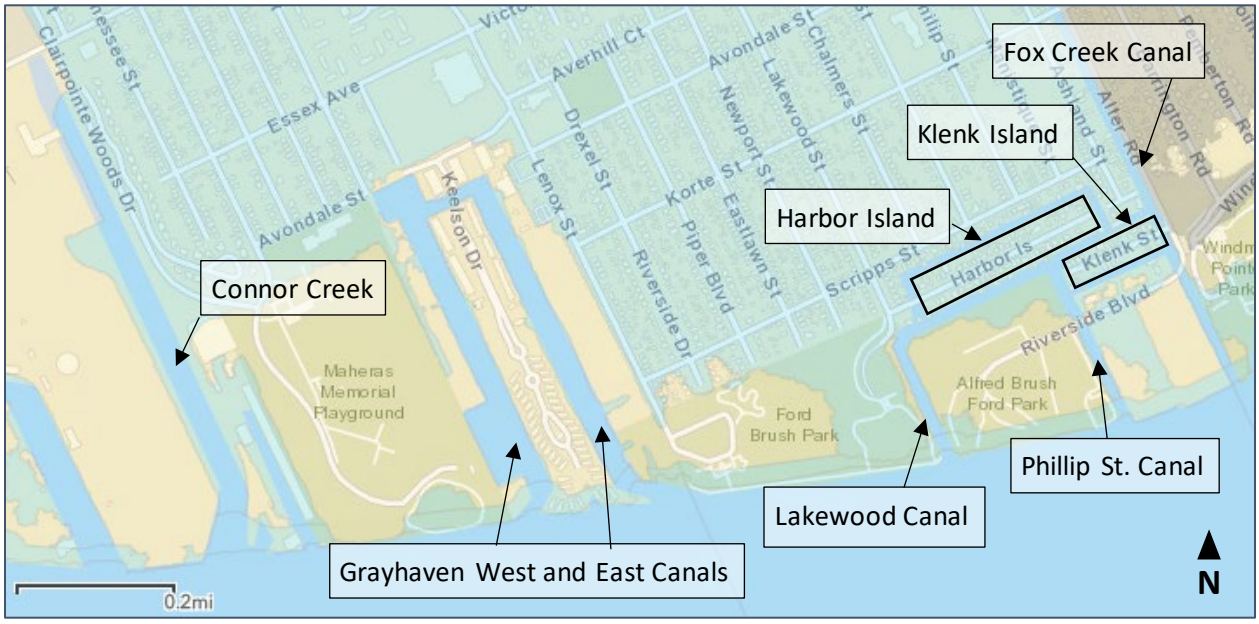

Figure 8: Jefferson Chalmers canal configuration

Lakewood Canal

The Lakewood Canal runs parallel and in line with Lakewood St. and is nearly 900 feet in length. The Lakewood canal connects to the Phillip St. and Fox Creek canals, as well as the waters surrounding Klenk and Harbor Islands. The Lakewood Canal is the widest and deepest canal entering the Detroit River, at 70-80 feet in width. For this reason, most boat owners in the Jefferson-Chalmers neighborhood use a route through the Lakewood Canal to get to the river. Both east and west banks consist of Steel Sheet Pile (SSP) seawall and the elevation of most of the land area surrounding the canal is 580 feet, which is above the FEMA flood hazard area. The property on both sides of the canal is owned by the City of Detroit Parks and Recreation Department and is used as minimally developed parkland.

Phillip St Canal

The Philip Street Canal runs parallel and in line with Phillip St. and is over 1,100 feet in length. Approximately 700 feet from the Detroit River, Riverside Rd. crosses the canal on a low bridge that only allows the passage of kayaks and small boats. The west bank of the Phillip St. Canal consists of SSP seawall and the elevation of most of the west bank land area is 580 feet, keeping it out of the FEMA flood hazard area. The east bank of the canal is natural, lined with riprap. The land elevation on this side of the canal is more variable but with most portions reaching 580 feet. The property on the west side of the canal is owned by the City of Detroit Parks and Recreation Department and used as minimally developed park land. The 7-acre property to the east of the canal is owned by Riverfront Limited Partnership and consists of vacant land, with a riprap lined shoreline along the Detroit River. This site has a $5.7M brownfield tax credit for blight and may also be considered as a wetland, which would increase permitting requirements for development in this area. Development in this area would require property acquisition or permanent easements.

Fox Creek Canal

Fox Creek Canal is the longest canal in the Jefferson-Chalmers region; 1.25 miles of it is included in the study area. On average, it is 40 feet wide throughout. The east bank of Fox Creek consists of a continuous SSP seawall built to elevation 580 feet. This seawall runs along Alter Rd. and was built to reduce flooding in the City of Grosse Pointe Park region. The west bank of the canal is characterized by varying structures built to varying elevations. Around 125 parcels have access to the canal on the west bank, approximately 75% of which are private resident-owned and the other 25% are owned by private companies. The Detroit Land Bank also has a small presence here. Around 30 of these parcels have boathouses, which tend to be locations of inundation, and nearly 40 of the parcels on Fox Creek were sandbagged for flood protection during the spring 2019 event.

