

July 2011

Analysis of the Flint River as a Permanent Water Supply for the City of Flint

Prepared for:

City of Flint

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I. Purpose

This study evaluates the feasibility of utilizing the City of Flint's Water Treatment Plant (WTP) and Flint River as the primary water supply for the City of Flint. The study evaluates whether the Flint River is an adequate source of water for the City of Flint and identifies upgrades needed to reliably supply water on a continuous basis.

II. History

The City of Flint's WTP was constructed in 1917 and supplied water to city customers for drinking and industrial uses. Records indicate that Flint supplied approximately 16 mgd in 1940 and that by the mid-1950s water use had increased to about 45 mgd. This significant increase coincided with increases in automobile production and population in the area. The Holloway Reservoir was constructed in 1954 to increase water supply capacity to meet the growing demand. Because of continued concerns regarding the adequacy of the Flint River for meeting the future water supply needs of the area, the city evaluated alternatives for a new water supply and ultimately contracted with the City of Detroit in 1967 for water supply. Detroit continues to supply water to Flint and its customers today. Detroit supplies finished water to the city via a single transmission pipeline. For reliability, the city's WTP has been maintained as a backup water supply in the event of a disruption to the single supply pipeline.

Because of recent concerns with the cost and reliability of the existing water supplies, the City of Flint, Genesee County, Lapeer County, the City of Lapeer, and Sanilac County are evaluating alternatives for their long-term water supply. The most recent study (Preliminary Engineering Report, Lake Huron Supply, Karegnondi Water Authority; September 2009) focused on two primary alternatives: Alternative 1 – continued supply by Detroit, and Alternative 2 – development of a new Lake Huron water supply. This study evaluates a third alternative. Alternative 3 provides for utilizing the existing City of Flint WTP to treat water from the Flint River. Alternative 3 assumes that water will be supplied only to customers within the city.

To evaluate the feasibility of Alternative 3, the river and WTP will be examined to determine their ability to supply water in sufficient quantity meeting current and anticipated regulations. There have been many new rules and regulations for treatment of surface water since 1967 when Flint's WTP was last used as a primary water supply.

III. Regulatory Requirements for Quantity of Source Water

Regulations require that the quantity of water at the source shall:

- Be adequate to meet the maximum projected water demand of the service area as shown by calculations based on a one in fifty year drought or the extreme drought of record, and should include consideration of multiple year droughts. Requirements for flows downstream of the intake shall comply with requirements of the appropriate reviewing authority.
- Provide reasonable surplus for anticipated growth.
- Be adequate to compensate for all losses such as silting, evaporation, seepage, etc.
- Be adequate to provide ample water for other legal users of the source.

IV. Demands

The alternative of utilizing the city's WTP and Flint River as a water supply will be evaluated on the basis of supplying water to Flint's direct customers only. Although Flint currently supplies water to GCDC-WWS, for this analysis it is assumed that GCDC-WWS receives its primary water supply by another source. Table 1 summarizes the city's current and projected demands for direct customers of the city. Projections have been provided by city representatives.

Table 1: City Customer Demand Summary

	2010	2035
Average Day Demand (ADD)	14.0 mgd	15.0 mgd
Maximum Day Demand (MDD)	17.5 mgd	18.0 mgd

Actual water requirements will be greater than the amount of water provided to customers. About ten percent additional water must be added for treatment processes and system operation. Water for fire-fighting is not included in customer demands and must be added to the quantity of water needed.

Surface water sources must be adequate to supply water through a drought period. Although the MDD is projected to be 18 mgd, the sustained maximum demand over a longer period will be less than the MDD. Analysis of records of water use indicates that the 30-day sustained maximum demand is about 80% of the MDD. Table 2 summarizes the source water requirements to supply the city's future needs.

Table 2: Source Water Requirements

Future Maximum Day Demand (Customers)	18.0 mgd
Future Maximum Day Demand (WTP Backwash / Process Water)	2.0 mgd
Subtotal (Future Maximum Day Demand)	20.0 mgd
Sustained (30 day) Future Maximum Day Demand	(80% of MDD) 16.0 mgd
Replenish Water from Fire Fighting	0.7 mgd
Future Maximum Day Demand (Source Water)	16.7 mgd

V. Drought Flows

USGS records indicate that the most severe drought in Michigan occurred between 1930 and 1937, and that the low stream flows experienced during this period have a recurrence interval of 50 to 70 years. River flow records which include the drought of the 1930s will be used to evaluate the adequacy of the river as a permanent water source.

VI. Reservoir Losses

Both the Holloway Dam and Mott Dam were constructed since the drought period of the 1930s. If used to simulate the "design drought conditions", the records of flow on the Flint River from the 1930's should be adjusted for potential impact from the addition of these two dams and resulting reservoirs.

A. Evaporation

If the two reservoirs had existed during the drought period, the flows in the river would have been a little less because of the volume of water which would have been lost to evaporation from these two bodies of water.

B. Sedimentation

The July 2001 Flint River Assessment completed by the MDNR indicates that sedimentation occurs in the Holloway Reservoir at an accelerated rate, but does not provide specific volumes. Sedimentation reduces the storage volume of reservoirs. No investigation to determine the amount of sedimentation has been completed in the Holloway Reservoir since its construction, but the storage volume of the reservoir has certainly decreased since its construction.

Mott Dam maintains a fixed water level, so storage for water supply is not available. Therefore, sedimentation in Mott Lake is not a concern with respect to water supply.

C. Seepage

The land adjacent to both the Holloway Reservoir and Mott Lake has a relatively high groundwater table. Any loss of water by seepage from the bottom of the reservoirs seems likely to flow back to the river downstream of the respective dams, resulting in little or no impact to the quantity of water available for water supply or flow augmentation. Loss from the reservoirs by seepage is not considered a significant factor.

VII. Other Water Uses

Since 1967 when Detroit began supplying water to Flint, the Holloway Reservoir has been utilized as a backup water source, source of flow augmentation for the river, and for recreational purposes. Although the city maintains control over the dam and water levels; the city has leased their surrounding lands to the Genesee County Parks and Recreation Commission (GCPRC) for park, recreational, and conservation purposes. In 1987, the city and GCPRC adopted the Holloway Reservoir Management Plan (HRMP) which defined how water levels in the reservoir were to be maintained to achieve the goals above. The HRMP establishes a summer water level of 755 and a winter level of 751. Discharge from the reservoir is to be maintained above 65 cfs except when the level is less than 751; outflow from the reservoir is not to exceed inflow to the reservoir. A copy of the HRMP is included in Appendix 1.

Flow augmentation for the city's WWTP discharge is another consideration. The city's NPDES permit for their WWTP indicates that a Flint River drought flow of 85 cfs was used to determine the permitted limits for WWTP effluent. It appears that the HRMP requirement to maintain a 65 cfs minimum at the Holloway Reservoir was established to provide adequate flow in the river at the city's WWTP outfall. An excerpt of the city's WWTP NPDES permit is included Appendix 2.

The existing water supply contract between the city and Genesee County Drain Commissioner Division of Water and Waste Services (GCDC-WWS) provides that both the city and GCDC-WWS supply the other up to 8 mgd of finished water in the event of an emergency or supply disruption. For this analysis, it is assumed that the Flint WTP and river must be able to supply 8 mgd to GCDC-

WWS in the event of an emergency in addition to the quantity consumed by the city's water customers. The need to provide backup to GCDC-WWS is assumed to be limited to a period of two weeks. Over a 14 day period, 125 million gallons of water should be reserved to meet the commitment for an emergency supply.

VIII. Analysis of Adequacy of Flint River

A detailed analysis of the adequacy of the Flint River as a water supply source is included in Appendix 3. This section provides an overview.

In 1977 when the HRMP was executed, water was not withdrawn from the Flint River for water supply. In 1977 without any withdrawal for water supply, the HRMP provided for a minimum discharge of 65 cfs from the Holloway Reservoir, to provide for a river flow of 85 cfs at the city's WWTP. If water is withdrawn from the river for water supply, the minimum flow from the reservoir must be increased by the rate of WTP withdrawal if the 85 cfs base flow is to be maintained at the city's WWTP. With Flint's future sustained demand estimated to be 16.7 mgd (26 cfs), a minimum flow of 91 cfs (65 cfs + 26 cfs) will be needed from the Holloway Reservoir to maintain the 85 cfs base flow at the WWTP.

The United States Geological Survey (USGS) in a 1963 report Water Resources of the Flint Area Michigan examined the Flint River as a water supply for Flint. Using river flow records between 1930 and 1952, the USGS report includes a Draft-Storage curve for the Holloway Reservoir. If a minimum discharge of 91 cfs is to be maintained during a drought period, 6.2 billion gallons water would need to be withdrawn from the reservoir to supplement natural river flow.

In addition to the 6.2 billion gallons of storage to maintain the existing rates of flow in the river plus water supply, additional storage is required to provide GCDC-WWS an emergency supply and to make up for reservoir losses. The following table summarizes the total storage needed.

Table 3: Storage Requirements

Storage to meet sustained demand and WWTP flow	6.20 billion gallons
Storage to provide backup supply to GCDC-WWS	0.11 billion gallons
Storage to make up loss by evaporation	0.90 billion gallons
Storage lost by siltation	0.64 billion gallons (assumed)
Storage to provide loss by seepage	0.00 billion gallons
Storage Needed to Supplement River Flow	7.85 billion gallons

To provide 7.85 billion gallons of storage, the Holloway Reservoir operating level must be raised by at least three feet to 758 feet. Although possible, there are many challenges associated with operating the Holloway Reservoir at the 758 feet level.

- The existing drum gates used to control reservoir level are designed for adjustment over a four foot range (751 feet to 755 feet). The design of the dam is such that the existing gates cannot simply be replaced with larger ones to increase the upper level to 758 feet. The dam spillway will likely need to be reworked to accommodate the larger drum gates. Drawings showing the details of the dam are included in Appendix 4.

- Although operation at the 758 water level provides five feet of freeboard to the top of the dam, the watershed contributing to the reservoir is quite large and has resulted in quick increases in the reservoir level during extreme rain events. The reduction in freeboard will result in a reduced safety factor for managing flood events.
- Seepage through the earthen dam embankment will increase as a result of the increased hydraulic pressure with the higher water level. Increased seepage through the dam's embankment will reduce the strength and integrity of the embankment and is likely to increase maintenance needs.
- The 758 feet water level is based on an assumption regarding the loss of the reservoir volume by siltation. The depth of siltation should be measured to better determine the quantity of siltation and its impact on storage and reservoir level.
- Recreational activities, the fishery, and adjacent properties will be impacted by use of the reservoir for water supply. Normal water levels will be increased by three feet and during dry periods, the water levels may vary by several feet. During an extreme drought period, water levels may be as much as 11 feet below normal levels.
- If the 85 cfs drought flow at the city's WWTP cannot be achieved, a new NPDES permit with stricter discharge limits may issued by the MDEQ. This could result in higher WWTP costs for the city.

Analysis shows that without modification, the Holloway Reservoir can support a sustained maximum day demand of 11.6 mgd for water supply through a drought period.

IX. Dams

If the Flint River is to be used as water supply, existing dams will continue to be critical for management of the flows in the river and water supply. Following is a summary of the dams on and adjacent to the river.

Table 4: Summary of Dams

Facility	Construction Completed	Catchment Area (sq. mi.)	Surface Area (Acres)	Storage (Acre-Feet)	Ownership	Hazard Classification	Condition
Holloway Dam	1954	523	1,973	17,678	Flint	High	Good
Mott Dam	1972	612	684	0	GCPRC		Good
Kearsley Dam	1929	115	175	2,000	Flint	Significant	Satisfactory
Utah Dam	1928	729		0	Flint	Low	Poor
Hamilton Dam		748	17		Flint	High	Poor
Thread Creek Dam	1973	63	80	320	Flint	Significant	Poor

A. Holloway Dam

The Holloway Dam was last inspected in 2008 and was reported to be in good condition. A copy of the 2008 Dam Safety Report is included in Appendix 5. Other than routine maintenance, the following upgrades / modifications are recommended to provide a water supply of up to 11.6 mgd:

- Replacement of drum gate bearings
- Installation of river flow gage on North Branch of Flint River
- Improved instrumentation to measure and monitor gate positions and water surface level

If the river is to be used as a water supply of greater capacity than 11.6 mgd, additional modifications are required at the Holloway Dam to allow for operation at an increased water level. These improvements will include replacement of gates with larger ones and reworking of the dam spillway to accommodate the larger gates. The existing embankment should be armored to strengthen the dam's embankment and protect against erosion from wave action. A budget of \$2.57 million is established for the upgrades to the Holloway Dam to provide adequate capacity for the projected future demands.

B. Mott Dam

The Mott Dam is under the jurisdiction of the GCPRC. The reservoir level is maintained by a fixed weir so the reservoir volume is not available for storage. The dam has been reported to be in good condition.

C. Utah Dam

Utah Dam is inoperable and in poor condition. A copy of the 2008 Dam Safety Report is included in Appendix 6. Recent studies and evaluations conclude that the dam is of little benefit and should be removed. The 2010 Hamilton Dam Modifications and Riverfront Restoration PER provides a budget of \$1.9 M for removal of the Utah Dam, including replacement with a pedestrian bridge, construction of a boat launch, and local storm sewer upgrades.

D. Hamilton Dam

The Hamilton Dam is in poor condition and considered unstable. A copy of the 2008 Dam Safety Report is provided in Appendix 7. The dam has been the subject of extensive study and recommended for removal and replacement. The 2010 Hamilton Dam Modifications and Riverfront Restoration PER provides a budget of \$7.1 M for the removal and replacement of the dam, including ancillary upgrades to adjacent portions of the river.

The new Hamilton Dam is proposed at a lower elevation than the existing dam to reduce potential for flooding. A reduced water level upstream of the dam will reduce the water pool depth at the WTP intake, unless the Utah Dam is replaced or another dam is added. Testing of pumps at the WTP was completed to determine the impact of a reduced water depth at the WTP intake. Allowing for two feet of loss through the WTP intake screens after operation, reduction of the height of the Hamilton Dam by 1.5 feet or more will impact WTP's ability to draw water from the river.

E. Kearsley Dam

The Kearsley Dam is reported in satisfactory condition. Although the dam is located downstream of the city's WTP, water from the dam and Kearsley Lake supplements the river flow in advance of the Hamilton Dam, therefore contributing to the impoundment from which the WTP draws water. Water from the Kearsley Creek also serves to augment river flow at the city's WWTP located further downstream.

The storage volume of Kearsley Lake is relatively minor in relation to the storage deficit from Section VIII. Supplemental flows to the river from the Kearsley Creek are included in the USGS records included in this analysis

The dam is an important component of the city's water supply system because of its potential contribution to the WTP intake. Although currently in satisfactory condition, there will be ongoing maintenance needs to be addressed.

F. Thread Lake Dam

The Thread Lake Dam is reported to be in poor condition. Flow from the Thread Creek supplements the river flow prior to the city's WWTP. The storage provided by Thread Lake is negligible and flow from Thread Creek is included in the USGS records of river flow used for this analysis.

The Thread Lake Dam remains a facility of the city which because of its poor condition needs to be addressed. However, since the dam appears to be of little benefit to the water supply considered in this analysis, a budget for upgrades or removal has not been included in the costs for water supply.

X. Source Water Quality

Since the Flint WTP is the backup water supply in the event of a disruption to the supply from Detroit, raw water at the WTP intake is regularly sampled and analyzed. Available records provide a good understanding of the characteristics of the raw water and ranges of variances, and will be helpful to design water treatment processes and estimate operating costs.

Preliminary analysis indicates that water from the river can be treated to meet current regulations; however, additional treatment will be required than for Lake Huron water. This results in higher operating costs than the alternative of a new Lake Huron supply.

Although water from the river can be treated to meet regulatory requirements, aesthetics of the finished water will be different than that from Lake Huron. As an example, the temperature of water supplied to customers during the summer will be warmer than the present Lake Huron supply, because of the increased summer temperature in the relatively shallow river.

A detailed investigation of potential sources of contamination has not been completed. The MDEQ has reported that the Richfield Landfill is considering an application for an NPDES permit to allow

for discharge of stormwater and/or treated leachate to the Holloway Reservoir. If an NPDES permit is issued, there may be an impact on the quality of source water.

If used for water supply, a source water protection management plan should be developed to study the watershed, identify potential sources of contamination, and enact safeguards to prevent or control future threats.

XI. Water Treatment

For comparison with other alternatives, it is assumed that the Flint WTP will treat water from the river to provide a finished water of similar quality to the other alternatives being considered (continued Detroit supply and new Lake Huron supply).

A review of the city's WTP has been completed (Technical Memorandum, Cost of Service Study, Flint Water Treatment Plant prepared by Lockwood, Andrews, and Newnam (LAN), dated June 2011) to evaluate its ability to treat water from the river on a continuous basis to meet current and anticipated regulations and produce high quality finished water. Details regarding this review and analysis are provided in Appendix 8.

Although the WTP has been maintained and operated as a backup water supply, there have been numerous changes in regulations and standards since the WTP last supplied water on a continuous basis. Although equipment and systems at the WTP have been used sparingly, some existing equipment and systems require replacement from deterioration or obsolescence to provide reliability for continuous operation.

Following is a summary of upgrades needed.

A. Lime Sludge Disposal

Prior to supply of water by DWSD, the city's WTP disposed of lime sludge from water treatment operations at the Bray Road disposal site. The city is working with the MDEQ to address concerns at the Bray Road site; for this study it has been assumed that new sludge handling and disposal provisions will be utilized. Lime residual handling and disposal facilities have an estimated project cost of \$15.1 million. No costs have been included for remediation of the Bray Road site.

B. Soda Ash Feed System

Records of analyses of the source water indicate non-carbonate hardness. To remove the non-carbonate hardness and provide softening, soda ash should be added during treatment. The addition of a soda ash feed system has an estimated project budget of \$0.5 million.

C. Chemical Storage

Bulk chemical storage of at least 30 days is needed if the plant operates on a continuous basis. New storage tanks for liquid carbon dioxide, liquid oxygen, and liquid nitrogen will be needed. The project budget for chemical storage is \$2.1 million.

D. Electrical and SCADA

The power requirements of equipment at the WTP exceed the capacity of the substation which supplies the plant. Backup power generators at the WTP are not currently operable. Upgrades are recommended to power feeders for several of the existing systems. New SCADA is recommended to provide control and monitoring of operations at the WTP. The project budget for these upgrades is \$8.1 million.

