

**HYDROELECTRIC REDEVELOPMENT
ARGO AND GEDDES DAMS
FEASIBILITY STUDY
CITY OF ANN ARBOR**

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1.0 INTRODUCTION

1.1 PURPOSE

The City of Ann Arbor commissioned Stantec Consulting Michigan Inc. (Stantec) to provide data for assistance in evaluating feasibility of redeveloping hydroelectric power facilities at the Argo and Geddes Dams within the City of Ann Arbor, Michigan. Specific data to be provided includes an estimate of the site power potential, estimate of redevelopment costs, including both initial capital cost and ongoing operation costs, and investigation into Federal Energy Regulatory Commission (FERC) licensing requirements. This data will be used by the City of Ann Arbor to evaluate the economic feasibility of redevelopment. The study is an update to a previous (1982) study performed by Stantec (formerly Ayres, Lewis, Norris & May, Inc.).

1.2 SUMMARY

Results of Stantec's preliminary investigation into reinstallation of hydroelectric power at Argo and Geddes Dams are summarized as follows:

1. Argo Dam

- The recommended installed capacity is 370 kw, which corresponds to 28% flow exceedance (536 cfs), i.e. the river flow will exceed the turbine rated hydraulic capacity 28% of the time.
- The estimated average annual power generation is approximately 2,000,000 kwh/yr.
- The preliminary estimate of probable project cost is \$4,350,000, which includes indirect costs such as engineering, licensing/permits, finance, legal and contingencies.
- In addition to initial capital expenditures, there will be ongoing annual expenses associated with plant operation and FERC license requirements. Based on historical data for the Barton and Superior plants, as compared to Argo and Geddes, the net additional operation and maintenance cost is estimated to be approximately \$70,000/year (excluding debt service).
- The preliminary development concept includes installation of a single 1,700mm bulb or pit double regulated propeller turbine with speed increaser and high speed generator. It is proposed to locate the power house adjacent to the left (east) side of the spillway. Locating the power house at the end of the existing millrace was evaluated and determined to be impractical due to high cost, minimal additional power production and environmental considerations.

- Generated power would be interconnected to the existing power grid adjacent to the site.

2. Geddes Dam

- The recommended installed capacity is 670 kw, which corresponds to 23% flow exceedance (633 cfs).
- The estimated average annual power generation is approximately 3,350,000 kwh/yr.
- The preliminary estimate of probable project cost is \$4,350,000, which includes indirect costs such as engineering, licensing/permits, finance, legal and contingencies.
- In addition to initial capital expenditures, there will be ongoing annual expenses associated with plant operation and FERC license requirements. Based on historical data for the Barton and Superior plants this cost is estimated to be approximately \$70,000/year (excluding debt service).
- The preliminary development concept includes installation of a single 1,700mm bulb or pit double regulated propeller turbine with speed increaser and high speed generator. It is proposed to locate the power house in the center island between the existing spillways.
- Generated power would be interconnected to the existing power grid adjacent to the site.

Should the City determine to further pursue redevelopment of either or both sites, it is recommended that the next phase of effort include performance of the following tasks in order to further validate preliminary assumptions/analysis:

- Confirm power production estimates by obtaining additional tailwater information, particularly at Geddes Dam.
- Confirm estimated project cost by developing more detailed preliminary drawings and associated estimates of cost.
- Hold further discussion with environmental resource agencies (MDNR, MDEQ, and USFWS) regarding potential environmental concerns, studies and license conditions.
- Perform detailed studies of power markets and potential sale rates.

2.0 BACKGROUND

2.1 BACKGROUND

The City of Ann Arbor owns four dams on the Huron River: Barton, Argo, Geddes, and Superior. Following a 1981 study of the hydroelectric generation potential at all four City dams by Ayres, Lewis, Norris and May, Inc, the citizens of Ann Arbor approved a \$3.2 million bond to restore hydropower at Barton and Superior Dams. Higher construction cost estimates and lower electric production potential kept Argo and Geddes from being recommended for restoration at that time. Economic analysis of the hydroelectric potential was based on 1981 electric costs of 3.1 cents/kwh and bond interest rates of 10.5%.