Recreational uses in Fox Creek include fishing, paddle boarding, and kayaking. The presence of Korte St. Bridge, approximately a half mile into the canal, limits the boat access from north of the bridge into the Detroit River. There is not normally enough clearance for many larger boats to pass under the bridge and when water levels are high, smaller boats are occasionally unable to pass under the bridge as well. Table 3 presents the details described above regarding Fox Creek.

It is also important to note that Fox Creek Canal does not receive stormwater inflow from the Jefferson Chalmers region. Much of the stormwater that would enter this canal is collected by the combined sewer system in Detroit and conveyed to the GLWA regional system or collected by separated stormwater sewers in Grosse Pointe Park and conveyed to Lake St. Clair. If activated, the discharge is a combination of stormwater and combined sewer overflow. If the canal is closed, accommodation for conveyance will be required.

Table 3: Fox Creek Canal Background

	North of Korte St Bridge	South of Korte St Bridge
Resident owned parcels	~65	26
Company owned parcels	~25	7
Land Bank Parcels	1	1
Approximate # of Boathouses	~25	6
# of Parcels Sandbagged	27	8

% of total properties sandbagged	28.4%	8.4%
Uses	Paddleboard, Kayak, Small Boats when water is low, Fishing	Paddleboard, Kayak, Boats, Fishing
Notes	When water levels are high, residents cannot take boats to the Detroit River.	

Harbor Island

Table 4: Harbor Island Background

	North of Korte St Bridge
Resident owned parcels	~91
Company owned parcels	~6
Land Bank Parcels	0
Approximate # of Boathouses	~36
# of Parcels Sandbagged	50
% of total properties sandbagged	51.5%
Uses	Paddleboard, Kayak, Boats, Fishing
Notes	

Klenk Island

Table 5: Klenk Island Background

	North of Korte St Bridge
Resident owned parcels	34
Company owned parcels	15
Land Bank Parcels	0
Approximate # of Boathouses	~7
# of Parcels Sandbagged	9
% of total properties sandbagged	18.4%
Uses	Paddleboard, Kayak, Boats, Fishing
Notes	

Conner Creek Canal

This canal receives limited stormwater from adjacent/nearby properties and treated combined sewer wet weather discharges from the GLWA Conner Creek Retention Treatment Basin (GLWA Conner Creek RTB). The Conner Creek RTB was designed to provide treatment for up to 13,200 cubic feet per second in accordance with its National Pollutant Discharge Elimination System (NPDES) permit. Discharge frequency and volume varies with precipitation. In a typical year the Conner Creek RTB will discharge approximately 15 times and the total annual treated discharge typically exceeds 5 billion gallons.

Additional Considerations:

- -Canals are not heavily used for recreational purposes, but any canal closure is likely to be unpopular with residents. The Conner Creek Canal and the Fox Creek Canal must provide hydraulic capacity to convey treated combined sewer overflows and stormwater and emergency discharges from the GLWA regional collection system (unless alternative measures are instituted that provide for conveyance/discharge).
- -All options should be presented against the "No Action" alternative that results in flood insurance premiums.
- -Limitations of bridges are increased when water levels are higher

Stormwater/Storm sewers

Fox Creek outfall: Much of the stormwater that would enter this canal is collected by the combined sewer system in Detroit and conveyed to the GLWA regional system or collected by separated stormwater sewers in Grosse Pointe Park and conveyed to Lake St. Clair. The GLWA discharge at Jefferson and Ashland at the Backwater Gate Chamber B001 is only activated on an emergency basis in accordance with its NPDES permit. If activated, the discharge is a combination of stormwater and combined sewer overflow.

Conner Creek: This canal receives limited stormwater from adjacent/nearby properties and treated combined sewer wet weather discharges from the GLWA Conner Creek Retention Treatment Basin (GLWA Conner Creek RTB). The Conner Creek RTB was designed to provide treatment for up to 13,200 cubic feet per second in accordance with its NPDES permit. Discharge frequency and volume varies with precipitation. In a typical year the Conner Creek RTB will discharge approximately 15 times and the total annual treated discharge typically exceeds 5 billion gallons.

Canal Dedications: If canals are dedicated to the public as "water highways", City Law Department review is needed with city code discussions.

5. Structural Flood Risk Reduction Measure Alternatives

The scope of this study includes development of conceptual level alternatives to reduce the coastal flood risk but does not include the detailed design or cost estimating of the features included. However, a detailed review of FEMA FIRMs, existing LiDAR data, and current land use was conducted to determine

the potential layouts of the structural measures. It is important to note that the scope of this study is focused on alternatives to reduce the coastal flooding risk. While there is a cost assumed for necessary interior drainage upgrades, interior drainage analysis or design is not included in this study.

The threat of flooding from *high lake levels and storm surges/run-up* in the Jefferson-Chalmers region stems from a series of canals allowing water to flow inland and overtop existing canal walls during periods of high lake levels and run-up. The canal walls are largely residential and have inconsistent elevations.

This can be addressed in two ways: 1) placing a structure across the mouth of canal to prevent high water and storm surges/run-up from entering the canals, or 2) raising the height of the shoreline protection across all properties that border Lake St. Clair/ Detroit River, as well as all properties along the canal. Alternative 2 includes the latter option, while Alternatives 1 & 3 include canal closure measures.