E. Post Chlorination and Zebra Mussel Control

Zebra mussels are an invasive shell fish which have been introduced to the Great Lakes basin, including the Flint River. Zebra mussels can obstruct pipes and water intake screens. A sodium permanganate feed system is proposed for zebra mussel control. The project budget is \$0.3 million.

F. Security Issues

Additional security measures to guard against malevolent threats or terrorism which target the new water source will be required. A project budget for this is \$0.3 million.

G. Pumping System Improvements (Low and High Service Pumps in PS No. 4)

The pumps are in poor condition and their capacity is not consistent with the projected demands of the city. The pumps should be replaced with new, more efficient pumps. The project budget for these is \$7.8 million.

H. Filter Transfer Station to Dorf Reservoir and UV Inactivation

Recent USEPA regulations require additional treatment or enhancement of existing treatment processes for microbial contaminants such as giardia, cryptosporidium, viruses, and bacteria. It is anticipated that enhanced contact time and ultraviolet light deactivation will be required to comply with these new standards. A project budget of \$7.0 million is established for compliance with the new surface water treatment rules.

I. Emergency Interconnect

The GCDC-WWS and City of Flint have a mutual aid agreement providing for each to provide the other up to 8 mgd of water as a back-up supply in the event of an emergency with either system's supply. A pumping station and piping interconnect is needed to effectively complete this exchange. The project budget for these upgrades is \$8.6 million.

The total of all WTP upgrades above is \$49.9 million.

In addition to upgrades to the treatment plant, there will be increased operating costs associated with the continuous operation of the WTP. For comparison with other alternatives for a long-term water supply, only the additional operational costs have been determined.

- Labor – Full scale operation of the WTP and dams on a continuous basis will require additional staffing. It is estimated that labor costs will increase by \$2,034,000 per year.
- Chemicals – The cost of chemicals used for water treatment are estimated at \$423 per million gallons of water produced.
- Residual Disposal – Disposal costs for lime sludge is estimated to be \$453,000 annually.

- Power – Increased power costs are estimated to be \$104 per million gallons of water produced.
- Ozone – Ozone treatment will be needed to meet new treatment standards. A budget of \$208,000 is assumed.
- Maintenance – Maintenance costs are assumed to be 20% of the O&M budget. Maintenance costs of the WTP and other facilities are expected to be relatively high because of the age of the facilities.

XII. Cost Summary

Upgrades to dams and the WTP will be needed for the Flint River to reliably supply drinking water on a continuous basis to Flint's customers. The cost of these upgrades is presented in the following table. Costs have been adjusted to an ENR Construction Cost Index of 8688 to allow for comparison with the 2009 Study. It has been assumed that design/construction commenced in 2010, to allow for comparison with the alternatives in the 2009 study.

Table 5: Project Costs

WTP Upgrades	\$49,888,000
Hamilton Dam Replacement	\$7,100,000
Holloway Dam /Reservoir Upgrades	\$2,570,000
Utah Dam Removal	\$1,900,000
Total Capital Cost	\$61,458,000

Costs shown are based on upgrades to existing facilities to supply the projected future maximum day demand of 18.0 mgd. These upgrades are based on the assumption that the HRMP is modified to allow for operation over a greater range of water levels. Other options for supplying the projected maximum day demand will result in higher costs.

Operating costs in the initial year of operation are estimated to increase \$7 million above current operating costs. Operating costs are projected to increase annually because of inflation and projected growth in demand over the study period.

Figure 1 shows the cost of water for Alternative 3, utilizing the existing WTP and Flint River for water supply. The cost of water is comprised of three components: continued purchase of water from Detroit during construction, debt for construction of facility upgrades, and ongoing operating costs.

Figure 1: Cost of Water Using Flint River as Source

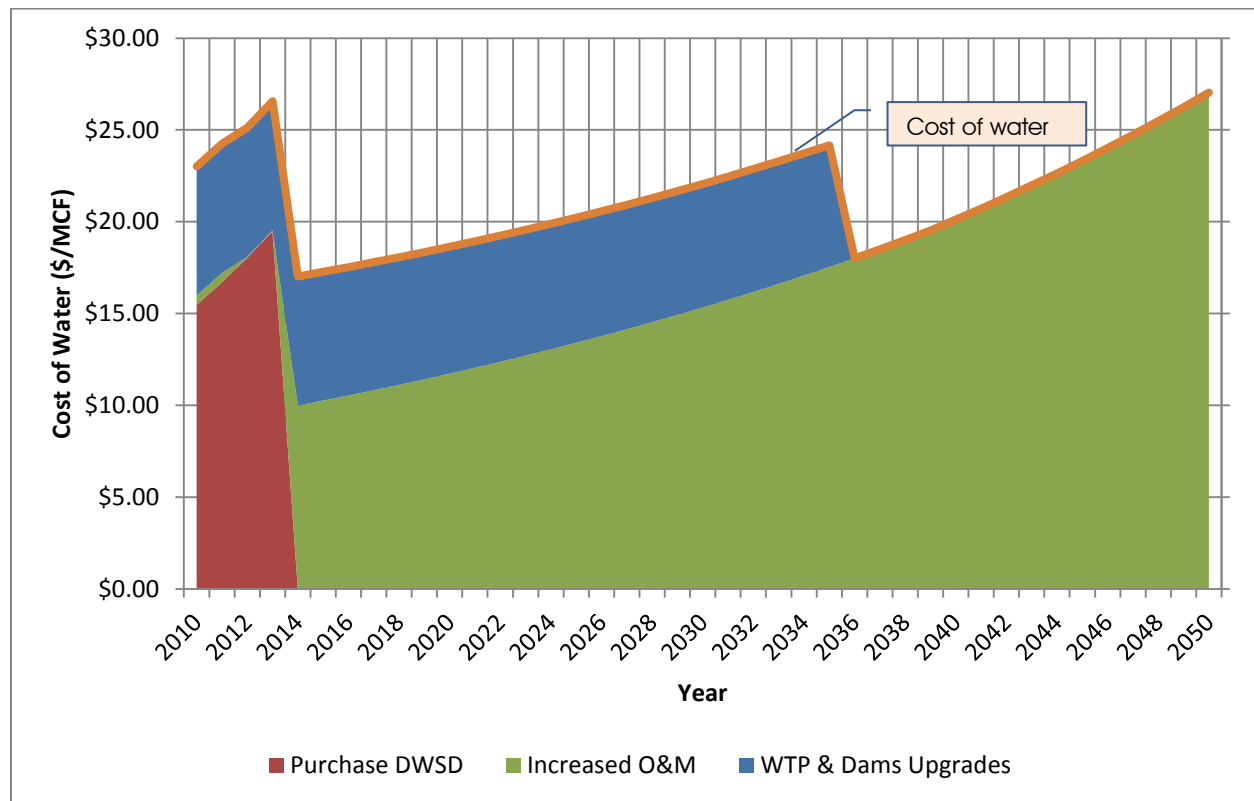
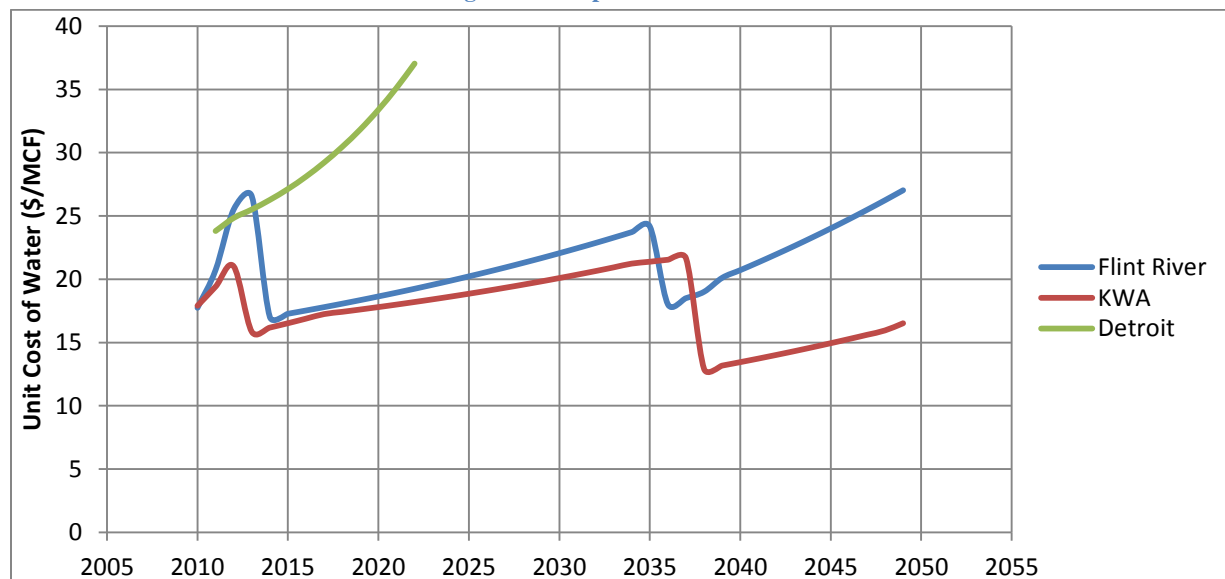


Figure 2 compares the cost of water for all three alternatives. Continued Supply by the City of Detroit results in a higher cost for water supply than the other two alternatives. The city's costs for The KWA-New Lake Huron Supply have been based upon the terms of the current KWA Raw Water Supply Contract, and the assumption that the city purchases 18 mgd capacity in the KWA system. The KWA alternative is projected to result in the lowest cost for water.

Figure 2: Comparison of Alternatives



XIII. Implementation

Planning, design, construction, and start-up will require 52 to 60 months for completion. Additional time may be required to address ancillary issues such as modifications to agreements, permits, and “non-construction related” environmental issues.

XIV. Intangibles

In addition to the upgrades identified for the dams and WTP, other issues will potentially need to be addressed if the Flint River is to be used as a water supply. Examples of these include:

- Environmental impact of work on dams or removal of sediment from the river or reservoirs
- Impact of construction and reservoir operation on the fishery
- Impact to recreational users and land owners adjacent to the Holloway Reservoir
- Potential upgrades to the city’s WWTP if river flows are reduced and stricter effluent limits are included in future NPDES permits
- Impacts of the replacement of the Hamilton Dam at a lower level for improved flood control may impact the ability for the WTP to draw water from the river
- Results of a Source Water Protection Plan which may identify potential threats of contamination or other impacts to the water supply

XV. Summary

Analysis indicates that the cost of supplying water from the Flint River on a continuous basis will be greater than the proposed KWA Raw Water Supply Contract, but less than continued supplied from Detroit. Additionally, if the Flint River is to be used for a water supply for city customers, there will need to be some modifications to existing facilities, operating agreements, and permits. Upgrades will be required at the city’s dams and the water treatment plant to reliably supply water to the city on a continuous basis. To meet the future maximum day demand of 18 mgd projected by city staff, one or more of the following will be required.

- Modify the Holloway Dam and Reservoir to provide additional storage
- Modify the HRMP to provide for more variance in water levels and/or modify limits on minimum discharge
- Modify the WWTP NPDES permit based on reduced flows in the river and provide resulting upgrades to WWTP for higher treatment
- Provide other raw water storage reservoirs

Addressing the preceding items is likely to require a great deal of time and effort because of the impacts on many other parties. Without making the modifications above, the river is limited to supplying a maximum day demand of about 11.6 mgd.

Appendices

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Appendix 1 - Holloway Reservoir Management Plan



March 13, 1987

TO: Members of the Ad Hoc Committee to Work With
City of Flint Officials on Management of the
Holloway Reservoir

FROM: Kenneth J. Smithee, Director
Genesee County Parks & Recreation Commission

CITIZEN REPRESENTATIVES: SUBJECT: Action of the Parks & Recreation Commission

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PRESIDENT

ARCHIE HALFORD, JR.
VICE PRESIDENT

CHARLES E. OLIVER, JR.
SECRETARY

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COMMISSIONERS

ANTHONY RAGNONE
GENESEE COUNTY
DRAIN COMMISSIONER

KENNETH J. SMITHEE
DIRECTOR

Please be advised that the recommendations as outlined on Attachment A were approved by the Genesee County Parks & Recreation Commission meeting in formal session on March 12, 1987.

On behalf of the Commission, I would like to extend our personal thanks to each of you for the assistance which you rendered which led to the agreement between the Parks & Recreation Commission and the City of Flint and will provide protection for recreational users of the Holloway Reservoir, adjacent property owners and also help protect the fish and other aquatic life.

Thanks again.

Sincerely,

Kenneth J. Smithee
Director

KJS:jp
Attachment

R-22

PRESENTED: 3/9/87

ADOPTED: 3/9/87

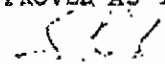
By the Mayor:

WHEREAS, the City of Flint in adopting ordinance 2208 granted to the Genesee County Parks and Recreation Commission the right to establish and operate park and recreational facilities and conservations programs on property owned by the City of Flint in the Holloway Reservoir area; reserving unto itself the power to control and regulate the dams and water levels of the Holloway Reservoir, and

WHEREAS, it is in the interests of the City and the Genesee County Parks and Recreation Commission to establish a Management Plan which optimizes the summer recreational programs available to the public while preserving downstream usages of the Flint River, and which will assist the City in implementing the provisions of ordinance 2208.

NOW, THEREFORE, BE IT RESOLVED, that the City of Flint adopts the attached Holloway Reservoir Management Plan.

APPROVED AS TO FORM:



Chief Legal Officer

R990

HOLLOWAY RESERVOIR MANAGEMENT PLAN

GENERAL OBJECTIVE:

To operate Holloway Dam in a manner that optimizes summer recreation on the Holloway Reservoir while preserving downstream usages of the waters of the Flint River and assuring availability of a back-up water supply for Flint.

GENERAL OPERATING PROCEDURE:

Spring Fill - The City of Flint shall operate the dam with the intention of capturing a sufficient quantity of spring run-off to maintain the reservoir at a minimum elevation of 755 feet no later than May 1 of each year.

Summer Operation - The City of Flint shall maintain a minimum outflow of 65 cfs until the level of the reservoir falls to an elevation of 752.7 feet.

At any time that the level reaches elevation 752.7 feet the city shall operate the dam such that the outflow does not exceed inflow, on any given day, provided, however, that the city shall not be obligated to make more than one adjustment to flow during any given day.

Winter Drawdown - The City of Flint shall operate the dam to gradually drawdown the reservoir during the first two weeks of November to an elevation of 751 feet in order to prevent structural damage to the dam from freezing.

Notification - The City of Flint shall provide prior notification to the Genesee County Parks and Recreation Commission before making a change in dam operations which result in significant drawdown.

Maintenance and Construction - Routine maintenance shall be scheduled to avoid conflicts with major events and peak usage periods on the reservoir. A minimum of 30 days notification shall precede all maintenance and construction involving significant drawdown. The Genesee County Parks and Recreation Commission shall promptly receive copies of all dam maintenance permit applications made by the City of Flint to the Michigan Department of Natural Resources.

Gauging of Water Flow into Reservoir - The City of Flint shall be a cooperator with the U.S.G.S. and State of Michigan to establish a stream gauge on the north branch of the Flint River upstream of the Holloway Reservoir and be a cooperator on the annual maintenance and operation of the existing gauge on the south branch of the Flint River and the new gauge on the north branch of the Flint River.

EMERGENCIES:

In emergency situations affecting public health, safety and welfare the City of Flint shall operate the Holloway dam in a manner to protect the public health, safety and welfare. This shall be done even though recreational users and others may be temporarily inconvenienced. Situations which shall be identified as emergencies shall include but not be limited to the following: flood conditions, interruption of the City of Flint's public water supply, and event(s) which threatens the structural integrity of the dam, and acts of God. However, low flow augmentation for sewage treatment shall not be considered as an emergency.

MONITORING:

The City of Flint in cooperation with the Genesee County Parks and Recreation Commission will assure conformance with the Holloway Reservoir Management Guidelines. A standing oversight committee shall be created to provide monitoring of the reservoir management and facilitate exchange of timely information regarding the Holloway dam and reservoir. The committee shall be composed of two members from both the City of Flint and the Genesee County Parks and Recreation Commission and shall meet in April and November of each year. The Genesee County Parks and Recreation Commission shall provide the City of Flint with a schedule for summer events on Holloway Reservoir at the April meeting of the Oversight Committee.

PERIOD AND EXECUTION OF AGREEMENT:

The Holloway Reservoir Management Plan shall be in full force and effect when officially adopted by the Flint City Council and the Genesee County Parks and Recreation Commission and shall remain so until altered by mutual agreement.

MANAGEMENT PLAN STATUS:

This management plan establishes targets for optimal operation of the Holloway Dam and Reservoir but does not replace the terms and conditions of Flint City Ordinance No. 2208.

p:DAM(a)

Appendix 2 - Excerpt of Flint WWTP NPDES permit

PART I

Section A. Limitations and Monitoring Requirements

1. Final Effluent Limitations, Monitoring Point 001A

During the period beginning on the effective date of this permit and lasting until the expiration date of this permit, the permittee is authorized to discharge treated municipal wastewater from Monitoring Point 001A through Outfall 001. Outfall 001 discharges to the Flint River. Such discharge shall be limited and monitored by the permittee as specified below.