In 2006, the Ann Arbor City Council passed a resolution calling for the City to use 30% renewable energy in its municipal operations by 2010, and 20% community-wide by 2015. Renewable electricity generated by City-owned dams may make a significant contribution toward meeting these goals. Given the City's push for renewable energy, today's electricity generation costs at 5-6 cents/kw, the increased value of "green" energy (1-2 cents/kwh over tariff prices) and lower interest rates available (5% or lower), it is important to re-evaluate the hydropower potential of Argo and Geddes Dams.

The City has also begun the Huron River and Impoundment Management Planning (HRIMP) process, a comprehensive, multi-stakeholder study of the stretch of the river that runs through Ann Arbor. An updated assessment of the hydroelectric potential of the City's dams will allow the HRIMP committee to make informed recommendations regarding the future of the Huron River.

Toward these ends – meeting renewable energy goals and developing a management plan for the Huron River – it is important to better understand the value of the City's dams for hydroelectric generation. This study will assist the City of Ann Arbor in making decisions about the future of its dams, the Huron River, and renewable energy in Ann Arbor.

2.2 POWER POTENTIAL

The theoretical power potential of a hydropower site is dependent on three factors:

1. the net hydraulic head (gross hydraulic head minus system headloss);
2. mean available stream flow;
3. plant efficiency (efficiency of the power producing equipment).

The relationship of these factors is given by the following formula:

$$\text{Power (kw)} = \frac{(\text{Head (ft.)}) (\text{Flow (cfs)}) (\text{Efficiency (\%/100)})}{11.8}$$

To determine values for the first variable, net head, we measured the gross head at each site under both normal and above normal flows. Two readings were taken for the purpose of this preliminary study, however, should the City desire to proceed to the next phase of investigation, additional readings should be taken over a range of flows, especially with regard to the tailwater elevation at the Geddes Dam. At both the Argo and Geddes dams, the headwater (impoundment) elevation is maintained relatively steady by operation of the floodgates. The tailwater (downstream) elevation increases with flow, which results in reduced gross head as the flow increases. For the purpose of this preliminary study, the gross head is reduced by 0.5 feet to compute net head available. The 0.5 foot headloss is attributed to system losses in the powerhouse forebay/intake. Net head available for power production for each site is shown in the power production tables included in **Appendix D**. Note that for Argo Dam, the option of placing the powerhouse at the end of the existing millrace results in an additional two feet of net head.

The second variable, flow, was determined by comparing MDEQ provided flow exceedance data to historic USGS gage data for USGS Gage No. 04174500, which is located near Maiden Lane, approximately 0.7 miles downstream from Argo Dam. Both MDEQ and USGS data are shown in **Appendix A**. The data compared favorably for normal to above normal flows. The MDEQ data resulted in slightly less flow in the lower (greater than 50% exceedance) flow range. For the purpose of this study we used the more conservative (MDEQ) values in computing potential site power.

The third variable, plant efficiency, is the function of the combined efficiencies of the various mechanical/electrical equipment components i.e. turbine, speed increaser, generator and transformer. In addition, an allowance for station power usage is typically applied. Equipment efficiencies are variable with load typically maximizing near rated load and decreasing as the load decreases. For the purpose of this study, these efficiencies were taken from equipment manufacturer quotations. The manufacturer quotes include turbine, speed increaser, and generator efficiencies. A further reduction of 2% is assumed for transformer efficiency and station power usage.

In order to compute estimated power production, a hydraulic capacity must be selected for each site. Hydraulic capacity is defined as the rated maximum flow that the turbine(s) will pass. The selection of the optimum hydraulic capacity at a hydroelectric site typically requires a detailed cost benefit analysis for various capacity options. Due to the variable flow rates, resource plant capacity is inversely proportional to plant utilization i.e. the higher the selected capacity, the lower the percentage of time that the unit will operate at the rated capacity. It is typical to see sites developed to 25% exceedance flow. We requested manufacturer quotes of 25%, 50% and

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75% exceedance; however, based on discussion with the manufacturers, settled on an approximate 25% exceedance for hydraulic capacity.