The following sections will describe the 'base alternatives', which are defined as the levees, floodwalls, and seawalls, as well as assumed costs for necessary interior drainage upgrades. The base alternatives *do not include* the canal closures for Alternatives 1 and 3. Conceptual cost estimates were developed separately for each of the 'base' alternatives and different canal closure options, so that different configurations could be compared easily. For Alternative 2 (Open Canals with Extensive Shoreline and Canal Steel Sheet Pile Structures), no additional cost for closure systems is needed, since that alternative includes flood risk reduction measures along the entire shoreline/ canal front, in lieu of closure.

For all three alternatives, the conceptual design west of Lenox Street is similar. In this area there are 'high ground" areas (areas that meet the required height including freeboard) surrounding the Grayhaven East & West Canals. On the west side of Clairpointe Street adjacent to the Conner Creek Canal, the Great Lakes Water Authority completed a new concrete wall in April 2022 to replace a former flood berm. The top elevation of the new wall is approximately El 582 (NAVD88). While not currently certified as a floodwall, the wall was designed to meet that certification. Therefore, all alternatives include a floodwall at this location, as well as a cost with the assumption it has not yet been constructed.

All alternatives will significantly reduce the risk of overloading the interior drainage structures during periods of high lake levels and run-up, and remove most, if not all, residents from the FEMA base flood (1% annual exceedance probability) flood event.

Conceptual cost estimates referenced in Section 5 are discussed in more detail in Section 6 (Appendix A).

5.1. Alternative 1: Closed Canal, Levees and Floodwalls Outside of Wave Run-up Zone

FEMAs requirements for levee heights in the project area are lower when the levee/floodwall is outside of the wave runup zone. For Alternative 1, the levee/floodwall alignment between Alter Road and Lenox Street would be set back from the waterfront. This has the advantage of a shorter structure elevation, as well as keeping the riverfront view. The closure structures (noted in red in Figure 9) would also be set back. It should be noted that any land lakeward of this alignment would not have any flood reduction benefits with this option.

Alternative 1 includes the following feature (see Figure 9):

- 560 linear feet of upland steel sheet pile floodwall (shown in purple)
- 1700 linear feet of earthen levee (shown in yellow)
- 3 canal closure structures (shown in red)
- Stop log closure or gate at KAM Marine/ Bayview Yacht Club entrance

Figure 9: Conceptual alignment, Alternative 1: Closed Canal with Levees and Floodwalls Outside of Wave Run-up Zone. NOTE: Circled portion is the same for all alternatives.

The proposed western portion of the project along Clairpointe Avenue, tying into the high ground areas near the Greyhaven Marina (circled area in Figure 9) is the same for all alternatives. A detailed discussion of these features is only included in Alternative 1 for brevity. The description of proposed features below is from west to east.

Clairpointe Street: Construction is expected to be complete in the near future for a floodwall along approximately 1400 feet of Clairpointe Street, and it is assumed as 'existing' for the alternatives developed. Review of design documentation was not included in the scope of work. Approximately 560 feet of floodwall is needed to extend the floodwall to high ground near Conner Street. To allow

access to the KAM Marina/Bayview Yacht Club, a removable stop log structure across the driveway is recommended.

The floodwall type and cross-section would be determined in the design phase, and can vary depending on soil types, land restrictions, aesthetics, and preferences for future O&M costs. They are typically constructed of either steel sheet pile, reinforced concrete, or a combination of the two. In Figure 10 below, typical "I-wall" type floodwalls are shown. I-walls are common for floodwalls less than 6 feet, but the exact wall type would be determined during design phase.

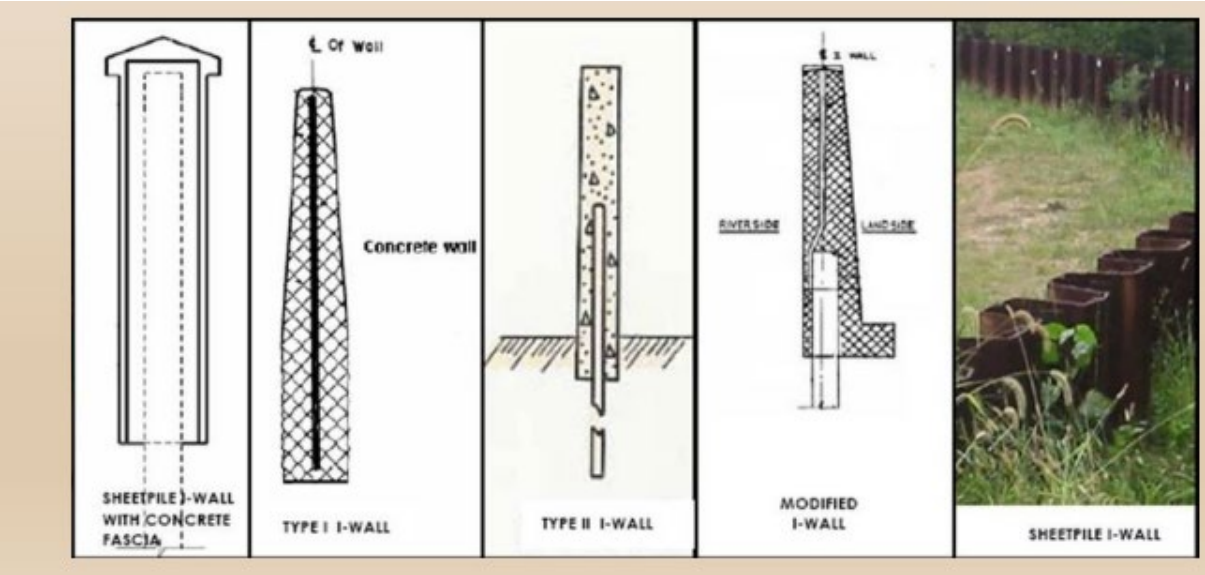

Figure 10: Typical "I wall" floodwalls (embedded portion not shown)