Parameter	Maximum Limits for Quantity or Loading				Maximum Limits for Quality or Concentration				Frequency of Analysis	Sample Type
	Monthly	7-Day	Daily	Units	Monthly	7-Day	Daily	Units		
Flow	(report)	---	(report)	MGD	---	---	---	---	Daily	Report Total Daily Flow
Carbonaceous Biochemical Oxygen Demand (CBOD ₅)										
4/1-4/30	6,672	10,000	---	lbs/day	16	---	24	mg/l	Daily	24-Hr Composite
5/1-10/31	2,920	3,750	---	lbs/day	7	---	9	mg/l	Daily	24-Hr Composite
11/1-11/30	4,590	6,672	---	lbs/day	11	---	16	mg/l	Daily	24-Hr Composite
12/1-3/31	5,420	8,340	---	lbs/day	13	---	20	mg/l	Daily	24-Hr Composite
Total Suspended Solids										
5/1-10/31	8,340	12,500	---	lbs/day	20	30	---	mg/l	Daily	24-Hr Composite
11/1-4/30	12,500	18,800	---	lbs/day	30	45	---	mg/l	Daily	24-Hr Composite
Ammonia Nitrogen (as N)										
4/1-4/30	2,920	4,170	---	lbs/day	7.0	---	10.0	mg/l	Daily	24-Hr Composite
5/1-10/31	667	1,460	---	lbs/day	1.6	---	3.5	mg/l	Daily	24-Hr Composite
11/1-11/30	2,080	2,920	---	lbs/day	5.0	---	7.0	mg/l	Daily	24-Hr Composite
12/1-3/31	2,500	3,128	---	lbs/day	6.0	---	7.5	mg/l	Daily	24-Hr Composite
Total Phosphorus (as P)	417	---	---	lbs/day	1.0	---	---	mg/l	Daily	24-Hr Composite
Fecal Coliform Bacteria	---	---	---	---	200	400	---	cts/100 ml	Daily	Grab
Total Residual Chlorine	---	---	---	---	---	---	0.038	mg/l	Daily	Grab
Total Mercury										
Through 12/31/2008	---	---	---	lbs/day	(report)	---	---	ng/l	Quarterly	Grab
Beginning 1/1/2009	0.0042	---	---	lbs/day	10	---	---	ng/l	Quarterly	Grab
Acute Toxicity										
Through 12/31/2008	---	---	---	---	---	---	(report)	TU _A	Quarterly	24-Hr Composite
Beginning 1/1/2009	---	---	---	---	---	---	1.0	TU _A	Quarterly	24-Hr Composite
Chronic Toxicity										
Through 12/31/2008	---	---	---	---	(report)	---	---	TU _C	Quarterly	24-Hr Composite
Beginning 1/1/2009	---	---	---	---	1.5	---	---	TU _C	Quarterly	24-Hr Composite
					Minimum Daily		Maximum Daily			
pH	---	---	---	---	6.5	---	9.0	S.U.	Daily	Grab

The following design flow was used in determining the above limitations, but is not to be considered a limitation or actual capacity: A rated design capacity of 50 MGD and the 1988 Water Resources Commission directive to use a 95 percent exceedance (Flint River drought) flow of 85 cfs (Holloway Reservoir Management Plan) for limit calculations.

Appendix 3 - Analysis of Adequacy of Flint River as a Water Supply

Technical Memorandum
Analysis of Adequacy of Flint River as Water Supply

1.0 Quantity of Water Required

Recommended Standards for Water Works, 2003 Edition indicates that the quantity of surface water at the source shall:

- Be adequate to meet the maximum projected water demand of the service area as shown by calculations based on a one in fifty year drought or the extreme drought of record, and should include consideration of multiple year droughts. Requirements for flows downstream of the intake shall comply with requirements of the appropriate reviewing authority.
- Provide reasonable surplus for anticipated growth
- Be adequate to compensate for all losses such as silting, evaporation, seepage, etc.
- Be adequate to provide ample water for other legal users of the source.

2.0 Demand Summary

City staff has indicated the future maximum day demand of the city is 18 mgd.

In addition to the water used by customers, some water will be required for water treatment processes and filter backwash. An allowance for WTP Backwash and Process water of 2 mgd is assumed.

Water used for fire-fighting is not included in customer demand or sales. An allowance 0.7mgd for replenishing water used for fire-fighting is assumed.

The maximum day demand represents the quantity of water which must be supplied on the particular day that the highest use (demand) occurs. Treatment and pumping must be designed to deliver the maximum day demand. During peak periods, storage from the Holloway Reservoir can be utilized to supplement the natural river flow. For analysis of the river as a source, the maximum month will be used as the demand.

A review of the city's water demands and precipitation records suggest that maximum month demand is about 80% of the maximum day demand.

The maximum sustained demand to be withdrawn from the river is computed in the following table:

Table 1: City of Flint Design Demand Summary

Future Maximum Day Demand (Customers)		18.0 mgd
Future Maximum Day Demand (WTP Backwash / Process Water)		2.0 mgd
Subtotal (Future Maximum Day Demand)		20.0 mgd
Sustained (30 day) Future Maximum Day Demand	(80% of MDD)	16.0 mgd
Replenish Water from Fire Fighting		0.7 mgd
Future Maximum Day Demand (Source Water)		16.7 mgd

3.0 Additional Demands and Requirements

In addition to the demands from Section 2, the following demands must be accounted for:

3.1 Mutual Aid

The City and GCDC-WWS have a mutual aid agreement to supply each other water in the event of a disruption in supply or other emergency. The agreement provides that the city will supply GCDC-WWS up to 8 mgd.

For this analysis, it is assumed that an emergency will be corrected within 14 days. The volume of water that may be required is therefore: $14 \text{ days} * 8,000,000 \text{ gal/day} = 112,000,000 \text{ gal}$. This volume will be reserved from the reservoir volume.

3.2 Evaporation

Both the Holloway and Mott dams have been constructed since the drought period of the 1930's, which is being used as the base river flow for analysis. Evaporation from the Holloway Reservoir and Mott Lake will reduce the amount of available from the river. The NWS publishes an atlas which shows evaporation rates. Evaporation is primarily a factor during the "growing season"; the atlas shows that about 24" of water is lost via evaporation from open water surfaces in Genesee County over the May through October period. Loss by evaporation will be offset by the addition of rainfall directly upon the water surface. Since the analysis is based upon drought conditions, the low rainfall having a recurrence rate of 100 years will be used. During the May through October period, 11.5 inches of rain is estimated during the 1 in 100 dry year. The net loss by evaporation is therefore 12.5 inches.

The following table summarizes the loss by evaporation, over the six month period from May through October.

Table 2: Reservoir Evaporation Loss

Reservoir	Surface Area (Acres)	Evaporation (inches)	Precipitation (inches)	Net Loss by Evaporation (Gallons)
Holloway Reservoir	1,973	24	11.5	669,646,065
Mott Lake	684	24	11.5	232,153,020
Total				901,799,085

3.3 Siltation

The July 2001 Flint River Assessment completed by the MDNR indicates that sedimentation occurs in the Holloway Reservoir at an accelerated rate, but does not provide quantities. Measurements of the silt accumulation in the reservoir have not been completed. Accumulations of several feet have occurred in other reservoirs. Sedimentation of an average of 1 foot across the Holloway Reservoir will result in the loss of 643,000,000 gallons of storage, or about ten percent of the total volume available.

Mott Lake is not used as a water storage reservoir. Its level is controlled by a fixed weir. Although siltation likely occurs in Mott Lake too, it has no impact on storage for water supply.

3.4 Seepage

Seepage is not believed to have a significant impact on the availability of water at the WTP. Seepage through the embankments of either the Holloway or Mott dams or through the bottom of the reservoirs seems likely to migrate back to the Flint River, although perhaps downstream of the reservoirs, prior to the WTP.

3.5 Flint WWTP

The City's WWTP discharges treated wastewater to the Flint River. The NPDES permit issued to the WWTP has established limits for the treated effluent, based on a drought flow in the river of at least 85 cfs.

3.6 Holloway Reservoir Management Plan

In 1977 the City and Genesee County executed the Holloway Reservoir Management Plan (HRMP) which established parameters for the operation of the dam and reservoir. In 1977, water was no longer withdrawn from the river for water supply and the HRMP appears to have been developed to address four primary issues:

- Availability to utilize the reservoir for water supply as a backup or alternative supply
- Provide for physical maintenance of the dam
- Provide for the recreational use of the reservoir
- Provide flow augmentation to Flint WWTP

The HRMP establishes a summer operating level of 755 and a winter level 751. The summer level maximizes the volume of water available during the dry period in the event that the river is to be used as a water supply. The higher level also supports recreational activities on the reservoir. The 751 winter level provides protection against damage from freezing during the winter. The HRMP establishes a minimum discharge of 65 cfs from the dam, presumably to provide a minimum flow of 85 cfs in the river at the WWTP.

4.0 Analysis

It is assumed that the demands and other requirements identified above are to be maintained in the event that water is withdrawn from the Flint River for water supply. In 1963, USGS published Water Resources Flint Area Michigan, which includes an analysis of the river as a water supply. This publication includes design information regarding the Holloway Reservoir and its operation for water supply.

In 1977 when the HRMP was executed, water was not withdrawn from the river for water supply. If the HRMP required a minimum discharge of 65 cfs at the Holloway Dam to provide for adequate flow in the river at the WWTP, the minimum discharge from the Holloway Dam should be increased by the amount of water withdrawn for water supply if the current river flow at the WWTP is to be maintained.

$$65 \text{ cfs} + 16.7 \text{ mgd (25.8 cfs)} = 90.8 \text{ cfs (58.7 mgd)}$$

Figure 1 shows the sustained discharge which can be maintained from the Holloway Reservoir during a drought period. This graph is based on USGS records of flow in the river between 1930 and 1952. This period includes the drought period of 1930 to 1937, which is USGS considers the most severe drought in Michigan history, having a recurrence period of 1 every 50 to 70 years. This period was prior to the construction of Holloway Dam, so river records reflect the natural flow of the river without impact by dam operations.

Figure 1: Draft-Storage Curve, Flint River near Otisville (excerpt from USGS Water Resources Flint Area Michigan)

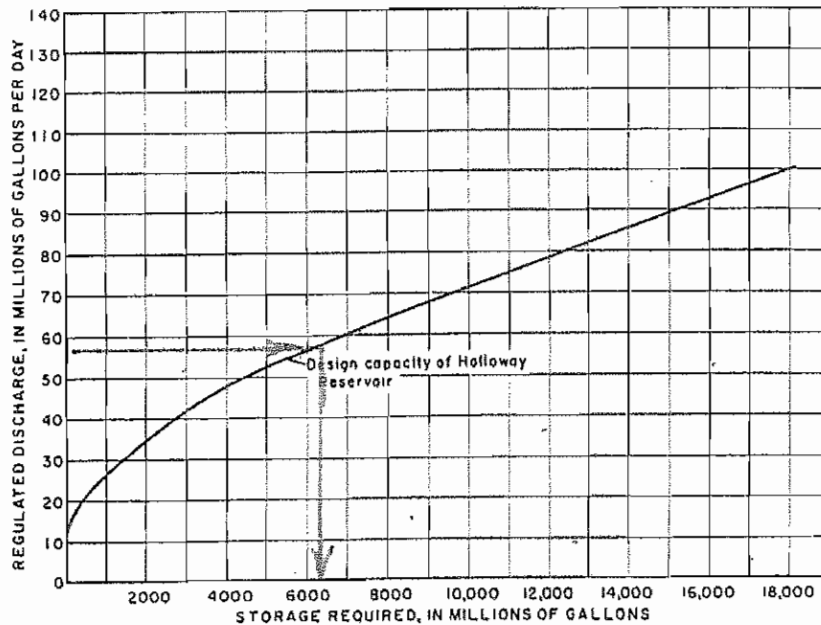


Figure 1 indicates that about 6.2 billion gallons of storage is needed to maintain a sustained discharge of 58.6 mgd from the reservoir to provide the minimum river flow of 85 cfs at the WWTP.

In addition to the 6.2 billion gallons of storage, additional storage is required to provide GCDC-WWS an emergency supply and to make up for reservoir loss by evaporation.

Table 3: Storage Requirements to Maintain Current Conditions plus Water Supply

Storage to meet sustained demand and WWTP flow:	6.20 billion gallons
Storage to provide backup supply to GCDC-WWS:	0.11 billion gallons
Storage to make up loss by evaporation:	0.90 billion gallons
Storage lost by siltation:	0.64 billion gallons (assumed)
Storage to provide loss by seepage:	0.00 billion gallons (assumed)
Storage Needed to Supplement River Flow:	7.85 billion gallons

For this analysis, it is assumed that storage is available from the Holloway Reservoir to supplement the natural river flow.

- The Holloway Reservoir was designed to provide storage for water supply in the 1950's
- The Mott Dam is a fixed weir, so storage is not available. The dam is owned by the Genesee county Parks Department and provides recreational benefit.
- The Hamilton Dam impoundment is limited to the river channel; storage volume is negligible.
- The Utah Dam is inoperable.

- The Kearsley Dam is not directly located on the Flint River, but on the Kearsley Creek just prior to its confluence with the Flint River. The Kearsley Creek discharges to the Flint River downstream of the City's WTP so storage from the river is not available for water supply; however, discharge from the Kearsley dam can be used to supplement downstream river flows, including the flow in the river at the WWTP. The Kearsley Reservoir can provide a maximum of 650 million gallons of storage.
- The Thread Lake Dam is not located on the Flint River, but the Thread Creek discharges into the Swartz Creek which discharges into the Flint River just west of the downtown area. The Thread Lake dam provides a maximum storage volume of 100 million gallons of storage. Discharge from the Thread Lake dam could be used to supplement downstream river flows, but not for water supply.
- For this analysis, storage from neither the Kearsley Reservoir nor Thread Lake is included. Both dams were constructed prior the Holloway Reservoir and discharges from the Kearsley Dam and Thread Lake Dam are assumed to be included in the analysis presented in the USGS publication.

Following is a capacity curve for the Holloway Reservoir, from the USGS Water Resources Flint Area.

Figure 2: Holloway Reservoir Storage Capacity (excerpt from USGS Water Resources Flint Area Michigan)

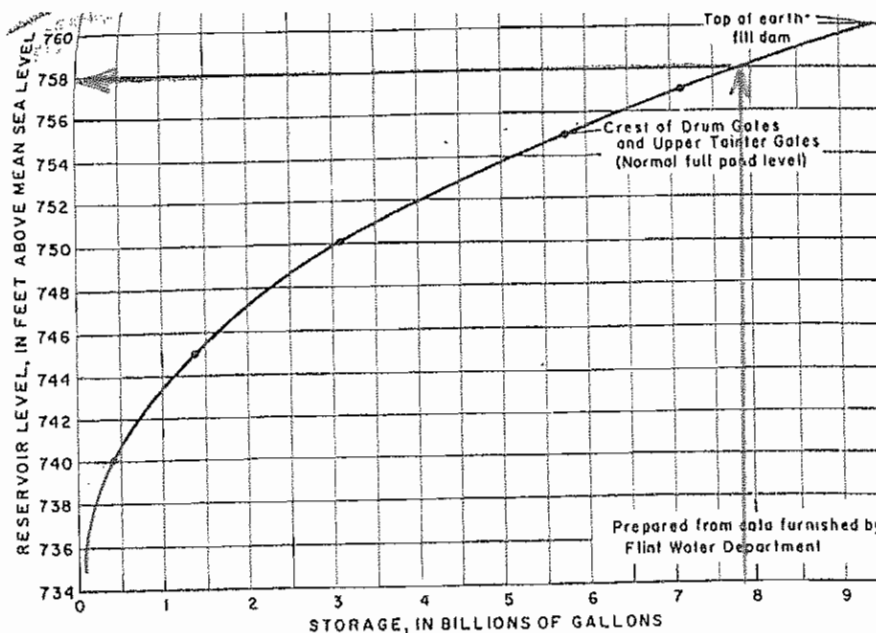


Figure 2 indicates that a Holloway Reservoir level of 758.0 feet provides storage of 7.85 billion gallons.

Review of design drawings of the Holloway Dam indicates that the dam was designed to use drum gates to maintain the normal water level(s) of the reservoir. The drum gates can rotate to allow for reservoir levels ranging from a low level of 751 feet to a high level of 755 feet. If the reservoir is to be maintained

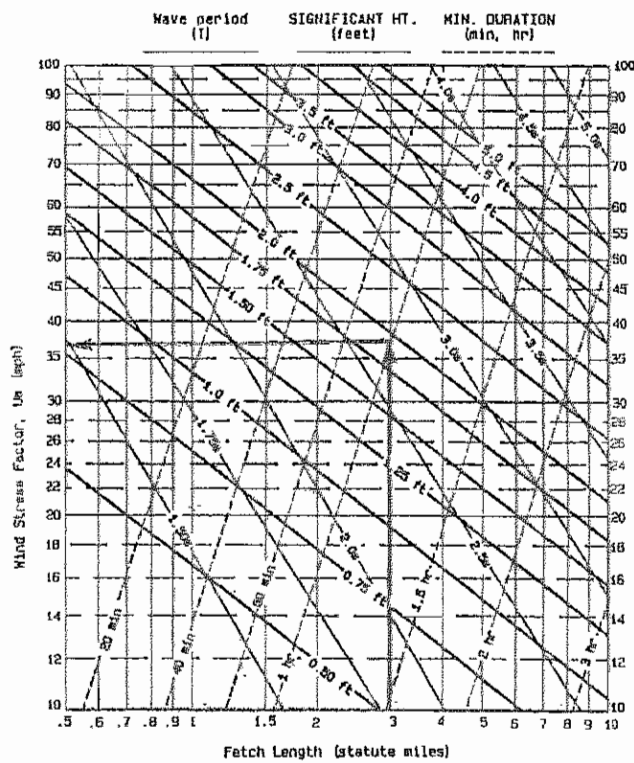
at a higher level than the current summer level of 755 feet, modifications will be required to the drum gates.

According to the original dam design drawings, the dam embankment was constructed to elevation 763 feet (however, the USGS reports shows the top elevation as 760 feet). If the reservoir level is raised to 758 feet, only about five feet of freeboard will be provided to guard against overtopping. There are three concerns regarding increasing the reservoir level from 755 to 758 feet.

The increased hydraulic pressure resulting from the higher water level on one side of the dam will result in increased seepage through the embankment, and a reduction in its integrity.

The reservoir has a fetch of about three miles east from the dam. Figure 3 shows that a 37 mph wind sustained for one hour duration from the east can result in waves capable of two feet. The original design drawings show rip-rap armoring on the reservoir side of the dam embankment to an elevation of 757 feet. Rip-rap armoring should be extended to at least two feet higher than the 758 feet level to protect against wave action.

Figure 3: Predicted Wave Action – Holloway Reservoir



The reservoir is tributary to a large watershed. There have been rapid increases in river flow (and reservoir level) soon after intense rain events in the watershed. A rain storm in June 1996 resulted in a 1.62 foot increase in the water level of the reservoir resulting in the opening of dam gates and discharge of 7,740 cfs. Reducing the freeboard also reduces the volume available for flood management.