The impact of potential downtime due to equipment maintenance, facility upkeep and low flow must also be taken into consideration. For the purpose of this study, the average annual generation is reduced by 10% for this consideration. This is conservative by industry standards; however, historic records indicate that Barton and Superior have experienced reductions of 13% and 19% respectively.

The resultant power production calculations are shown in **Appendix D**. Please note that computations were made for two equipment suppliers, Canadian Hydro Components and Ossberger Turbines (HTS, Inc.). For presentation purposes, we have selected Canadian Hydro Components data. Power production statistics are summarized as follows (for the purposes of comparison, figures from the 1982 study are also included):

Argo Dam	2008	1982
Installed hydraulic capacity	536 cfs (28% exceedance)	--
Installed generating capacity	370 kw	450 kw
Estimated average annual energy	2,000,000 kwh/yr	1,646,000 kwh/yr
Estimated average annual utilization	62%	42%

Geddes Dam	2008	1982
Installed hydraulic capacity	633 cfs (23% exceedance)	--
Installed generating capacity	670 kw	570 kw
Estimated average annual energy	3,350,000 kwh/yr	2,196,000 kwh/yr
Estimated average annual utilization	57%	48%

Historical production data is available at the Barton and Superior dams, which can be evaluated for comparative purposes. It should be noted that the head/flow characteristics of Superior site closely match those at Geddes Dam. The historical production data is included in **Appendix E**. A review of this data indicates the following (1982 estimated data included for comparison):

Barton Dam	Actual	1982 Study
Installed generating capacity	900 kw	900 kw
Average Annual Energy	4,220,000 kwh/yr	3,600,000 kwh/yr
Maximum Annual Energy	7,449,000 kwh/yr	--

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Barton Dam	Actual	1982 Study
Minimum Annual Energy	585,000 kwh/yr	--
Average Annual Utilization	54%	46%
Maximum Annual Utilization	95%	--
Minimum Annual Utilization	7%	--

Superior Dam	Actual	1982 Study
Installed generating capacity	570 kw	590kw
Average Annual Energy	2,294,000kwh/yr	2,426,000kwh/yr
Maximum Annual Energy	4,174,000 kwh/yr	--
Minimum Annual Energy	354,000 kwh/yr	--
Average Annual Utilization	46%	47%
Maximum Annual Utilization	84%	--
Minimum Annual Utilization	7%	--

As can be seen, the Barton facility has exceeded the 1982 projections, while Superior has not met the estimated production. Based on discussion with operations personnel, downtime due to equipment repairs appears to be the cause of the Superior deficiency.

It should be noted that while the Superior site characteristics are very similar to Geddes, the estimated production at Geddes is significantly greater than that experienced to date at Superior (3,350,000 kwh/yr versus 2,294,000 kwh/yr). The main reason for this is the recommended installed capacity and assumed utilization rate are both greater than Superior's historical performance.

Based on review of this information and for the purpose of this preliminary investigation, it was determined to utilize the Canadian Hydro Components Ltd. proposal for detailed evaluation and costing. Pit turbines such as that proposed by Canadian Hydro have been recently utilized on numerous low head sites. They are believed to offer an efficient powerhouse footprint and effective use of the power (water) resource. The proposed unit is essentially a horizontal axial flow (or propeller) unit. Double regulated relates to the fact that both the runner pitch and wicket gates are adjustable. Their position is varied with flow to achieve maximum efficiency over a wide range of flows. In this case, the proposed turbine will operate from 120 cfs-550 cfs (Argo); 125 cfs-650 cfs (Geddes). This will essentially mean that the units can operate down to 90% exceedance at these sites while still achieving the goal of having a rated capacity near 25% exceedance flow (Argo 28% exceedance; Geddes 23% exceedance). The turbines will operate at 200 RPM (Argo) and 240 RPM (Geddes), which will be increased to 720 RPM by a parallel shaft speed increaser similar to those that are installed at Barton and Superior dams. The high speed generators will be synchronous. Switchgear with utility grade relays and metering will be installed at each site. It is assumed that the produced power will be sold to the local utility (Detroit Edison Co.) and thus a transformer will be required to step voltage up to local grid specifications. At both sites, grid interconnection is available in close proximity to the proposed powerhouse.