KAM Marina/Bayview Yacht Club: In order to maintain access to the KAM Marina/Bayview Yacht Club, a closure structure is needed that would be placed during high water periods to prevent floodwaters from entering the neighborhood. The elevations near the access to the Marina dip and are approximately 6 feet below the required elevation based on LiDAR Data. (See Figure 11). The area would be open during normal water levels, but during high water periods, stop logs would be placed across the road, as shown in Figure 12a and 12b. A storage shed would be needed nearby to store the stoplogs when not needed. Aluminum stop logs were assumed for this report but other types of closures, such as slide gates, could be explored. Slide gates are more expensive but have the advantage of less time and labor needed to close.

Figure 11: Elevations from LiDAR data near KAM Marina/ Bayview Yacht Club. (Location of proposed upland stop log structure in red)

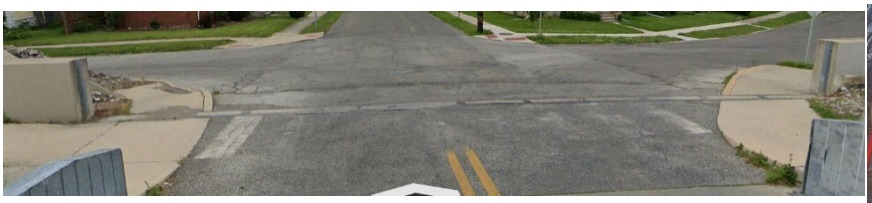

Figure 12a (left): Stop logs retracted during normal water levels. Figure 12b (right): Aluminum stop log panels being installed.

Greyhaven Canal: Only the northwestern corner of the Greyhaven Canal is less than the required elevation. A levee is proposed in this area, approximately 3 feet high, based on current LiDAR data. This would result in a levee with a 28-foot wide foundation. We would also recommend a 15-foot setback from the levee toe that is kept clear of any structures, to allow for proper inspection, maintenance, and floodfighting. In addition, no vegetation other than grass is recommended on the levee, or within 15 feet of the levee toe. Trees and brush can create seepage and stability issues, as well inhibit inspection. A typical levee design cross section is illustrated in Figure 13 below.

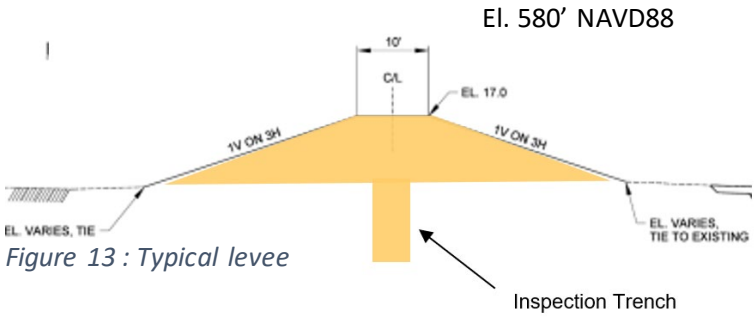

Figure 13 : Typical levee

(Note: from this point on, Alternatives differ)

Alfred Brush Ford Park: The western portion of the park meets the required stillwater elevation, approximately 150 feet from the water's edge. No structures are needed in this area, but the wave run up zone may be flooded during the 1% annual exceedance probability event (100 year). The eastern portion is lower, and a 3-foot levee is estimated to be needed for this area. This is set back further from the waterfront (at the City's request) to allow for aquatic habitat creation along the river. This would tie into a canal closure structure across the Lakewood Street Canal. (See section 5.4 for more discussion on canal closures).

Lakewood East Park: The eastern portion of the park between Lakewood Street Canal and Phillip Street Canal largely meets the elevation requirements. However, there is a portion in the middle of the park that appears lower, based on LiDAR data, and could be inundated. A structure was not assumed for this area since flooding of the park would not have significant consequences. The elevations and land use for this area should be evaluated in future design efforts.

Riverside Boulevard: On the east side of the Phillip Street Canal, a 3-foot levee, approximately 380 feet long, is proposed, tying into high ground at Windmill Point Lighthouse Road. Another canal closure is needed at the Fox Canal, tying into high ground in Grosse Pointe Park.

The cost for Alternative 1 (no closure structure included) is approximately $32.5 Million. For this option, closure structures are needed across the three canals that cross the proposed alignment: Lakewood Street Canal, Phillip Street Canal, and Fox Creek Canal.