5.0 Quantity of Water Supply Available

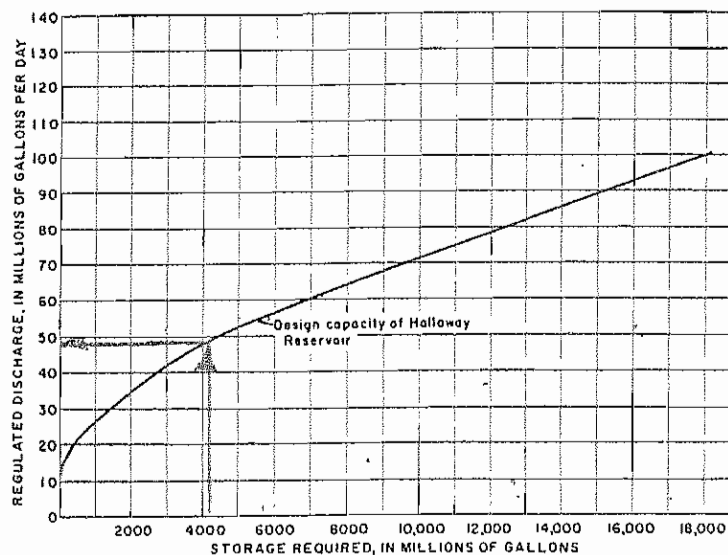
Analysis has shown that without modifications to facilities and/or permits and agreements, the river cannot supply the future maximum demand of the city.

Table 4: Storage Available for Water Supply

Original Storage Volume of Holloway Reservoir (elevation 755')	5.76 billion gallons
Storage lost by Sedimentation (assumed)	0.64 billion gallons
Storage to make up for Evaporation	0.9 billion gallons
Storage to provide backup supply for GCDC-WWS	0.11 billion gallons
Storage available to supplement river flow	4.11 billion gallons

The following figure shows that 4.11 billion gallons of storage can sustain a supplemental flow of 48 mgd.

Figure 4 – Sustained Discharge Available from Holloway Reservoir



A minimum discharge of 48 cfs from the Holloway Reservoir can support a sustained water withdrawal of about 11 mgd and maintain 85 cfs at the WWTP, as shown in the following table.

Table 5 – Maximum Sustained WTP Withdrawal Available

	1978 - Holloway Reservoir Management Plan	Future
Minimum Reservoir Discharge	65 cfs	48 cfs
River Inflow	20 cfs	20 cfs
WTP Withdrawal	0 cfs	17 cfs (10.99 Mgd)
River Flow at WWTP	85 cfs	85 cfs

A sustained water withdrawal of 11 mgd will support a maximum day demand of 11.6 mgd, as shown in the following table.

Table 6 – Available WTP Maximum Day Demand

Sustained Withdrawal Available		11.0 mgd
Water to replenish fire fighting		0.7 mgd
Sustained (30 day) Future Maximum Day Demand Available		10.3 mgd
Future Maximum Day Demand Available	(Multiply by 125%)	12.9 mgd
Water available for WTP Backwash/Process		1.3 mgd
Water available for customer Max Day Demand		11.6 mgd

Appendix 4 - Holloway Dam Drawings

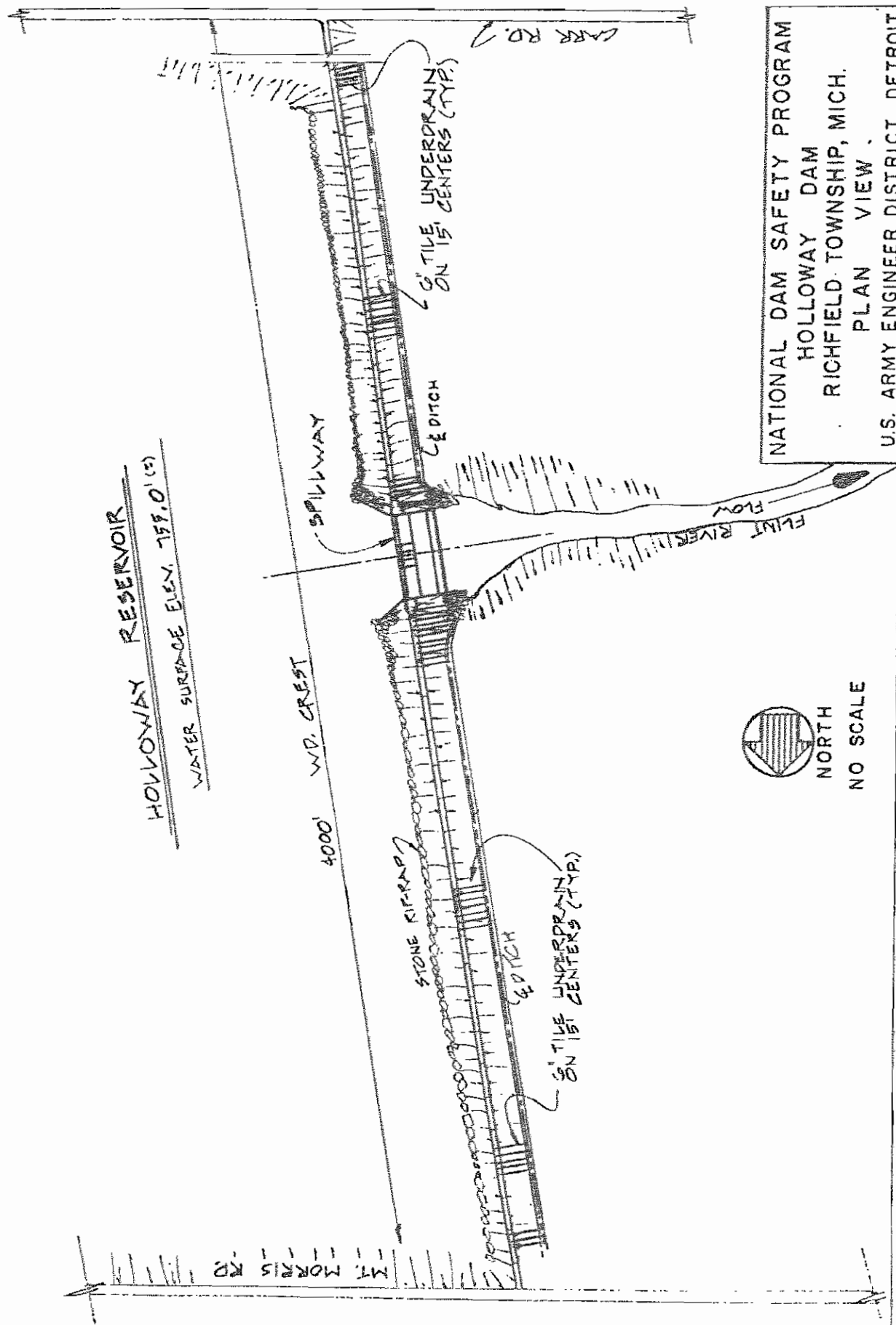


FIGURE No. 5

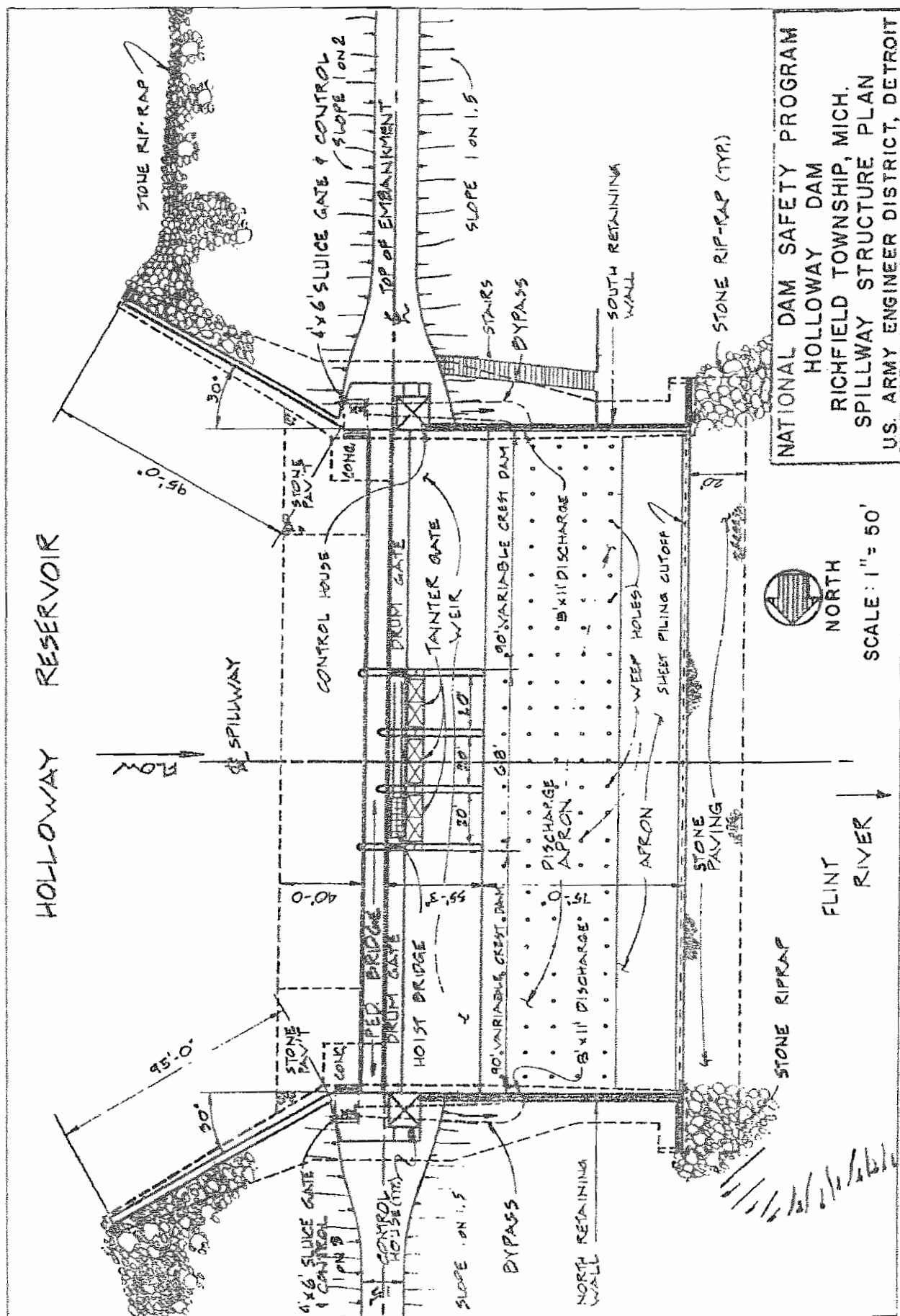


FIGURE No. 6

PEDESTRIAN BRIDGE
EL. 766.92 @ E. OF DAM
EL. 764.4 @ ENDS

HOIST BRIDGE

EL. 766.92

LIFT
CHAIN

TANTER GATE
20' WIDE

EL. 750.0

EL. 751.0

EL. 745.0

PIERS #1 & 4

PIERS #2 & 3

EL. 725.0

STEEL SH. PILING
CUT OFF -
25' LONG.

50'-0"

EL. 720.0

STEEL SH. PILING
CUT OFF -
25' LONG

WEEP HOLES

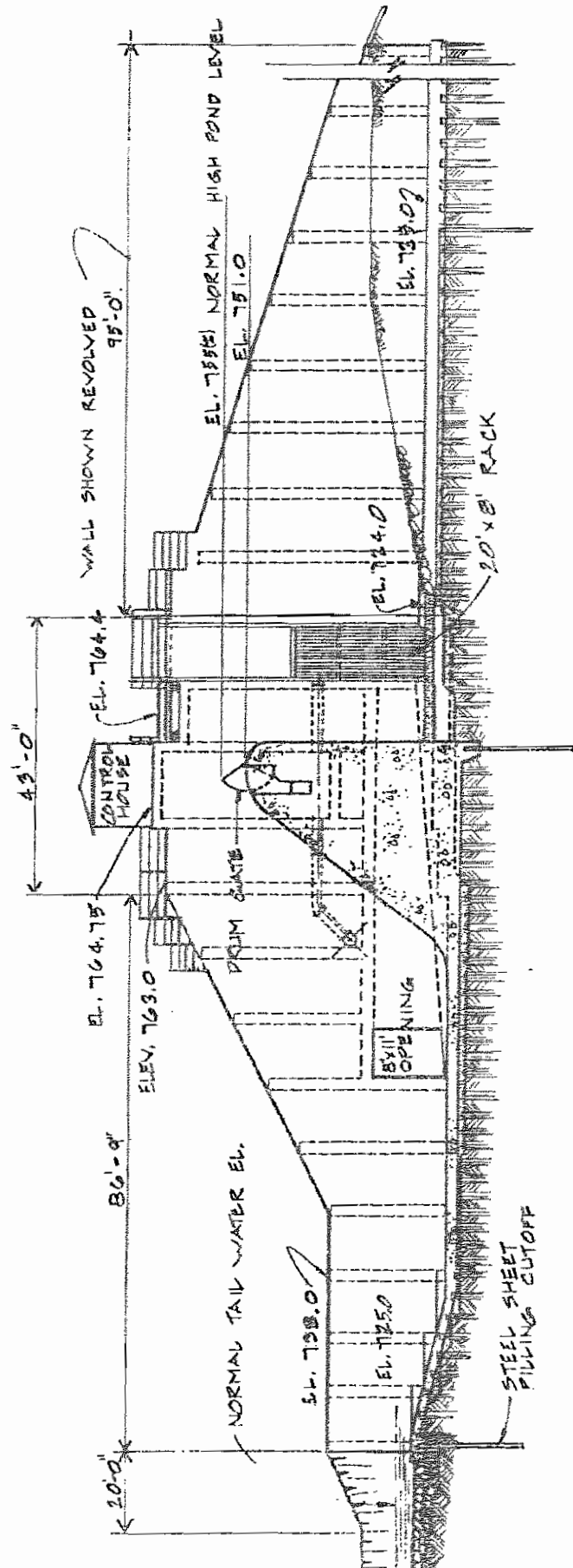
WOOD FOUNDATION PILING
UNDER ENTIRE DAM.

NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
SPILLWAY & TANTER GATE PROFILE
U.S. ARMY ENGINEER DISTRICT, DETROIT

SPILLWAY & TANTER GATE PROFILE

SCALE: 1/4" = 1'-0"

FIGURE No.7



SPILLWAY AND DRUM GATE PROFILE

NO SCALE

NATIONAL DAM SAFETY PROGRAM
 HOLLOWAY DAM
 RICHFIELD TOWNSHIP, MICH.
 SPILLWAY & DRUM GATE PROFILE
 U.S. ARMY ENGINEER DISTRICT, DETROIT

FIGURE No. 8

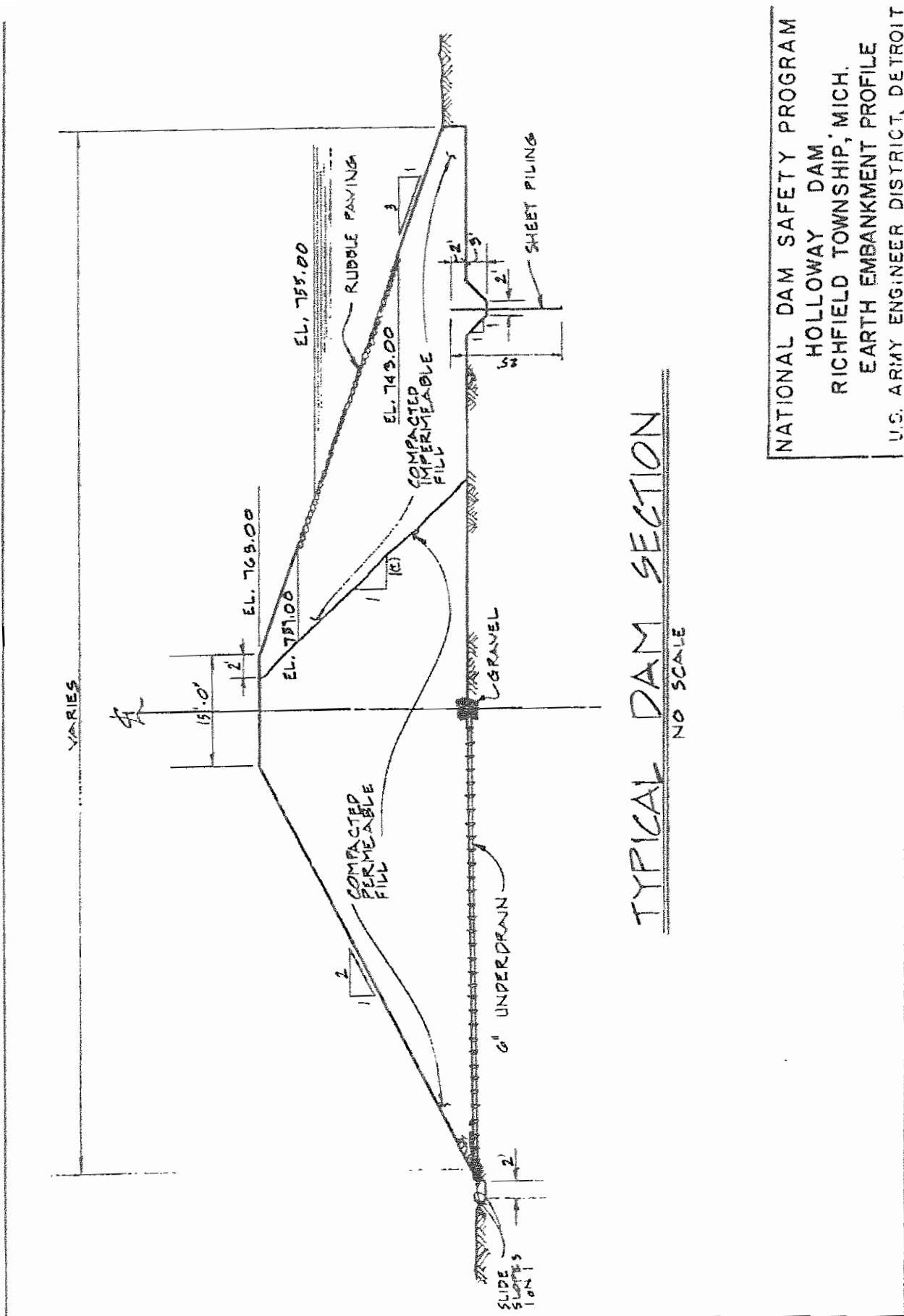
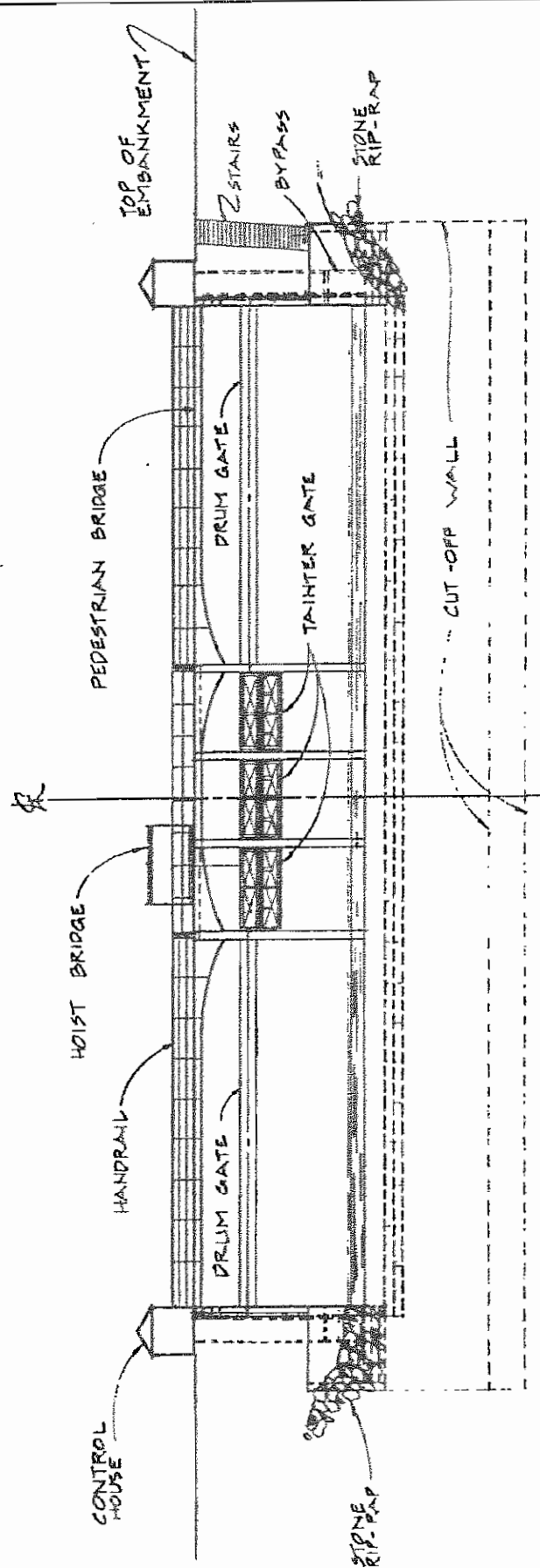