3.2 CIVIL WORKS

The civil works for each site will be similar. A rough preliminary layout is shown in **Appendix C**. Beginning at the upstream of the facility, the various civil works components are described as follows:

- The preliminary location of the proposed powerhouse at Argo is to the left (east) and adjacent to the existing spillway. This location is selected as it represents the most cost effective civil works option. It is envisioned that the powerhouse would be placed at a slight (approximately 30 degree) angle to the spillway to facilitate integration with the existing embankment and to optimize hydraulic efficiencies. This location is at, or near, the original spillway location and, depending on the extent of removal, some debris may be encountered during excavation. It should also be noted that existing vegetation (trees and brush) will need to be removed from the embankment. It appears that the proposed powerhouse location is outside of the limits of the endangered species (purple turtlehead) which exists on the embankment; however, further investigation is needed to confirm this fact. The option of locating the powerhouse at the end of the existing millrace was evaluated and determined to be impractical. This location results in an increased head of two feet; however, installation costs associated with stability enhancements to the millrace berm are expensive and environmentally obtrusive due to exiting vegetation, including the aforementioned endangered species (purple turtlehead). In order to negate the need to work on this embankment, we evaluated the installation of a penstock in the millrace. A twelve foot diameter penstock would be needed, which would cost approximately \$3 million.

- It is proposed to locate the proposed powerhouse at Geddes, between the two existing spillways. Should further investigation prove this to be unfeasible, then locating the powerhouse left (north) of the existing left (north) spillway should be investigated. The mid-spillway location is believed to be optimum from a hydraulic standpoint. The impoundment depth is greater at this location, which should positively influence intake hydraulics. This location will result in a fairly compact, but workable, powerhouse/spillway setting with easy access from the downstream roadway.
- Impoundment dredging. Some dredging of the impoundment is anticipated in order to lower the proposed intake elevation to provide adequate intake submergence. Since the Argo Dam has a lower head than Geddes, the dredging depth footprint and volume will be greater. At Geddes, the impoundment was dredged to the needed elevations in 1970 as part of the spillway reconstruction. It is assumed that some siltation has taken place since that date, which will require removal. For the purpose of this study, it is assumed that two feet of silt will be removed throughout the front of the spillways and proposed powerhouse.
- The intake trash rack is sized to provide minimal intake velocities at the trash racks. We do know from discussion with the Michigan Department of Natural Resource (MDNR), Fisheries Division, that it will be their preference to have an intake at the lower elevations of the impoundment. This is preferred in order to provide mixing of impoundment waters in order to minimize temperature stratification in the vertical water column. The MDNR also indicated that fish protection would need to be evaluated in the intake design. The concern is for turbine mortality for the various fish species. For the purpose of this study, we will assume an intake velocity of 1.5 ft/sec and an intake bar spacing of 1-inch clear spacing. This should result in a net velocity through the racks of approximately 2 ft/sec, which by industry standards is typically satisfactory for fish entrainment and mortality concerns. The resultant trash rack size is 14-feet high by 36-feet wide. The bottom of the racks would be placed 15-feet below normal headwater i.e. top of rack would be 1-foot below normal headwater. A concrete breast wall with access platform for cleaning the racks would be provided. It should be noted that at Geddes, the bottom elevation of the proposed intake appears to be above the elevation of the existing right (south) spillway and slightly below the elevation of the existing left (north) spillway. This is based on review of the 1970 reconstruction drawings, and should be confirmed through further review of the original Geddes powerhouse drawings. If this is confirmed, then some protection of the left (north) spillway will be required during excavation to prevent undercutting of that spillway. An allowance has been provided in the preliminary cot estimate for this work.
- The forebay section of the powerhouse will be a transition from the trash rack section to a narrower turbine intake. It is proposed that this would be a open-flume concrete lined forebay. The convergence angle should be maintained between 15 and 30 degrees. A head gate is placed at the downstream terminus of the forebay used for dewatering of

the powerhouse. For the purpose of this study, we have assumed a permanent, steel bulkhead head gate with lifting superstructure and crane. This head gate would be approximately 15-feet wide by 15-feet high.