The full estimated construction cost with canal closure structures, ranges from $34 Million (3 earthen dam permanent closures) to $161 Million (two stop log structure and a lock system). The range in annual operation and maintenance cost is approximately $315,000 to $1.8 Million, with the high end of the range including a lock system that would allow continual use of Lakewood Canal. Canal closure options are discussed in paragraph 5.4.

5.2. Alternative 2: Open Canal with Extensive Floodwalls

If closure structures are not desired, another option for reducing impact to existing water treatment system and reducing flood risk to residents is placing flood risk reduction structures (seawalls) and levees around the creek bordering Klenk Island, along Fox Creek and near KAM Marine/Bayview Yacht Club. The full length of the canal that meets FEMAs required elevation for levee system accreditation (for the 1% AEP stillwater elevation plus the required 2 feet of freeboard, or 580 feet elevation, see Table 2). The canal front is extremely varied in both alignment and elevation, with numerous boathouses. A detailed evaluation of each property would be required for design. The conceptual alignment is provided in Figure 13. Alternative 2 includes the following features:

- 560 linear feet of upland steel sheet pile floodwall (shown in purple)
- 15,800 linear feet of steel sheet pile seawalls along *all properties* along the canals between Fox Creek and Klenk Island, that are within the FEMA base flood hazard area (between Alter Road and Lenox Road). Walls would function as both seawalls and floodwalls and would be constructed to an elevation of 580' NAVD88.
- 1600 linear feet of earthen levee
- *No canal closure structures*
- Stop log closure or gate at KAM Marine/Bayview Yacht Club

Figure 14: Conceptual Alignment, Alternative 2: Open Canal with Extensive Floodwalls Along Canal Front.

This alternative is similar to Alternative 1, from Clairepointe Street to Lakewood Street Canal. Since this alternative does not keep canal waters out of the neighborhood, structures are needed along the entire canal front to an elevation of 580' NAVD88, estimated at 15,800 lineal feet, or almost 3 miles of seawall. Floodwalls and levees will also be needed on the south side of Riverside Boulevard to prevent floodwaters from inundating Riverside Boulevard.

This alternative would allow the canals to remain open to the public and would remove the Jefferson-Chalmers neighborhood from the FEMA Flood Hazard Area. However, this would effectively eliminate direct water access for individual homeowners due to the height of the new wall. This would be extremely difficult, due to the numerous properties along the canal that feature a variety of structures, including boat houses and docks. This alternative would require significant modification of the existing canal front and require support of the community to proceed.

The base cost for Alternative 2 (no closure structure included) is approximately $88 Million with an estimated annual O&M cost for the levees and floodwalls of $425,000. The cost estimates prepared for this alternative did not include maintaining water access for residents.

5.3. Alternative 3: Closed Canal, Levees & Floodwalls Within Wave Run-up Zone

The alternative is very similar to Alternative 1, with the exception that the flood risk reduction structures are along the waterfront, east of Lenox Street.

This provides flood risk reduction for the entire footprint of the study area, including the parks and open spaces that were excluded in Alternative 1. However, this alignment falls within FEMA's coastal zone designation, and any structures built within this zone will require a higher elevation to prevent waves from overtopping the structure. In addition, these structures would need to be resistant to wave and ice forces that they would be subjected to along the shoreline. Alternative 3 includes the following features (see Figure 15, below):

- 560 linear feet of upland steel sheet pile floodwall (shown in Figure 15)
- 1800 linear feet of riverfront floodwalls
- 2,600 linear feet of earthen levee (shown in yellow)
- 3 canal closure structures (shown in red)
- Upland stop-log closure or gate at KAM Marine/Bayview Yacht Club entrance (shown in orange)

Figure 15: Conceptual layout of Alternative 3

The proposed structures west of Lenox Road are the same as Alternative 1, and only need to meet the stillwater elevation requirement of 580 feet NAVD88.

From the high ground west of Lenox Street, approximately 1900 feet of 6-foot high levees, up to the Lakewood Canal, and approximately 1800 feet of 6-foot high seawall between Lakewood Street Canal and Fox Creek Canal near Alter Street is proposed with this alternative. Three closure structures are included in this alternative, similar to Alternative 1, but the required height would be 583 feet, 3 feet higher than Alternative 1, to account for wave run-up. It should be noted that either floodwalls or levees could be used along these areas.

While this alternative provides flood risk reduction to a larger footprint, constructing a floodwall or levee to 583 feet NAVD88 would eliminate, or significantly impact, access to the waterfront. For example, at Alfred Brush Park (east of Lenox Street), the existing ground is approximately 577.4 feet NAVD88.[4] To meet FEMAs flood insurance criteria, the levees and seawalls would need to be constructed to 583 feet NAVD88, or 5 feet, 7 inches above the approximate ground height. If a seawall is constructed in this area, the riverfront view and access for recreational fishing would be significantly impacted. This could be alleviated by including recreational walkways into the design at an extra cost. *Due to the waterfront impact, the City has not expressed interest in this alternative.*

The base cost for Alternative 3 (no closure structures included) is approximately $45 Million, with an estimated annual O&M cost for the levees and floodwalls of $210,000. The full estimated construction cost with closure structures ranges from $47 Million (3 earthen dam permanent closures), to $173 Million (two stop log structures and a lock system). The annual operation and maintenance cost ranges from $500,000 to $2 Million , with the high end of the range including a lock system that would allow continual use of Lakewood Canal. Canal closure options are discussed in paragraph 5.4.