FIGURE No.9

NATIONAL DAM SAFETY PROGRAM
 HOLLOWAY DAM
 RICHFIELD TOWNSHIP, MICH.
 EARTH EMBANKMENT PROFILE
 U.S. ARMY ENGINEER DISTRICT, DETROIT

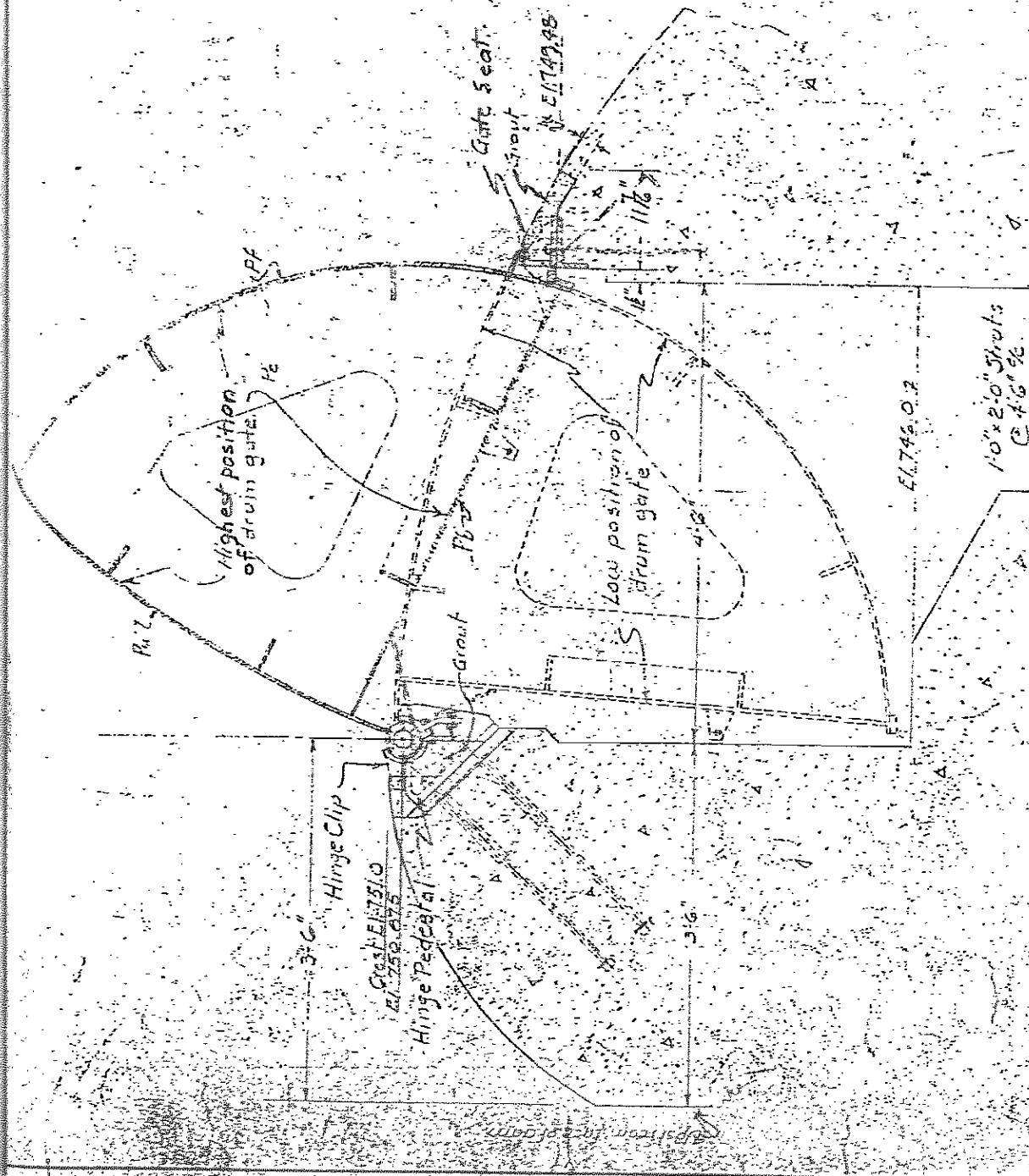


SPILLWAY ELEVATION VIEW

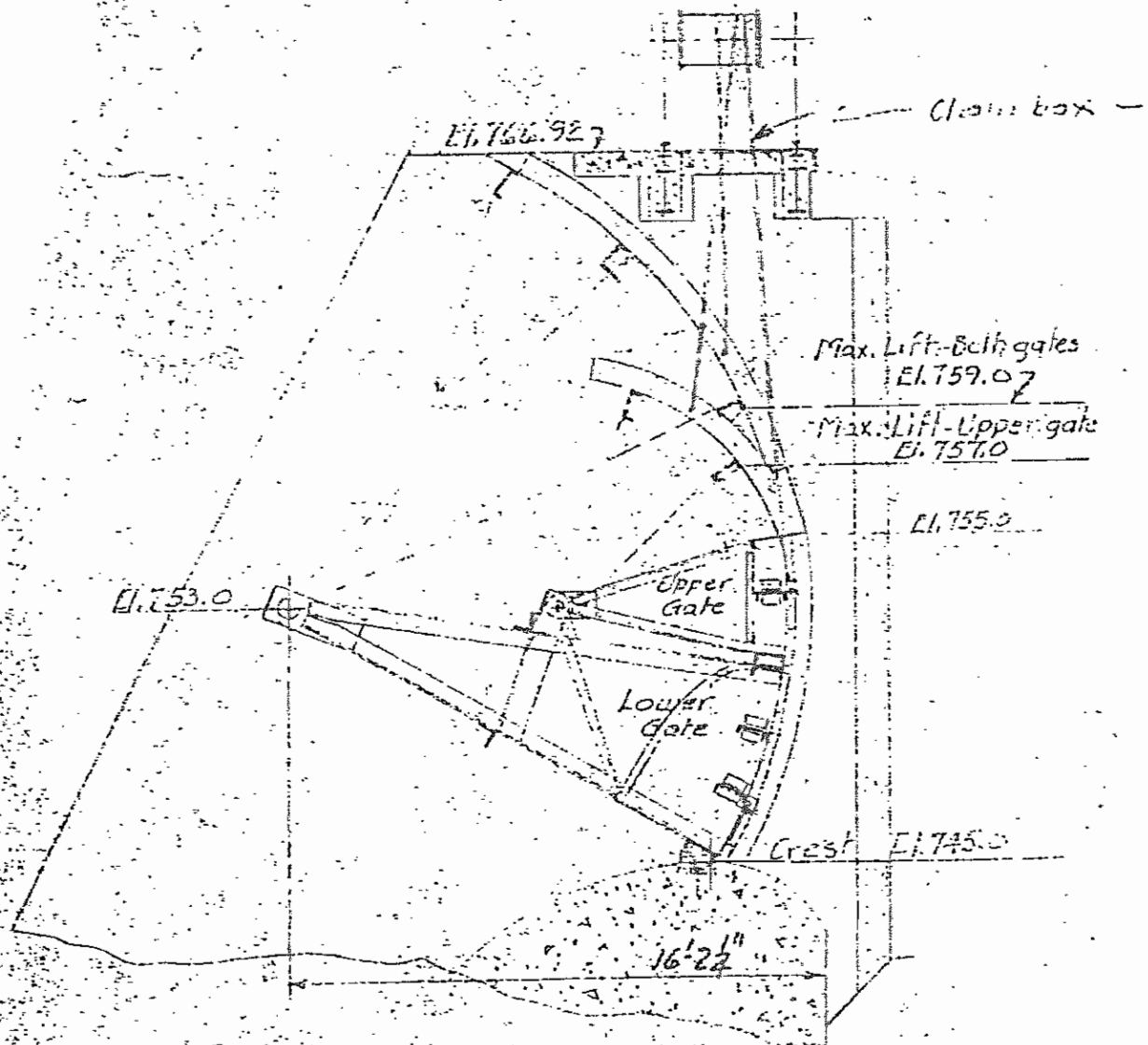
SCALE: 1" = 40'

NATIONAL DAM SAFETY PROGRAM
 HOLLOWAY DAM
 RICHFIELD TOWNSHIP, MICH.
 SPILLWAY ELEVATION VIEW
 U.S. ARMY ENGINEER DISTRICT, DETROIT

FIGURE No. 10



DRUM GATE SECTION



SECTIONAL ELEVATION
OF TAINTER GATE.

Appendix 5 - 2008 Holloway Dam Safety Report

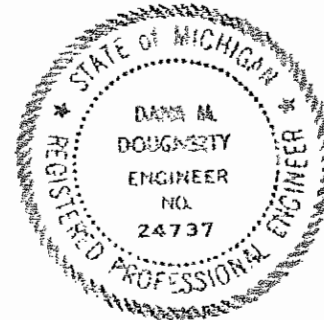
MICHIGAN PUBLIC ACT 451, PART 315
INSPECTION REPORT
HOLLOWAY DAM
GENESEE COUNTY, MICHIGAN
INVENTORY NUMBER 064 – HIGH HAZARD

FOR

CITY OF FLINT
WATER TREATMENT PLANT
4500 N. DORT HIGHWAY
FLINT, MICHIGAN 48505
ATTN: MR BRENT WRIGHT
(810) 787-6537

BY

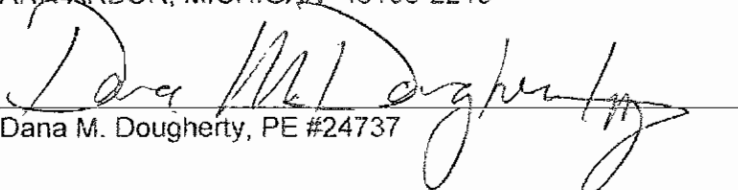
Stantec Consulting Michigan Inc.
Engineers – Planners – Surveyors
3959 Research Park Drive
Ann Arbor, Michigan 48108-2219
(734) 761-1010



INSPECTOR(S): Dana M. Dougherty – Stantec Consulting Michigan Inc.

DATE OF INSPECTION: October 19, 2008

PROFESSIONAL ENGINEER: Dana M. Dougherty, PE
STANTEC CONSULTING MICHIGAN INC.
3959 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48108-2219


Dana M. Dougherty, PE #24737

HOLLOWAY DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

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HOLLOWAY DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

1.0 Purpose and Authority

The purpose of the report is to present a summary of findings for the field inspection of the Holloway Dam completed by Stantec Consulting Michigan Inc. (Stantec) on October 19, 2008 pursuant to the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, Section 31518.

This dam inspection Report and associated inspection activities were commissioned by the City of Flint, Michigan, the dam owner. The Holloway Dam is registered with the Michigan Department of Environmental Quality (MDEQ) as Dam Number 064.

References in the report to "left" and "right" are based on the observer facing downstream.

2.0 Conclusions and Recommendations

The Holloway Dam was inspected on October 19, 2008 in accordance with Michigan P.A. 451, Part 315 criteria. The dam, including spillway and embankments was found to be in good condition. A summary of comments/recommendations is as follows:

1. The City of Flint should continue their operation and maintenance procedures as outlined in the "Holloway Reservoir Operation and Maintenance Plan".
2. The Emergency Action Plan should be exercised annually and Notification List concurrently updated.
3. Small brush should be removed from the left and right embankments.
4. Minor spalls and cracks in the spillway concrete should be monitored. These do not require immediate correction, but should be planned and budgeted in the City's long term Capital Improvement Plan (CIP).
5. The seepage monitoring weirs should be placed back into operation by repairing the eroded channel. Periodic observations of seepage rates and observed fines deposition should be performed and logged for long term data comparison.
6. Warning signs on the concrete abutments should be re-painted.
7. The security fence in the downstream right embankment should be repaired.
8. Monitor the sloughed area in the downstream right embankment and repair as needed.
9. Further inspections should be performed in accordance with P.A. 451, Part 315 regulations.

HOLLOWAY DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

3.0 Project Information

The Holloway Dam is located on the Flint River in Richfield Township, Genesee County, Michigan (Section 11, T8N, R5E). The dam and lower one fourth of the reservoir are in Genesee County while the upper three fourths of the reservoir are in Lapeer County. The dam was built in 1954 to maintain a base flow in the Flint River for water supply and sewage dilution requirements. The Holloway Dam was previously referred to as the Richfield Storage Dam. Presently the reservoir's uses are primarily, base water flow implementation, sewage dilution and recreation. The dam consists of earth embankments and a 248 ft long gated concrete spillway structure. The total length of the dam is approximately 3,350 ft between the natural moraine banks. The top of the embankment serves as a gravel road for maintenance purposes. A steel framed walkway spans the top of the spillway structure for operation and maintenance of the gates. The embankment side slopes are 3 horizontal to 1 vertical on the upstream face and 2 horizontal to 1 vertical on the downstream face.

3.1 PERTINENT DATA

The embankment is comprised of two zones: an upstream section and key trench of compacted impervious clay; and a larger downstream section of essentially granular material, predominantly sand with some gravel.

The plans show a sheet pile cutoff wall along the full length of the dam near the upstream toe, extending 23 ft below the base of the embankment and two feet into the embankment. A subdrain system, originating just downstream of the centerline of the crest and transverse to the dam axis, is also shown. The plans indicate that this subdrain system is formed by tile drain pipes with a center-to-center drain spacing of 15 ft. Plan details indicate a graded filter surrounding the tile drain pipes. The pipes empty into a collection ditch at the toe of the downstream slope. The right embankment has been modified by installation of fill at the toe with a bench located mid point on the slope. Weep drains were extended with 6" PVC pipe.

The outlet works of the dam consist of a reinforced concrete spillway controlled by seven gates. There is a control house on each end of the spillway. A telemark water level recording gage is in the left control house.

The following is a tabulation of principal data obtained from the construction drawings.

Hazard Classification – High (per 1978 USACE report).

Length of Dam – Overall length of the dam including the concrete spillway structure and the right and left embankments is approximately 3,350 ft.

Height of Dam – The total height of the dam, defined in P.A. 451, Part 315 as the difference in elevation between the natural stream bed and the design flood elevation, is approximately 30 ft. the crest of the dam is at El. 763.0 ft.

Crest Width of Embankments – Approximately 15 ft.

Side Slopes – The earth embankments have 3.0 H to 1.0 V slopes on the upstream face and 2.0 H to 1.0 V slopes on the downstream face. The right embankment downstream slope has been modified with fill at the toe and a bench at midpoint.

Spillway: 248 ft long concrete spillway structure with:

- a) two 90 ft long drum gates
- b) three 20 ft long taintor gates
- c) two 4 ft by 6 ft sluice gates perpendicular to the dam axis
- d) 75 ft by 248 ft wide discharge apron

Cutoff: 25 ft deep steel sheet pile cutoff wall at the upstream toe of the full length of the dam, and 15 ft deep steel sheet pile cutoff wall along the downstream side of the spillway structure.

Embankments: Upstream section and key trench of compacted impervious clay and a larger downstream section of granular material, predominantly sand with some gravel.

Further details of the spillway structure and embankments are shown in **Appendix A**. These figures have been taken from the 1978 Phase I Inspection Report.

4.0 Field Inspection

An inspection of the facilities was performed by Dana M. Dougherty, PE (Stantec) on October 19, 2008. The weather on the date of inspection was clear with temperature at approximately 55°F. The impoundment elevation was near normal (summer) i.e. 755. Flow was passing over the drum gates as well as through the left (looking downstream) sluiceway.

The following items were noted: (Referenced photographs can be found in Appendix C.)

4.1 SPILLWAY

Overall the spillway appeared to be in excellent condition. Recent preventative maintenance work includes painting of miscellaneous metals including handrails, gates, and support beams, installation of new galvanized steel grating on the gate operator platform and patching concrete at the upper downstream end of the taintor gate piers.