[4] Approximate elevation taken from LIDAR data

5.4 Canal Closure Options

Canal closures can be used to reduce the likelihood of high-water levels and storm surges/wave run-up from Lake St. Clair/Detroit River from entering the Jefferson-Chalmers neighborhood. There are several options for the type of structure that can be used. The key factors separating the options are cost and impacts to the use of the canal.

5.4.1 Permanent Canal Closure (Earth/ Rock Dam Fill)

Under this option, a portion of the canal would be filled with earthen materials (soil, rock) to create a permanent damming structure that would prevent high lake levels or storm surges/wave run-up from entering the canal. The exact dimensions and requirements would be determined in design. Under this partial fill option, consideration would need to be given to maintaining sufficient flow to prevent the canals from becoming stagnant and maintaining requirements for any discharges for interior drainage and pumping systems. This would be determined during design phase but could include a drainage structure with a flap gate.

Earthen dams were estimated at a cost of $320,000 – $990,000, with Philip Street Canal at the lower cost due to the smaller width of the canal, compared to Fox and Lakewood Canals (40-foot width vs. 80 and 90 feet, respectively). Costs also vary dependent on location along the canal in Alternatives 1 & 3. An average value of $560,000 was used for a canal closure, for ease of comparison between alternative configurations in the cost matrix (Table 6).

Note: A formal alternative for complete filling of the canals is not included in this report, due to objection to this alternative by the non-federal sponsor. The City desires continued use of the canals by the Jefferson-Chalmers neighborhood and area residents. However, this option was listed to show it was considered for this analysis.

5.4.2 Stop Log Structures

Since permanent closure of the canal is not desirable, a more costly (but flexible) option is to install a structure that can be closed during high water. A stop log structure, such as the one shown in 16, can be used. A stop log closure system would require manual installation of the stop logs into recessed areas during high water periods and would require removal when water levels return to an acceptable range. A lift system would need to be purchased *(not included in the cost estimate provided)*

Figure 16: Stop log closure across Hero Canal, New Orleans, LA

Stop log structures were estimated at a cost of $1.9 million – $4.2 million with Philip Street Canal at the lower cost due to the smaller width of the Canal compared to Fox and Lakewood Canals. Costs also vary dependent on location along the canal in Alternatives 1 & 3. An average value of $3.2 million was used for a canal closure for ease of comparison between alternative configurations.

5.4.3 Lock Structure

Permanent closure of the canal to resident boaters will likely be extremely unpopular, and not supported by the non-federal sponsor. The closure of the canals during high lake level events that may stretch months at a time will also have impacts to the use of the canal for recreational activities and have impacts to water quality and interior drainage that would have to be managed.

A lock system would have the benefit of maintaining use of the canal system continuously but comes at a much higher cost. Miter gate lock systems are common for smaller locks and can be either manually or remotely operated. Either system will likely require permanent staff to operate and maintain the lock system. During water levels within an acceptable range, the gates could be maintained in an open position. During higher water levels, the double gate system would be utilized to transport recreational watercraft from the canal system to Lake St. Clair/ Detroit River.

Canal lock systems were estimated at a cost of $50 million to $122 million, with Philip Street Canal at the lower cost due to the smaller width of the Canal compared to Fox and Lakewood Canals.

The widest and deepest canal, Lockwood Canal, would likely be the chosen location for the lock system as it is the most heavily used and can transport larger watercraft. The remaining two canals (Fox Creek Canal and Philip Street Canal) would require other closure systems such as stop logs or earthen dams. It is highly unlikely that the City would be interested in constructing and maintaining three lock systems in such proximity. Therefore, construction and O&M costs for of the Lakewood Canal were used in the Cost Matrix (Table 6).

Additional benefits include the ease of obtaining property easements since private land easements or resident relocation would not be required. Land use agreements are needed from both the Riverfront Limited Partnership and the City of Grosse Point Park.

5.5 Permit Requirements

Any work performed in water will require state and federal permits:

Section 10 of the Rivers and Harbors Act of 1899 provides the Corps with jurisdiction over work waterward of the Ordinary High Water Mark of navigable waters. Section 404 of the Clean Water Act gives the US Army Corps jurisdiction over discharges of fill material in waters of the United States including wetlands.

The State and Federal government maintain jurisdiction over many waters. In Michigan the Federal government has transferred jurisdiction of inland waters to the State of Michigan. In most cases, in these areas you will only be required to obtain a permit from the State. Michigan is one of two states in the country to have been transferred this Federal jurisdiction.

The following permitting criteria is required prior to construction:

- For environmental clearance, proposed scope of work at each specific location for Fish and Wildlife Service (FWS) Threatened and Endangered (T&E) species impacts.
- Quantities (CYD) of excavation (may require sediment testing for contaminant determination and placement) and proposed fill areas (wetlands and floodplains).
- Areas not previously disturbed to project depth that will be impacted by excavation (archeological survey may be required), any tree cutting (number of trees and approximate locations for impacts to T&E bat species).

- Based on the description of the proposed scope of work and locations, a National Environmental Policy Act (NEPA) environmental evaluation is required.
- Michigan Department of Environment, Great Lakes, and Energy (EGLE) State required permits under Part 31, 301 and 404 303.
- In the case where modifications are made to stormwater drainage with discharge through new piping, the piping will need to be added to the City MS4 Stormwater permit with classification as a new outfall.
- Federal Section 10 Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act along with State issued National Pollutant Discharge Elimination System (NPEDS) permit under Section 402(p).

6. Conceptual Level Cost Estimate Assumptions

Cost estimates were developed for each of the base alternatives, and for each closure option based on approximations of quantities needed to construct the work. Cost estimates are conceptual and will need to be refined when the design is complete. Please refer to the quantity take off (QTOs) and cost appendix (Appendix A) for further discussion.

Since the project is not in the design phase and there are several unknowns, the following assumptions were made to develop quantity take-off calculations that were used as the basis for the conceptual level cost estimate.

Levee Assumptions:

Levees constructed of compacted clay.

Total cubic yards of clay were roughly approximated from LiDAR data values. No detailed CADD models were developed to calculate required quantities.

Crest width: 10 feet

Levee slopes: 1V: 3H. Levee slopes assumed to be 1V:3H (33% grade).

Inspection trench included

Potential utility modification/relocation included (rough approximation)

No seepage cutoff included (this will be determined in design phase)

Inland Floodwall Assumptions:

PZ-27 Steel sheet pile floodwall assumed. Material requirements/ preferences would be determined during design phase.

"I-wall" type floodwall assumed. I-walls do not have foundations and are limited to walls less than 6 feet in 'stick up' height. Requirements will be determined in design phase.

Interior Drainage Assumptions:

This study did not include an interior drainage study. However, raising floodwalls and levees along the lakefront and canals will cut off existing pathways for stormwater runoff. The existing interior drainage

system would need to be upgraded to allow for the increased drainage requirement. In the estimates provided in this report, costs included in 2005 were escalated to 2023 dollars using CWCCIS values.

***Earthen Dam Closure Assumptions**:*

Design & construction requirements need to be determined to create a permanent damming surface across the canal. The following assumptions were made to get an order of magnitude cost estimate:

- Rock and/or earth fill construction, likely in a zoned construction.
- Length of 25 feet, width = approximate width of canal.
- Assumed height of 13 feet for Alternative 1, and 16 feet for Alternative 3.

Stop Log Closure Assumptions:

- Design/ use requirements to be determined in design phase. Assumed opening for small watercraft to pass.
- A portage system around the structure when closed may be desired but is not included in this estimate.
- The canal widths were roughly estimated from ArcGIS base map images.

The cost matrix below summarizes the full cost estimates for the alternatives with different closure configurations. The quantity calculations and conceptual level cost estimate are provided in Appendix A.

Table 6: Cost Matrix for Alternatives with Closure Options

Base cost (w/o closures)

Alternative 1	$ 32,464,375
Alternative 2	$ 87,924,563
Alternative 3	$ 44,835,563

Closure Options:

			Annual O&M costs	
Rock/ Earth closure	$ 558,000	each	$ 55,800	10%
Stop log closure	$ 3,285,083	each	$ 197,105	6%
Miter Lock system	$ 121,836,000	each	$ 1,218,360	1% Assuming lock is at Lakewood Ave.

Note: Costs are rough approximate only. Closure costs for different locations were assumed equal for simplicity.

Only enter values into the green cells to build alternatives with different closure options.

		CONSTRUCTION				OPERATION & MAINTENANCE					
Description	Alternative	earth dam	stop log	miter	Total Construction	O&M, levees & floodwalls	O&M, earthen dam	O&M, stop log	O&M miter	Annual O&M	% of const.cost
Closed canal outside of wave run up zone; 2 stop logs & 1 lock	Alternative 1	0	2	1			0	2	1		
	$ 32,464,375	$ -	$ 6,570,167	$ 121,836,000	$ 160,870,542	$ 147,400	$ -	$ 394,210	$ 1,218,360	$ 1,759,970	1.1%
Closed canal outside of wave run up zone; 3 stop logs	Alternative 1	0	3	0			0	3	0		
	$ 32,464,375	$ -	$ 9,855,250	$ -	$ 42,319,625	$ 147,400	$ -	$ 591,315	$ -	$ 738,715	1.7%
Closed canal outside of wave run up zone; 3 earthen closures	Alternative 1	3	0	0			3	0	0		
	$ 32,464,375	$ 1,674,000	$ -	$ -	$ 34,138,375	$ 147,400	$ 167,400	$ -	$ -	$ 314,800	0.9%
Closed canal outside of wave run up zone; 3 earthen closures	Alternative 1	2	1	0			2	1	0		
	$ 32,464,375	$ 1,116,000	$ 3,285,083	$ -	$ 36,865,458	$ 147,400	$ 111,600	$ 197,105	$ -	$ 456,105	1.2%
Open canals, extensive steel sheet pile structures	Alternative 2	0	0	0			0	0	0		
	$ 87,924,563	$ -	$ -	$ -	$ 87,924,563	$ 423,540	$ -	$ -	$ -	$ 423,540	0.5%
Closed canal outside of wave run up zone; 2 stop logs & 1 lock	Alternative 3	0	2	1			0	2	1		
	$ 44,835,563	$ -	$ 6,570,167	$ 121,836,000	$ 173,241,729	$ 207,540	$ -	$ 394,210	$ 1,218,360	$ 1,820,110	1.1%
Closed canal outside of wave run up zone; 3 stop logs	Alternative 3	0	3	0			0	3	0		
	$ 44,835,563	$ -	$ 9,855,250	$ -	$ 54,690,813	$ 207,540	$ -	$ 591,315	$ -	$ 798,855	1.5%
Closed canal outside of wave run up zone; 3 earthen closures	Alternative 3	3	0	0			3	0	0		
	$ 44,835,563	$ 1,674,000	$ -	$ -	$ 46,509,563	$ 207,540	$ 167,400	$ -	$ -	$ 374,940	0.8%
Closed canal outside of wave run up zone; 2 earthen closures & 1 stop log	Alternative 3	2	1	0			2	0	0		
	44835562.5	$ 1,116,000	$ 3,285,083	$ -	$ 49,236,646	$ 207,540	$ 111,600	$ -	$ -	$ 319,140	0.6%