Some minor items were noted with regard to concrete condition including:

1. There was spalled concrete on the top of the upstream right wingwall. The face of the wall exhibited cracking and efflorescence at this location (Ref. Photos #3 and #4).
2. There was a small crack in the right abutment immediately above the drum gate. There is no evidence of movement or displacement at this crack (Ref. Photo #6). This should be monitored.
3. Minor alligator cracking was noted in the taintor gate piers (Ref. Photos #7 and #8). These do not pose any immediate concern but should be monitored.
4. There were cracks in the left abutment and left downstream retaining walls. No displacement was noted. These cracks should be monitored for future movement (Ref. Photos #9 and #10).
5. The upper portion of the downstream end of the left downstream retaining wall has alligator cracking and efflorescence. This should be monitored (Ref. Photo #12).
6. The warning signs that are painted on the upstream abutment/wingwall faces are faded and difficult to read. These should be repainted.

4.2 RIGHT EMBANKMENT

Overall the condition of the right embankment appears to be good with no significant erosion, seepage, settlement, sloughing or animal burrows noted. The following specific items were noted:

1. There was a minor amount of erosion beneath the riprap on the upstream embankment face immediately adjacent to the spillway.
2. Some brush has begun to grow on the upstream slope. This should be selectively removed (Ref Photos #14 and #16). Small natural growth such as wildflowers and grasses should remain.
3. Considerable brush was observed on the downstream embankment face and within the toe-of-slope drain. This should be removed (Ref. Photos #17 and #20).
4. For the most part weep tiles are dry. There is one section midway in the embankment where the weep tiles are active. Some sloughing of the slope was observed in this area. It appeared that this has been addressed through addition of a blanket drain with geotextile fabric. This should be monitored for further displacement.
5. A short section of the security fence was in disrepair. This should be corrected (Ref. Photo #23).
6. The seepage monitoring weir is not functioning. Flow was passing around the weir through an eroded section. This should be corrected (Ref. Photo #24).

4.3 LEFT EMBANKMENT

The observed condition of the left embankment was good to excellent. There was no evidence of significant erosion, seepage, settlement, sloughing or animal burrows. The following specific items were noted:

1. A minor amount of small brush should be removed from the downstream slope (Ref. Photo #28).
2. There was no evidence of seepage from the weep drains, however the toe-of-slope drain was flowing, in particular the final 100 ft (Ref. Photo #29).
3. The seepage monitoring weir is not functioning similar to the right side. Flow was passing around the weir through an eroded section. This should be corrected (Ref. Photo #30).

HOLLOWAY DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

5.0 Structural Stability

The assessment of stability is based on visual observations made during our field inspection (10/19/08).

No deficiencies were noted that would impact the structural integrity of the dam; however minor items were noted that should be proactively addressed to mitigate potential future deficiencies. Over all the condition of the facility remains good.

6.0 Hydrology and Hydraulics

The MDEQ has estimated the required spillway capacity at the Holloway Dam to be 9900 cfs (reference **Appendix B**). This equates to the 200 year frequency flood which is mandated by statute – P.A. 451, Part 315, Section 324.31516.

Headwater rating curves previously produced by the USACE (1978) and Acres International (1993) indicate that this discharge capacity can be met at an impoundment elevation of approximately 755. This would allow for approximately 8 feet of freeboard. Thus, the spillway discharge capacity is sufficient to meet P.A. 451, Part 315 requirements. Furthermore, the spillway capacity at overtopping (El. 763) is approximately 40,000 cfs or $\frac{1}{2}$ PMF.

The spillway capacity has also been determined with the assumption that the drum gates fail to operate and are locked in the up position (reference Ayres, Lewis, Norris & May, Inc. (ALNM) Report – 1996). The resultant 200 year impoundment elevation is computed to be approximately 761 or two feet of freeboard. Therefore, the required spillway design capacity can be met through operation of the taintor gates only.

HOLLOWAY DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

7.0 Operation and Maintenance

The dam is operated and maintained by staff from the City of Flint Water Treatment Plant. Routine operation and maintenance is performed in accordance with the Holloway Reservoir Operation and Maintenance Plan which is on file at the City of Flint WTP.

Impoundment elevation is continuously monitored via an on-site level transducer. Instantaneous level information is available remotely to assist operations personnel in maintenance of the impoundment elevation.

During summer months, the drum gates are in a raised position and taintor gates closed. The impoundment elevation is maintained between 755.0 and 755.75 by operating the drum and/or taintor gates as needed.

The impoundment elevation is lowered in the winter to approximately elevation 751.0. The drum gates are lowered during this period.

Emergency backup power is available to operate the taintor gates in case of a power loss. An Auxiliary Generator Power System Report is available at the WTP.

The City has performed routine maintenance of the facilities on an "as needed" basis. The most recent work consisted of painting exposed steel components including the taintor gates and access platform support steel.

In addition to routine surveillance by operations staff, supervisor staff also performs an annual inspection of the facilities. Noted deficiencies are scheduled for correction the following year.

Appendix 6 - 2008 Utah Dam Safety Report

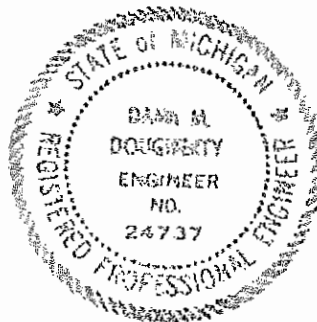
MICHIGAN PUBLIC ACT 451, PART 315
INSPECTION REPORT
UTAH DAM
GENESEE COUNTY, MICHIGAN
INVENTORY NUMBER 1275 - LOW HAZARD

FOR

CITY OF FLINT
WATER TREATMENT PLANT
4500 N. DORT HIGHWAY
FLINT, MICHIGAN 48505
ATTN: MR BRENT WRIGHT
(810) 787-6537

BY

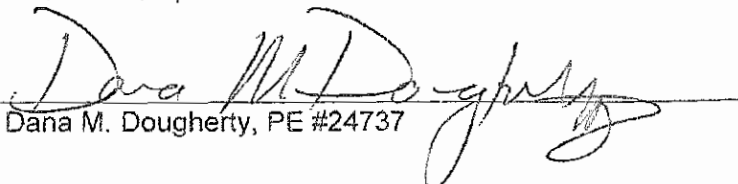
Stantec Consulting Michigan Inc.
Engineers - Planners - Surveyors
3959 Research Park Drive
Ann Arbor, Michigan 48108-2219
(734) 761-1010



INSPECTOR(S): Dana M. Dougherty - Stantec Consulting Michigan Inc.

DATE OF INSPECTION: October 19, 2008

PROFESSIONAL ENGINEER: Dana M. Dougherty, PE
STANTEC CONSULTING MICHIGAN INC.
3959 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48108-2219


Dana M. Dougherty, PE #24737

Stantec
INSPECTION REPORT
UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

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UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

1.0 Purpose and Authority

The purpose of the report is to present a summary of findings for the field inspection of the Utah Dam completed by Stantec Consulting Michigan Inc. (Stantec) on October 19, 2008 pursuant to the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, Section 31518.

This dam inspection Report and associated inspection activities were commissioned by the City of Flint, Michigan, the dam owner. The Utah Dam is registered with the Michigan Department of Environmental Quality (MDEQ) as Dam Number 11275.

References in the report to "left" and "right" are based on the observer facing downstream.

UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

2.0 Conclusions and Recommendations

The Utah Dam was inspected on October 19, 2008 in accordance with Michigan P.A. 451, Part 315 criteria. The dam was found to be in fair to poor condition. A summary of comments/recommendations is as follows:

1. The stability of the exposed portion of the structure is poor and is no longer capable of serving its intended purpose.
2. The operating components of the facility (floodgates) have been decommissioned for sometime and are no longer functional.
3. The purpose of the dam (impound water for the upstream water treatment plant) is no longer needed as the Hamilton Dam, which is located downstream, provides this capability.
4. The Hamilton Dam is currently being evaluated for potential reconstruction and should the decision be made to proceed with that project the Utah Dam will serve no useful future function.
5. The spillway hydraulic capacity is deficient with regard to P.A. 451, Part 315, Section 324.31516 rules. This is further exacerbated by the fact that the partially open gates impede high flows resulting in an increased backwater.
6. The City should consider full or partial removal of the dam. It is possible that the foundation and submerged portion of the piers may be reused to support a new pedestrian crossing bridge. The minimum removal effort would consist of removing the gates from the dam. Due to the aforementioned deficiencies and related public safety liabilities the City should take immediate action perhaps concurrent with the proposed Hamilton Dam reconstruction.

**UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN**

3.0 Project Information

Utah Dam is located on the Flint River in the City of Flint, Genesee County, Michigan (T08N, R07E, Section 32) at the south end of Whaley Park. The site location map is shown in **Appendix A**.

Utah Dam is owned by the City of Flint and plans for the dam are on file with the City. It was designed by the Ambursen Dam Company of New York and San Francisco and built around 1928. The dam was constructed to maintain a reservoir at El. 711 to provide sufficient head on the City's water treatment plant intake pipe. The pool created by the dam was limited to the main channel of the Flint River. The dam was built between the two banks of the river and has a total length of 240 ft. It consists of a concrete gravity structure with six spillway bays and 4 ft wide piers. Each bay has a 12 ft high by 25 ft long vertical lift gate.

There are two bridge decks on the structure. The upper deck is approximately 11 ft wide and it is used to move the gate hoist along the length of the dam. The gate hoist travels the length of the dam on two No. 40 rails, each of which is supported by 15 inch "I" beams. The beams are supported by the piers.

The lower bridge deck is separated by the vertical lift gates. The downstream side of the deck is 7 ft wide and it serves as a pedestrian walkway. The upstream side of the deck is 5 ft wide and it is used by the operator to gain access to the upper deck via a steel ladder.

Presently, the dam serves as a walkway over the Flint River and as a backup for Hamilton dam for providing a head on the water intake pipe. The gates of Utah Dam are currently locked open above the normal backwater elevation created by Hamilton Dam, which is 2.2 miles downstream. Elevations given in this report are referenced to National Geodetic Vertical Datum.

Six spillway bays and vertical lift gates are contained within the structure. Pertinent data about Utah Dam is give below.

Height of Dam – The total height of the dam, defined in P.A. 451, Part 315 as the difference in elevation between the natural stream bed (El. 696.8 ft) and the design flood elevation (El. 717.2 ft) is approximately 20.4 ft.

Crest Width of Structure – 30 ft as measured along the lower deck.

Sill of Vertical Lift Gates – El. 697.3 ft.

Sketches of the dam are included in **Appendix A**.

UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

4.0 Field Inspection

An inspection of the facilities was performed by Dana M. Dougherty, P.E. (Stantec) on October 19, 2008. The weather on the date of inspection was clear with temperature at approximately 55°F. The impoundment elevation was approximately 1.9 ft below normal elevation. The City was in the process of lowering the Hamilton Dam impoundment per directive from the MDEQ. This directive requires that the Hamilton Dam impoundment be lowered 3.25 ft.

The following items were noted (Reference photographs can be found in **Appendix C**):

1. The concrete condition on the downstream face of the dam is fair to poor. The right downstream retaining wall shows significant spalling in its top and outside corner. The left downstream retaining wall has significant spalling and cracking. The pier noses (three of five) are spalled. The access platform or walkway on the dam, concrete is in fair to poor condition. There is effervescence and cracking in the access platform support beams. There is no displacement. (Ref. Photos #1 and #5.)
2. The concrete condition of the upstream dam face is fair to poor. The noses of all piers show effervescence and some alligator cracking. This is also true for the right and left upstream retaining walls. There does not appear to be any substantial structural cracking in any of these members or displacement. There is spalling of concrete at the top of the piers as well as at the top of the abutment walls where the access platform rests. There is also some indication of spalling in the access platform beams and in some cases at the bottom of the beams themselves (Ref. Photos #2 and #6).
3. The gates are randomly open. The left gate, Bay No. 1, is 2 feet above the water level on this date. Bay No. 2 and No. 3 from the left, are 4 feet above water level on this date and Bay No. 4, 5, and 6 are 6.5 feet above water level. All dimensions reference water level to the bottom of the gate.
4. The superstructure appears to be in very poor condition. Concrete is in fair to poor condition. The operating platform, which housed a single moveable gantry crane for all six gates, has spalling in the beams as well as the piers. Protective railings are all intact, but in poor condition and require painting (Ref. Photos #7 and #8).
5. The top of the right embankment has a paved walkway with chain link fence on either side of the walkway. This is also true for the left embankment. There is also lighting at the site, utility poles in each embankment with a light fixture (Ref. Photos #3 and #4).
6. The embankments have some tree growth which should be removed.

UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN
Field Inspection
December 2008

7. On the date of the inspection, the water level is about 10.6 feet below the operating/walkway platform (El. 706.6 NGVD).
8. There is a 4 foot wide opening in the fence on the left downstream face of the dam, next to the utility pole, which allows access and is a safety issue. Also, the safety fencing that was installed on the upstream side of the dam, between the walkway and the gates, has been removed and is a safety issue.

5.0 Structural Stability

The assessment of stability is based on visual observations made during our field inspection (10/10/08).

The overall structural condition of the Utah Dam is categorized to be fair to poor. Substantial deteriorated concrete is evident with numerous spalls, cracks, and some exposed reinforcing steel. The superstructure concrete is in the poorest condition with the gate lift support structure no longer capable of supporting its intended function i.e. gate operation.

The condition of the access platforms and exposed portions of the piers is somewhat better than the superstructure but still would be categorized as poor. The submerged portion of the piers and foundation were not inspected as part of this report, however experience with similar structures would imply that their condition would be better than the exposed components.

In conclusion, the Utah Dam structural stability will no longer support gate operation. Furthermore, continued use of the access platforms for pedestrian crossing will be dependent on future evaluation, repair and/or modification of those components.

6.0 Hydrology and Hydraulics

The MDEQ has established the required spillway capacity at the Utah Dam to be 11,800 cfs (reference **Appendix B**). This equates to the 100 year frequency flood which is mandated by statute, P.A. 451, Part 315, Section 324.31516, for dams classified as low hazard such as the Utah Dam.

The hydraulic capacity of the Utah Dam is greatly impacted by the downstream Hamilton Dam. The normal impoundment elevation of the Hamilton Dam impoundment is approximately El. 708.0 (NGVD) while the gate sill elevation of the Utah Dam is 697.3. Thus, the Utah Dam is partially submerged under normal conditions.

Overtopping of the right embankment occurs at or near El. 714.0. The 1993 Acres Report (**Appendix B**) indicates that overtopping of this embankment will be experienced at flows over 7,830 cfs. The FEMA Flood Insurance Study (**Appendix B**) shows the 100 year flood elevation at the Utah Dam to be approximately El. 716.0. Thus the right embankment is overtopped under high flow conditions due to backwater impacts from the Hamilton Dam. It should be noted that the FEMA Flood Insurance Study assumes that all six gates are operable at Hamilton Dam. Since 1991 only three gates have been operable thus the backwater impact would be greater than shown on the FEMA maps.

The Utah Dam's hydraulic capacity is further diminished by the fact that the floodgates are currently locked in a partially open position. The bottom of gate elevation for each bay (numbered left to right locking downstream) is approximately:

Bay No. 1	708.5
Bays No. 2 and 3	710.5
Bays No. 4 through 6	713.0

Under high flows (100 year El. 716.0) the gates will impede flow thereby further exacerbating flood conditions.

For the above described reasons, it is concluded that the Utah Dam does not meet spillway capacity requirements as required by statute.

UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

7.0 Operation and Maintenance

The Utah Dam is operated and maintained by staff from the City of Flint Water Treatment Plant. The floodgates are currently non-functional and are locked in a partially open position. Power has been disconnected from the gate operators. The impoundment elevation is maintained by the downstream Hamilton Dam thereby negating the usefulness of the Utah Dam.

The City staff therefore maintains a minimal surveillance effort at the dam. Minimal preventative maintenance has been performed in the recent past. It is the City's intent to remove all or a portion of the structure as funds become available. Until that time maintenance will be limited to those items necessary to insure public safety with regard to the pedestrian bridge crossing.

Appendix 7 - 2008 Hamilton Dam Safety Report

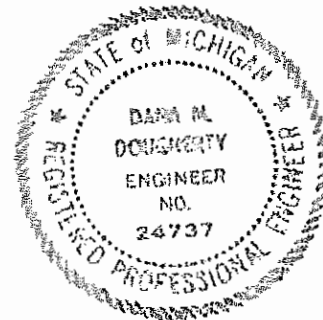
MICHIGAN PUBLIC ACT 451, PART 315
INSPECTION REPORT
HAMILTON DAM
GENESEE COUNTY, MICHIGAN
INVENTORY NUMBER 060 – HIGH HAZARD

FOR

CITY OF FLINT
WATER TREATMENT PLANT
4500 N. DORT HIGHWAY
FLINT, MICHIGAN 48505
ATTN: MR BRENT WRIGHT
(810) 787-6537

BY

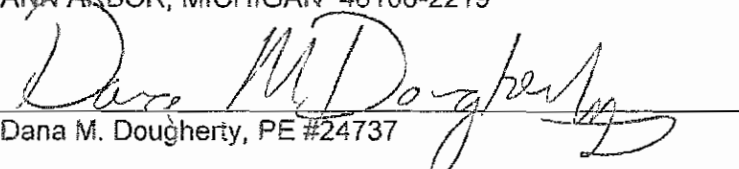
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INSPECTOR(S): Dana M. Dougherty – Stantec Consulting Michigan Inc.

DATE OF INSPECTION: October 19, 2008

PROFESSIONAL ENGINEER: Dana M. Dougherty, PE
STANTEC CONSULTING MICHIGAN INC.
3959 RESEARCH PARK DRIVE
ANN-ARBOR, MICHIGAN 48108-2219


Dana M. Dougherty, PE #24737

Stantec
INSPECTION REPORT
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Stantec
INSPECTION REPORT
HAMILTON DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

1.0 PURPOSE AND AUTHORITY

The purpose of this report is to present a summary of findings for the field inspection of the Hamilton Dam completed by Stantec Consulting Michigan Inc. on October 19, 2008 pursuant to the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, Section 31518.

This Dam Inspection Report and associated inspection activities were commissioned by the City of Flint, the dam owner. The Hamilton Dam is registered with the Michigan Department of Environmental Quality (MDEQ) as Dam Number 060.

References in this report to "left" and "right" are based on the observer facing downstream.