Table 7: Structural Alternative Comparison

Measure Description	Pros	Cons	Notes/ Requirements
Levee Along Waterfront	• Continuous structure • Kayaking and canoeing could still take place in the canals • Unchanged canal front environment • Overland flooding prevented • Minimal property easements required to obtain • No Operation needs, minimal maintenance	• Access to Detroit River and Lake St. Clair removed for all residents • Higher levee height and width requirements for wave run-up • Significant amount of material would be required to build a levee to meet FEMA's standards • Would conflict with EPA Park Project if it is in area of park • May hinder residents' water views • Loss of property values	• Stagnant canal water - Would require gated pipe for water circulation/ pumping facility • Internal drainage system improvements required • Closing Fox Creek would require an agreement with the City of Grosse Pointe Park • Require accommodation and/or agreement with GLWA regarding operations or alternate discharge accommodations
Floodwall along Waterfront	• Continuous structure • Kayaking and canoeing could still take place in the canals • Takes less space • Minimal property easements required to obtain	• Access to Detroit River and Lake St. Clair removed for all residents • High height requirements • Would conflict with EPA Park Project if it is in area of park • May hinder residents' water views • Loss of property values • May hinder residents' water view	
Setback Levees/ Floodwalls	• Would accommodate both canal and coastal EPA project wetlands • Public would have an easier time accessing the water • Fishing could take place at the mouths of the canals • Lowest cost • Lower levee height and width requirements • Kayaking and canoeing could still take place in the canals • Minimal property easements required to obtain • A boat launch could be installed near the mouth	• Watercraft access to Detroit River and Lake St. Clair restricted; removed entirely during high water occasions for all residents. • Would need to develop a way to keep canals from being stagnant (flush out) • Loss of property values	

	of the canal for easier access		
Above Options with Canal Fill	• Could use as park area Possible additional yard space for residents or pu • Limited land easements	• No Access to water for residents, • No potential for sewer discharges (without new discharge system) • Environmental Impacts • Likely to be least acceptable to residents • Private property easements required and difficult to obtain. • Loss of property values	Internal drainage system improvements required. A boat launch could be installed near the mouth of the canal

7. Conclusion

This study developed and analyzed three structural flood risk reduction alternatives to assist with mitigating flood impacts to the Jefferson-Chalmers neighborhood, located in Detroit, MI. Upon extensive hydrological analysis, it is determined that the source of the reoccurring flooding is from heightened lake levels, combined with surge and wave-runup. During east and northeast wind events, water is forced into the local canals connected to Lake St. Clair, raising water levels in the canals and resulting in flooding. It is important to note that the scope of this study is focused on alternatives to reduce the coastal flooding risk. While there is a cost assumed for necessary interior drainage upgrades, interior drainage analysis or design is not included in this study. The recommended structural flood risk reduction alternatives to be considered are as follows:

- **Alternative 1 (3 Configuration Options):** Closed canal, levees and floodwalls *outside* of the wave run up zone
- **Alternative 2 (1 Configuration Option):** Open Canal with Extensive Floodwalls
- **Alternative 3 (3 Configuration Options):** Closed Canal, levees & floodwalls *within* the wave run up zone

The recommended alternatives included in this report are conceptual. Significant design efforts and hydraulic modeling are needed prior to construction. Modifications and refinement to the concept level alternatives based on these design efforts shall be expected.

Estimated material quantities and total cost (labor and material) for each alternative are detailed in Sections 5 and 6 of this report. Each alternative recommendation, if implemented, will provide flood protection to the Jefferson-Chalmers neighborhood from heightened lake levels overwhelming the series of associated canals in the area. The three alternatives presented would result in flood risk reduction by preventing storm surge/wave run-up from overtopping the canal walls, which results in inland surface flooding that has historically overwhelmed storm and sanitary sewer drainage systems. Additionally, each alternative would qualify the Jefferson-Chalmers area to be removed from the 100-year (1% annual chance of flooding) floodplain (currently listed as a high-risk flood zone) within the

limits of the study area detailed in this report, resulting in less cost and more grant opportunities for flood insurance coverage.