Stantec
INSPECTION REPORT
HAMILTON DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

2.0 CONCLUSIONS AND RECOMMENDATIONS

The Hamilton Dam was inspected on October 19, 2008 in accordance with the Michigan P.A. 415, Part 315 criteria. The dam was found to be in poor condition which supports the conclusion found in previous dam safety reports. Specific comments/recommendations are as follows:

1. The stability of the exposed structural components including gate piers, access and operating platforms, and abutments is poor. These components are no longer capable of serving their intended purpose.
2. Three of the floodgates have been decommissioned while the reliability of the remaining gates is suspect. With three gates operating inadequate freeboard exists at the right embankment (looking downstream). In addition upstream flood elevations will be greater than those included in the FMEA Flood Insurance maps.
3. The MDEQ mandated drawdown should be adhered to until the dam is reconstructed.
4. The City should proceed immediately to implement the preferred option from the 2008 Reconstruction Feasibility Study.
5. In the interim, the City should exercise the Emergency Action Plan (EAP) annually to insure an efficient implementation when and if needed.

Stantec
INSPECTION REPORT
HAMILTON DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

3.0 PROJECT INFORMATION

Hamilton Dam is located on the Flint River in downtown Flint, Michigan near the Flint Branch of the University of Michigan campus, and approximately 800 ft. upstream from the Saginaw Street Bridge.

Plans for the current dam are on file with the City of Flint, but original design data is not available. The dam was designed by Fargo Engineering Company of Jackson, Michigan, and was constructed about 1920 by Price Brothers Company of Lansing, Michigan on the site of a previous mill dam. The dam was constructed to sustain a head for the upstream water treatment plant intake.

The existing structure is a reinforced concrete gravity dam with six gated spillway bays. Each bay has a tainter gate on the fixed crest of a concrete spillway. The six bays, each 33 ft. long, and the five piers, each four feet thick, make a total length of 218 ft. There is an end sill below the spillway and an 18 ft. concrete apron beyond the end sill. The gates are operated during flood flows.

The original 1920 dam had seven bays with tainter gates. In 1964, the southern (left) most gate, its spillway and headrace were removed.

A fish ladder was constructed through the right abutment sidewalls in 1978. Also in 1978, the right concrete abutment was modified to install an Archimedean screw pump.

Repairs to Hamilton Dam were carried out in the summer of 1992. Steel sheet piling was placed just upstream of the gates for Bays 1, 2 and 6 because of the deteriorated condition of the gates. The sheet piles were to maintain the headpond in case of gate failure. The top elevation of the sheet piles was placed near the top of the tainter gates (Elev. 707.8 ft.) in a closed position. Gate repairs were completed in Bays 3, 4, and 5. These repairs included the complete removal of the existing gates and replacement with new gates, repair of buttress and sill concrete, repair of gate trunnions, replacement of lift chains, and painting of all exposed gate steel.

The top deck of the structure is divided lengthwise into a pedestrian walkway and the gate hoist rails for the two gate hoists. The hoist rails consist of two "I" beams (18 inch and 15 inch) that are supported by the piers. The two hoists for raising the spillway tainter gates are driven by attached electric motors.

A U.S. Army Corps of Engineer's bronze disk is set flush with the bridge deck in the walkway at the second pier from the right end. Unless otherwise noted, data given in this report is based on the assumption that the E1 715.06 ft. elevation given for this benchmark is on National Geodetic Vertical Datum (NGVD).

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The terrain near the dam and reservoir is urban and gently rolling. Five borings from the original plans show sand with an occasional pocket of clay or gravel in the soils overlying a soft sandstone which is 40 or 50 ft. below ground surface.

Six spillway bays and tainter gates make up the structure. Only Gates 3, 4 and 5 are currently operable. Sketches and pertinent data about Hamilton Dam are shown in **Appendix A**.

Hamilton Dam was classified by the U.S. Army Corp of Engineers as High Hazard in the 1980 Phase I Inspection Report. This classification remains in effect to date.

Plans for the original Dam construction in 1920 and plans for repairs performed in 1992 are on file with the City of Flint. Past inspection reports on file include the following:

- 1980 USACE, Phase I, National Dam Safety Program Report
- 1986 Ayres, Lewis, Norris & May, Inc. (ALNM) and Sublakes Diving Inspection Report
- 1988 MDNR Inspection Report
- 1989 Ayres, Lewis, Norris & May, Inc. (ALNM) Structural Evaluation and Reconstruction of Hamilton Dam Report
- 1993 Acres International Corp., Dam Inspection Report
- 1996 Ayres, Lewis, Norris & May, Inc. (ALNM) Inspection Report
- 1999 Paul C. Rizzo Associates, Inc. Dam Inspection Report
- 2000 USACE Hamilton Dam Condition Survey
- 2005 Soil & Materials Engineers, Inc. Dam Inspection Report
- 2008 Stantec Feasibility Study for Reconstruction

These reports have been consistent in their recommendations to undertake corrective action to address structural deficiencies within the facility. The 1989 Ayres, Lewis, Norris & May, Inc. (ALNM) and 2000 USACE Reports included estimated costs of \$3,830,000 and \$5,588,000 respectively to make the necessary improvements to insure dam safety and integrity. The 2008 Stantec Report estimated the reconstruction cost to be \$4,901,000.

On March 14, 2008, acting under the authority of Part 315, Dam Safety of the Natural Resources and Environmental Protection Act, 1994 P.A. 451 as amended, the Michigan

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Department of Environmental Quality issued an order to the City of Flint to drawdown the Hamilton impoundment 3.25 ft. to an elevation not greater than 705.25 NGVD for the purpose of public health, welfare and safety protection. The depth of necessary drawdown was computed by the MDEQ to eliminate the danger of loss of life downstream in the event of a sudden dam failure.

A permit under Part 301, Inland Lakes and Streams was issued for this activity on September 30, 2008. The City of Flint has subsequently abided by the conditions of this permit and has lowered the normal impoundment elevation to the prescribed elevation. It should also be noted that the MDEQ permit requires permanent deflation of the Obermeyer (Inflatable) Dam.

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4.0 FIELD INSPECTION

An inspection of the facilities was performed on October 19, 2008 by Dana M. Dougherty, PE. The weather on the date of the inspection was clear with temperatures at approximately 55°F. The impoundment elevation was below normal by approximately 1.5 ft. The City was in the process of lowering the impoundment per directive from the MDEQ. This directive requires that the impoundment be lowered 3.25 ft. The floodgate in Bay #3 has been opened to accomplish this task.

The following items were noted during the field inspection (referenced photographs can be found in Appendix C):

1. The condition of the exposed concrete including piers, slabs, abutments is poor with numerous spalls, cracks and exposed reinforcing steel (Ref. Photos #1 through #4, #7, #8, #10).
2. The floodgates in Bays 1, 2 and 6 have been decommissioned by placement of steel sheeting across the face of these bays (Ref. Photos #2 and #8).
3. The City reports that the remaining floodgates (Bays 3 through 5) are operative, however, Bays 4 and 5 have not been operated with any frequency and thus their reliability is suspect.
4. The access walkway/platform remains closed to the public due to safety concerns (Ref. Photos #3 and #4).
5. Overall the condition of the dam continues to worsen with the structural integrity of numerous components compromised.

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5.0 STRUCTURAL STABILITY

The assessment of stability is based on a visual observation made during our field inspection (10/19/08) and visual observations made during preparation of the 2008 Reconstruction Feasibility Study, as well as the 1989 condition survey (concrete corings).

The overall structural condition of the Hamilton Dam is poor. Exposed surfaces including gate piers, access and operating platforms and abutments all exhibit conditions that indicate these components have exceeded their useful life. Numerous spalls, cracks and exposed reinforcing steel exist.

In conclusion, the Hamilton Dam structural stability is deficient and thus this facility represents a potential liability with regard to public health, welfare and safety.

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6.0 HYDROLOGY AND HYDRAULICS

The dam is regulated under State of Michigan P.A. 451 Part 315 statute. Guidelines that accompany this statute require high hazard potential dams with heights less than 40 ft. to be capable of passing a 200-year flood or the flood of record whichever is greater. For the Hamilton Dam, the 200-year flood controls and has been computed by the Michigan Department of Environmental Quality to be 13,000 cfs (reference **Appendix B**).

The computed maximum impoundment elevation for the 200-year flood event varies dependent on assumptions made with regard to the number of floodgates that are operative. In 1981, calculations were performed by the United States Geologic Survey and form the basis for the FEMA Flood Insurance mapping that is used to this day. The USGS assumed that all six floodgates were operational. The USACE also computed the maximum impoundment elevation in their 1981 National Dam Safety Inspection Report. They assumed that just two gates were operational due to the fact that the gates could not be locked in an open position and only two operators existed. In 1993 after decommissioning of Gates 1, 2 and 6, Acres International Corporation computed the maximum headwater elevation assuming that gates were operational in Bays 3, 4 and 5.

The results of these various studies is as follows (refer to **Appendix B** for more information):

Source	Estimated 200-year Impoundment Elevation NGVD Datum
1981 F.I.S. (U.S.G.S.)	709.05*
1981 Dam Safety Inspection Report (USACE)	711.6
1993 Dam Safety Inspection Report (ACRES)	712.8

** USGS added 0.95' to the computed impoundment elevation for the purpose of floodplain mapping. Therefore the floodplain mapping indicates a 200-year flood elevation of approximately 710.0 NGVD.*

It should be noted that there is uncertainty as to whether or not adequate freeboard exists at this site. The Acres report indicates that freeboard is sufficient based on the fact that the upstream right streambank area was raised in the mid 1980's. However, a recent survey conducted as part of the 2008 Reconstruction Feasibility Study indicates the elevation of this area to be similar to that shown in the 1981 USACE report i.e. \pm 711.5 NGVD. Thus, it would appear that inadequate freeboard currently exists.

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7.0 OPERATION AND MAINTENANCE

The Hamilton Dam is operated and maintained by staff from the City of Flint Water Treatment Plant. Floodgates in Bays 1, 2 and 6 are currently non-functional. Floodgates in the remaining bays can be operated, however their reliability is diminished due to the deteriorated condition of the operating slab.

City staff maintains the impoundment elevation by operating the gates on an as needed basis. The impoundment is currently being maintained at the MDEQ mandated level of 705.25 NGVD i.e. 3.25 ft below normal.

The City has performed minimal maintenance to the structure in anticipation of reconstruction.

Appendix 8 - Cost of Service Study – Flint Water Treatment Plant

**Technical Memorandum
Cost of Service Study
Flint Water Treatment Plant**

DRAFT

I. Introduction

This Technical Memorandum describes the proposed improvements needed at the Flint Water Plant to treat Flint River water on a continuous basis. The primary foundations for this evaluation were the "Water Treatment Plant Rehabilitation – Phase II" report dated December 2003 and the "Preliminary Engineering Report, Lake Huron Water Supply, Karegnondi Water Authority" dated September 2009. The findings, as presented in the following sections, address the improvements required for the water plant to produce finished water in conformance with the current federal and state drinking water regulations. In addition, operation and maintenance costs for continuous operation have been evaluated and included in order to determine the total cost associated with using the Flint River as a source of water.

Improvements, as proposed in this evaluation, along with those previously made during the Phase I improvements program, will produce a finished water quality equal to the current water quality as received from the DWSD. The design parameters are as follows:

- 1) Minimum Day Demand – 10-mgd
Average Day Demand – 15-mgd (14-mgd in 2010 increasing to 15-mgd in 2050)
Maximum Day Demand – 28-mgd
- 2) Turbidity – 0.20 NTU
- 3) Hardness – 80 to 100 mg/l as CaCO₃
- 4) Cryptosporidium – 3-Log Inactivation
- 5) Giardia – >3-Log Inactivation
- 6) Viruses – >4-Log Inactivation
- 7) Taste and Odor – Eliminated with pre-ozonation
- 8) Trihalomethanes – Less than 80 µg/l
- 9) HAA5 – Less than 60 µg/l

As part of this investigation, an inspection of the Flint Water Plant was performed on May 3, 2011. The purpose of this inspection was to determine if the recommendations in the Phase II report, as referenced above, needed to be revised due to changed conditions or water supply needs. Based on findings from this meeting, the major adjustment to be made is the reduction of average day demand from 20-mgd to 14-mgd and maximum day demand being reduced from 36-mgd to 28-mgd. Required improvements as recommended in this study have taken these new demands into account. The conceptual design of these new facilities would allow cost effective expansion to 36-mgd, as needed, to meet future demands.

II. Required Capital Improvements

The following describes the required improvements as required for the Flint Water Plant to operate on a continual basis using the Flint River as a water source. Most of these improvements are more fully described in the Phase II report and are not repeated to avoid duplicative effort.

A. Lime Sludge Disposal

Lime sludge is proposed to be pumped from the east and west softening basins to two new 42-ft diameter thickeners (25-ft SWD) located adjacent to the plate settling building. Decant from the thickener will flow by gravity to the primary clarifier influent channel. Thickened sludge (12% solids) will be pumped to a new plate-and-frame filter press located at the north end of the WTP 1 primary settling basin. A new two-story building would be constructed at that location to house the pumping facilities and presses. Each press, located on the second floor, will have a 225-cf per hour capacity and will drop the dewatered sludge into a first floor bunker area. The dewatered cake will be transferred to a lime storage concrete bunker located approximately 60 feet north of the sludge press building. The storage bunker (100-ft x 192-ft) will have the capacity to store three to four months of dewatered lime sludge cake. About every three months, contract haulers will remove the lime sludge and place on agricultural lands that are permitted for final disposal.

The capacities of these facilities are based on average day flow of 15-mgd, maximum day demand of 28-mgd and water quality softening requirements. Based on raw water quality data provided by the City of Flint, a lime dosage of 209 mg/l, soda ash dosage of 47 mg/l and carbon dioxide dosage of 37 mg/l were used to estimate lime sludge quantities and flows.

Opinion of Probable Cost:

Site and Access:

Site Demolition	\$	129,000
Roadway Improvements	\$	385,000
Partial Settling Basin Demolition	\$	129,000
On-site Truck Scale	\$	257,000
Subtotal Construction:	\$	900,000
Construction Contingencies (15%):	\$	135,000
Design Contingencies (5%):	\$	45,000
Engineering, Legal, Bonds & Administration (17%):	\$	153,000

Opinion of Probable Cost: \$ 1,233,000

Thickener Basins - 42 ft Diameter:

Two Thickener Mechanisms	\$	310,000
Two Concrete Basins (25 ft SWD)	\$	513,000
Two Geodesic Dome Covers	\$	180,000
Install Equipment	\$	257,000
Site Work	\$	97,000
Utilities, Piping and Process	\$	193,000
Subtotal Construction:	\$	1,550,000
Construction Contingencies (15%):	\$	232,500
Design Contingencies (5%):	\$	77,500
Engineering, Legal, Bonds & Administration (17%):	\$	263,500

Opinion of Probable Cost: \$ 2,124,000

Filter Presses and Building:

Two-225 cf Plate & Frame Press	\$	1,650,000	
Building (70 ft x 60 ft)	\$	3,331,000	
MEP	\$	1,089,000	
Site Utilities	\$	129,000	
Subtotal Construction:	\$	6,199,000	
Construction Contingencies (15%):	\$	929,850	
Design Contingencies (5%):	\$	309,950	
Engineering, Legal, Bonds & Administration (17%):	\$	1,053,830	

Opinion of Probable Cost: \$ 8,493,000

Lime Storage Bunker and Site Work:

12 ft Concrete Walls and Slab	\$	833,000	
Frame and Fabric Building Cover	\$	325,000	
Site Improvements	\$	385,000	
Front End Loader (5 cyd)	\$	308,000	
Site Utilities	\$	513,000	
Subtotal Construction:	\$	2,364,000	
Construction Contingencies (15%):	\$	354,600	
Design Contingencies (5%):	\$	118,200	
Engineering, Legal, Bonds & Administration (17%):	\$	401,880	

Opinion of Probable Cost: \$ 3,239,000

Total for Lime Disposal : \$ 15,089,000

B. Soda Ash Feed System

In order to remove the non-carbonate hardness, soda ash will be needed to meet the finished water hardness concentrations. Two new 800 #/hour feeders will be needed to meet the dosage requirements. Each of these feeders will be connected to the existing silos.

Opinion of Probable Cost:

Demolition of Existing Feeders	\$	20,000	
Two 800 #/hr Feeders	\$	112,000	
MEP	\$	109,000	
Chemical	\$	77,000	
New Pneumatic Fill System	\$	58,000	
Subtotal Construction:	\$	376,000	
Construction Contingencies (15%):	\$	56,400	
Design Contingencies (5%):	\$	18,800	
Engineering, Legal, Bonds & Administration (17%):	\$	63,920	

Opinion of Probable Cost: \$ 516,000

C. Additional Chemical Storage

During the Phase I improvements, the MDEQ did not mandate 30-day chemical bulk storage requirements since the plant was a redundant water supply to the DWSD. However, if the facility becomes a continuously operated treatment plant, then additional chemical storage must be added to meet the minimum storage volume requirements. To comply with the regulations, new oxygen, nitrogen and carbon dioxide storage facilities must be provided as follows.

Liquid Carbon Dioxide:

Capacity – 34 tons

Vaporizer – 750 #/hour @ 300 psig

Piping – Schedule 80 Carbon Steel and Schedule 40 - 304L Stainless Steel

Liquid Oxygen

Capacity – 9000 gallons

Operating pressure – 75 psi

Feed Rate – 175 scfm

Piping – Type K Copper

Liquid Nitrogen

Capacity – 540 gallons

Operating pressure – 100 psi

Feed Rate – 1 scfm

Piping – Type K Copper

Opinion of Probable Cost:

Carbon Dioxide Storage Facilities	\$	328,000	
MEP	\$	103,000	
Oxygen & Nitrogen Storage Facilities	\$	961,000	
MEP	\$	109,000	
		Subtotal Construction:	\$ 1,501,000
		Construction Contingencies (15%):	\$ 225,150
		Design Contingencies (5%):	\$ 75,050
		Engineering, Legal, Bonds & Administration (17%):	\$ 255,170
		Opinion of Probable Cost:	\$ 2,057,000

D. Electrical and SCADA Improvements

Section 9, relating to power and controls, of the Phase II study was prepared by Dmytryka Jacobs Engineers (DJE). The scope of the Phase II work did not include detailed investigations of the water plant site-wide power distribution nor the secondary power distribution within each of the facility structures. However, a number of observations and basic recommendations were presented in Section 9 by DJE.

The Flint Water Plant currently uses 2400V as primary power throughout the facility. All of the power feeders in the plant site are 5kV rated and it appears the existing switchgear is also rated at 5kV. Most of the major electrical improvements installed during Phase I were dual voltage (2400/4160) equipment in anticipation of the plant power being changed to 4160V in the near future. This change would allow the existing network of power feeders to handle approximately twice the power and would eliminate running new feeders to various portions of the plant.

The current sub-station has two 2.5MVA transformers running in parallel for a total capacity 5 MVA. These old transformers are not equipped with cooling fans. The full connected load to these transformers is estimated to be 6.97 MVA while the estimated power load at 36 MGD is 4.22MVA. Based on these estimates there is sufficient power for the plant with both sub-station transformers in service. Even though the transformers are owned by Consumers Energy, it could take weeks to replace one of these main transformers in the event of a unit failure, which will result in reduced treatment and pumping capacity. The sub-station switchgear was installed in 1960 and is antiquated and difficult to maintain.

The two existing Fairbanks Morse generators are currently inoperable and would cost approximately \$1M to rehabilitate. The DJE team recommended installing two new emergency generators in lieu of re-building the existing units.

Section 9 of the Phase II report provides sufficient detail for the purposes of this report, but a detailed electric system evaluation of the entire plant should be performed prior to any major improvements to this facility.

While LAN did not perform a detailed review of the WTP electrical system during our site visit, it appears that all of the DJE findings are still pertinent. We, therefore, concur with the improvements as recommended by DJE in the Phase I report.

Opinion of Probable Cost:

Substation Upgrade	\$	961,000	
Standby Power Generation	\$	2,242,000	
Pump Station No. 4 Upgrade	\$	1,365,000	
Filter Press Building Feeder	\$	87,000	
WTP SCADA, Equipment & Programming	\$	720,000	
Telemetry System Equipment & Programming	\$	103,000	
Computers, Software & Training	\$	155,000	
Filter Transfer PS Power Feeders	\$	135,000	
Emergency PS Power Feeders	\$	145,000	
		Subtotal Construction:	\$ 5,913,000
		Construction Contingencies (15%):	\$ 886,950
		Design Contingencies (5%):	\$ 295,650
		Engineering, Legal, Bonds & Administration (17%):	\$ 1,005,210
Opinion of Probable Cost:			\$ 8,101,000

E. Post-Chlorination and Zebra Mussel Control

The previous report recommended changing the disinfection system from gaseous chlorine to sodium hypochlorite due to the potential for hazardous gas release and the requirements imposed by new federal regulations. Previous treatability studies have not addressed the potential impact of re-growth in the system due to ozonation by-products. These impacts should be addressed prior to proceeding with final plans for using river water.

The Flint River is known to be infested with Zebra mussels and mitigation measures will have to be implemented if the plant is placed into continuous operation. A sodium permanganate feed system is proposed to address these concerns.

Opinion of Probable Cost:

Demolition of Existing Equipment	\$	39,000	
Storage Tanks	\$	9,000	
Metering Pumps and Tables	\$	11,000	
Piping, Valves & Tables	\$	9,000	
Containment	\$	59,000	
Installation	\$	108,000	
Subtotal Construction:	\$	235,000	
Construction Contingencies (15%):	\$	35,250	
Design Contingencies (5%):	\$	11,750	
Engineering, Legal, Bonds & Administration (17%):	\$	39,950	
Opinion of Probable Cost:		\$	322,000

F. Security Issues

For water plant security issues, please refer to City of Flint Vulnerability Assessment. Details are omitted in this report due to confidentiality.

Not available at the time of the previous report, a source water monitoring system is included in the study due to recent advancements in technology. The proposed system design is based on Hach Model SC1000, equipped with UVAS, NH4D, pH, ORP, turbidity and DO probes.

Opinion of Probable Cost:

Security Improvements	\$	145,000	
Source Water Monitoring System	\$	95,000	
Subtotal Construction:	\$	240,000	
Construction Contingencies (15%):	\$	36,000	
Design Contingencies (5%):	\$	12,000	
Engineering, Legal, Bonds & Administration (17%):	\$	40,800	
Opinion of Probable Cost:		\$	329,000

G. PS No. 4 - Low and High Service Pumps

Section 7 of the Phase II report included recommendations to replace two of the low lift pumps and two of the high lift pumps along with various other improvements. During the site visit, it was apparent the condition of this facility has continued to deteriorate. Furthermore, with the reduction in water system demands, the various pump capacities are no longer properly sized to efficiently meet the new plant flow ranges. The pumps and motors are oversized and are operating outside their best efficiency ranges and should be replaced due to age, condition and cost to operate.

Additionally, some of these pumps cannot be operated due to excessive vibrations in the shaft and steady bearings. Existing vibration monitors are functioning as designed and are shutting the power off to the motors to avoid damage.

For low lift service, it is proposed to install two 10-mgd and two 15-mgd (nominal ratings) vertically mounted pumps equipped with low voltage inverter duty motors. The motors would be powered by low

voltage variable frequency drives. This will provide a firm rated capacity of approximately 35-mgd in low lift capacity.

For high lift service, it is proposed to install one 10-mgd, two 15-mgd and one 20-mgd (nominal ratings) pumps equipped with medium voltage inverter duty motors. These motors will be powered by medium voltage variable frequency drives. This combination of pumps will provide a firm rated capacity of 40-mgd.

Opinion of Probable Cost:

Demolition of Existing Equipment	\$	135,000
Install Two (2) 10 MGD @ 40 ft of TDH Vertically Mounted Pumps with 125 HP, 480 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	\$	473,000
Install Two (2) 15 MGD @ 40 ft of TDH Vertically Mounted Pumps with 150 HP, 480 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	\$	495,000
Install One (1) 10 MGD @ 190 ft of TDH Vertically Mounted Pump with 450 HP, 4160 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	\$	245,000
Install Two (2) 15 MGD @ 190 ft of TDH Vertically Mounted Pumps with 700 HP, 4160 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	\$	520,000
Install One (1) 20 MGD @ 190 ft of TDH Vertically Mounted Pump with 800 HP, 4160 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	\$	285,000
Piping, Valves, Supports & Bearings	\$	480,000
Intermediate Platforms, Ladders & Stairs	\$	360,000
Ventilation & Boiler Systems	\$	340,000
Install Three (3) Low Voltage VFD Units	\$	85,000
Install Four (4) Medium Voltage VFD Units	\$	2,250,000
Subtotal Construction:	\$	5,668,000
Construction Contingencies (15%):	\$	850,200
Design Contingencies (5%):	\$	283,400
Engineering, Legal, Bonds & Administration (17%):	\$	963,560
Opinion of Probable Cost:	\$	7,766,000

H. Filter Transfer Station to Dort Reservoir and UV Inactivation

Under the requirements as outlined in the USEPA drinking water regulations addressing potential microbial contaminants, additional treatment technologies and enhancement of existing processes must be implemented to comply with these regulations.

As required under the enhanced surface water treatment rules, it is essential for water utilities to address giardia, cryptosporidium, viruses and bacteria in finished water. The level of treatment is dependent on



the source water classification. The City of Flint will need to perform a two-year source water study to determine the bin placement for the Flint River. For the purposes of this report, a Bin 4 placement was selected due to the nature of the watershed and, therefore, it is assumed enhanced Ct and UV inactivation will be required.

Reservoir No. 3 does not provide sufficient Ct to meet the current regulations, therefore, Dort Reservoir will need to be placed into the process train. Since Dort Reservoir does not match the hydraulic profile of the plant, an intermediate pump station will be required. This new facility will also include a UV inactivation system to comply with the enhanced water quality regulations.

This proposed facility, located west of the filters and south of Dort Reservoir, will house three 14-mgd (nominal rating) variable speed pumps with inverter duty, low voltage motors for a firm rated capacity of 28-mgd. Housed in a separate part of this same structure will be the UV system that will be equipped with three 12" medium pressure units with a rated capacity of 28-mgd.

Opinion of Probable Cost:

Site Work & Utilities	\$	77,000	
Building (80 ft x 60 ft)	\$	1,440,000	
Three (3) 14 MGD @ 40 ft of TDH, Vertically Mounted Pumps with 150 HP, 480 V Inverter Duty Motor			
MEP	\$	940,000	
Valves and Controls	\$	205,000	
Install Three (3) 12" MP UV Units	\$	590,000	
UV Piping & Controls	\$	368,000	
Ventilation & Boiler Systems	\$	165,000	
Install Three (3) Low Voltage VFD Units	\$	85,000	
Piping Connections	\$	125,000	
200 ft of 30" Water Main	\$	200,000	
600 ft of 36" Water Main	\$	420,000	
Subtotal Construction:		\$	5,150,000
Construction Contingencies (15%):		\$	772,500
Design Contingencies (5%):		\$	257,500
Engineering, Legal, Bonds & Administration (17%):		\$	875,500
Opinion of Probable Cost:		\$	7,056,000

I. Emergency Interconnect Pumping Station

The City of Flint and Genesee County DWWS have entered into an agreement to provide 8-mgd of back-up service to each other under emergency conditions. There are several alternatives for pumping station locations and configurations to accomplish this interconnect. For the purposes of this report, a station located west of the filter building was selected as the most practical from an operational cost perspective. While the opinions of cost presented below indicate that these pumps will be housed in their own structure, it is feasible to house the pumps in the filter transfer station for potential savings.

Preliminary design for this pumping station include two constant speed 8-mgd pumps equipped with soft starts and medium voltage motors. A reverse flow control station will be included within the same structure to allow for flow from the DWWS to assist the City of Flint. Approximately three miles of 24-inch pipeline will be needed to connect the two systems.

Opinion of Probable Cost:

Site Work & Utilities	\$	90,000	
Building (32 ft x 24 ft)	\$	245,000	
Install Two (2) 8 MGD @ 290 ft of TDH, Vertically Mounted Pumps with 600 HP, 4160V Motor	\$	380,000	
MEP	\$	335,000	
Valves and Controls	\$	128,000	
Reverse Flow Control Station	\$	110,000	
Ventilation Systems	\$	35,000	
16000 ft of 24" Water Main	\$	4,992,000	
Subtotal Construction:	\$	6,315,000	
Construction Contingencies (15%):	\$	947,250	
Design Contingencies (5%):	\$	315,750	
Engineering, Legal, Bonds & Administration (17%):	\$	1,073,550	
Opinion of Probable Cost:			\$ 8,652,000

The opinions of capital cost presented in the preceding sections are tied to an ENR Index of 8688 to match the September 2009 Lake Huron Water Supply Report. Furthermore, the contingency percentages included with each opinion of cost are the same as in the September 2009 report. The total opinion of probable project cost of these proposed improvements is as follows:

Lime Sludge Disposal	\$	15,089,000
Soda Ash Feed System	\$	516,000
Additional Chemical Storage	\$	2,057,000
Electrical and SCADA Improvements	\$	8,101,000
Post-Chlorination and Zebra Mussel Control	\$	322,000
Security Issues	\$	329,000
PS No. 4 - Low & High Service Pumps	\$	7,766,000
Filter Transfer Pumping Station & UV	\$	7,056,000
Emergency Interconnect Pumping Station	\$	8,652,000

Total Opinion of Probable Project Cost: \$ 49,888,000

III. Cost of Additional Operation

The City of Flint currently operates the water treatment plant periodically during the year to maintain the systems and to meet regulatory requirements. The water treatment plant is staffed with various classifications of employees to operate and maintain the facility for these minimal operations.

As part of this work, and to develop all costs of providing water service from the Flint River, it is necessary to determine the probable cost for operating and maintaining this facility for continuous operation. Water quality differences between the Flint River and Lake Huron are significant and require different treatment chemicals and dosages. Most noticeable is the fact that Lake Huron water does not require softening which negates the need for softening process and the associated lime sludge disposal.

The primary cost parameters that are included in this difference are labor, chemicals, residual disposal and electrical power. Each will be discussed in the following sections. These costs were projected through the year 2050.

A. Labor

Additional staffing was discussed and developed with representatives from the City of Flint to provide full time coverage on a 24/7/365 schedule, plus provide staff for residual management and operations of the various dams. Hourly rates and fringe benefits were based on current budget figures and inflated at a rate of 3% for future costs. The following table outlines the proposed staffing a cost for this operational element.

Classification	Number	Cost/Hr	Hrs/Year	Total	Fringe (%)	Total
Operators	12	\$ 20.00	2080	\$ 499,200	90.40%	\$ 950,477
Maintenance	4	\$ 25.00	2080	\$ 208,000	90.40%	\$ 396,032
Laboratory QA/QC	2	\$ 24.00	2080	\$ 99,840	90.40%	\$ 190,095
Laboratory SDWA	2	\$ 20.00	2080	\$ 83,200	90.40%	\$ 158,413
Planned Overtime	NA	MIXED	8320	\$ 178,048	90.40%	\$ 339,003

This estimate represents approximately \$2,034,000 per year of additional labor.

B. Chemicals

Chemical costs are based on the projected average day water demand of 14-mgd and the average dose for each of the chemicals based on the raw water quality information and other operational records. Further, data from the previous treatability work performed during the Phase I improvements was also incorporated into these estimates. Chemical suppliers and other water utilities were contacted to obtain current chemical purchase costs which were adjusted by the ENR ratio back to an index of 8688. Where necessary, transportation costs to the Flint, MI area were included. The following summarizes the chemical costs associated with treating the Flint River water.

Chemical	Dose(mg/l)	Cost/#	Cost/ MGD
Ferric	44.50	\$0.24	\$89.07
Lime	209.00	\$0.10	\$174.31
Soda Ash	47.00	\$0.29	\$113.67
CO ₂	37.00	\$0.10	\$30.86
Cl ₂	3.00	\$0.34	\$8.51
Fluoride	1.00	\$0.33	\$2.75
Phosphate*	1.00	\$0.51	\$4.25
Cost per MGD			\$423.42

*Costs range from \$0.51 to \$0.96 per pound

In addition to the above, the cost of ozone will need to be added which is approximately \$20.08 per million gallons per day per mg/l dose. This cost includes oxygen, nitrogen and power costs.

C. Residual Disposal

This category is divided into two groups: clarifier sludge collected in the plate settling basins and lime sludge from the softening process. The clarifier sludge is pumped from the clarifier basins by zone (six zones per train, three trains, total of 18 zones) to the plant main drain. As part of the Phase I work, the main drain was connected to a new wastewater pumping station located south of the filter gallery building. This pump station discharges the collected residuals to the city's sanitary sewer system. Nearly all of the filter wash water is recirculated back to the head of the ozone facility for re-use.

The cost to treat clarified sludge discharged into the sanitary sewer system is calculated as follows:

Plate Clarifier Sludge

Flow (MGD)	14
SS (mg/l)	75
Primary Sludge (#/d)	13,435
% Solids	2%
Sludge (gals/day)	80,500
Sludge (cf/day)	10,762

Based on the City of Flint's current wastewater charges of \$1.00 per 100 cf, the annual cost would be \$39,200 per year.

Lime/Soda Ash softening generates large quantities of residual wastes that have high disposal costs. The treatment proposed in this study involves pumping the sludge, at about 4% concentration, from the softening basins to two gravity thickeners, where it will concentrate to about 12% solids. After thickening, sludge will be pumped to the filter presses to be dewatered to approximately 55% solids. The filter presses will drop the cake into a lower bunker where it will be removed by an end loader to the main storage bunker. About every three months, the sludge will be loaded onto trucks and applied to agricultural land.

The volume of sludge is estimated as follows:

Sludge Production from Clarifier

Reaction	meq/l	meq/l as CaCO ₃	meq/l as Mg(OH) ₂
CO ₂	0.25	0.25	0
Ca(HCO ₃) ₂	4.65	9.30	0
Mg(HCO ₃) ₂	0.30	0.60	0.30
MgSO ₄	0.89	0.89	0.89
Excess Lime	1.25	1.25	0
Total meq/l		12.28	1.19
Less Practical Limits meq/l		0.60	0.20
Precipitate Produced meq/l		11.68	0.99
Precipitate Produced mg/l		584	49
Precipitate Produced #/MG		4872	412
Total #/MG		5284	
WTP Flow (MGD)	14	27	
Dry Sludge Production in #/day		73,983	142,681
@ 4% Solids (gals/day)		221,771	427,701
@ 12% Solids (gals/day)		73,924	142,567
@ 12% Solids (gals/week)		517,466	997,970
Dry Sludge Production (tons/week)	259	SG CaCO ₃	2.71
Number of Hours per Week to Press	48	SG Mg(OH) ₂	2.36
Dry Sludge Processed (#/hr)	10,789	SG solids	2.68
@ 55% Solids Sludge Processed (#/hr)	19,617		
55% Solids Sludge (#/cy)	2571	Sludge Solids =	55% as CaCO ₃
@ 55% Solids Sludge Processed (cf/hr)	206	Sludge Unit Wt. =	95.22 pcf

Based on the preceding, 471 tons of softening sludge at 55% solids will be handled each week based on average flow and chemical dosage. Several Michigan water facilities were contacted to obtain lime sludge hauling and disposal costs. From this data a rate of \$18.50 per wet ton was selected as a reasonable rate for disposal cost. This rate will result in an annual cost of \$453,000.

D. Power

Practically all of the additional power costs are associated with low lift, intermediate transfer and high service pumping. Additional power costs will be used for process and handling of the softening sludge. The City of Flint is currently paying \$0.07 per kwhr for service at the water plant. Power costs are calculated as follows:

TDH (ft) - High	190
TDH (ft) - Filter Transfer	40
TDH (ft) - Low	40
TDH Total (ft)	270
Pump Eff. (W to W)	80.00%
\$/kwhr	\$0.070
Pumping Cost Per MGD	\$99.51
Solids Handling per MGD	\$4.98
Total Power Cost per MGD	\$104.49

Annual costs associated with the operation and maintenance of the Flint Water Plant are summarized in the attached tables following this section.

IV. Project Implementation Schedule

There are a number of issues that will impact the implementation schedule for this work. The source water studies to define bin number associated with cryptosporidium and giardia will take approximately two years. Part of these studies can be performed concurrently with design, but sufficient work will need to be performed to avoid impacting design schedule or work. A planning period of one year should be allowed for preliminary water quality and regulatory evaluations prior to initiating design work. Design of this project will require 10 to 12 months, with an additional three months required for permitting. After permits are received, allow three months for bidding and contract execution. Major equipment procurement and construction will take from 24 to 30 months. Plant commissioning will take about 2 months.

Total time required from notice to proceed to project completion 52 months to 60 months. This time frame does not include financing issues.