- The powerhouse substructure will be sized to accommodate the proposed turbine, speed increaser and generator. Fabricated steel access stairs, railings and platforms will be used to enhance operator access. A removable hatch will be placed above the turbine generator equipment for maintenance removal of these equipment components, should that be required. A masonry powerhouse superstructure is envisioned. This would be a single story structure and would house switchgear and station power equipment, as well as provide access to the powerhouse substructure.
- A reinforced concrete draft tube approximately 10-feet high by 15-feet wide would be placed beneath the existing roadway with an exit point at the existing downstream retaining wall between the two spillways. This retaining wall would be reconstructed with a new reinforced concrete retaining wall. A fabricated steel tailgate, 15-feet wide by 10-feet high, is assumed. No lifting structure or crane is assumed as the gate would be installed by a portable crane located on the nearby roadway.
- Tailwater dredging would be required since the discharge elevation will be beneath the existing stream bed. This excavation, which would be sloped at approximately 1 vertical to 4 horizontal, would be lined with heavy riprap to prevent stream bed scour.
- Produced power would be interconnected to the existing utility grid. In the case of Argo Dam, there is an existing transmission line which follows the north side of the millrace to an existing switch yard adjacent to the historic powerhouse. In the case of the Geddes Dam, there is existing electrical distribution transmission lines on either side of the river with an existing switch yard located on the right (south) side of the river a few hundred feet from the spillway. A detailed evaluation will need to be performed to determine the proper interconnect point.

A preliminary estimate of probable cost has been prepared for the above described development option. The estimate was performed at the Geddes site, but since the development options for the two sites are similar, it is anticipated that the estimated cost at Argo will also be similar. A summary of the estimated probable cost is shown in Table 1. The subtotal for the direct construction cost is approximately \$3,328,000. After including indirect costs the total estimated probable project cost increases to \$4,358,000.

**TABLE 1
PRELIMINARY ESTIMATE OF PROBABLE COST**

DIRECT CONSTRUCTION COSTS	
Mobilization	\$ 90,000
Site Clearing/Soil Erosion Control (SEC)	\$ 11,000
Dewatering	\$ 245,000
Demolition	\$ 30,000
Earthwork	\$ 311,000
Concrete Work	\$ 830,000
Powerhouse Superstructure	\$ 106,000
Miscellaneous Metals	\$ 83,000
Turbine Generator Equipment	\$ 1,410,000
Electric Interconnection	\$ 151,000
Controls/Instrumentation	\$ 40,000
Site Improvements	\$ 21,000
Subtotal Direct Construction Cost	\$ 3,328,000
INDIRECT COSTS	
Licensing/Permits	\$ 300,000
Engineering	\$ 350,000
Legal/Financial	\$ 50,000
Contingency (10%)	\$ 330,000
Subtotal Indirect Costs	\$ 1,030,000
TOTAL PRELIMINARY ESTIMATE OF PROBABLE COST	\$ 4,358,000

4.0 LICENSE/PERMITS

4.1 LICENSE/PERMITS

As is the case with the existing Barton and Superior sites, any hydroelectric redevelopment will require that the City file for an operating license from the Federal Energy Regulatory Commission (FERC). One exception to this rule may be if the City were to utilize all generated power internally. In other words, the proposed facility, including interconnected loads, would be completely off grid. In this case, the City could confirm the need for a FERC license by applying to FERC for a Determination of Jurisdiction. **Appendix F** contains more information on the FERC licensing process, including the procedure for jurisdiction determination.

An allowance of \$300,000 has been provided in the preliminary estimate of probable cost for the FERC licensing. This cost is highly dependent on the number and extent of environmental studies required to be performed as part of the license application. A copy of the MDNR/MDEQ study guidelines for FERC licensing is attached in **Appendix G**. Per conversations with MDNR/MDEQ representatives, it can be expected that a thorough review of environmental issues will be required as part of any FERC license process. Should the City desire to move to the next phase of effort, further communication with resource agencies is recommended.

In addition to the cost for filing the FERC license, it can be expected that there will be additional conditions imposed and obligations to be met as part of the FERC license. Many of these relate to dam safety issues as FERC has a rigorous dam safety program. Both the Barton and Superior sites have experienced this oversight and associated costs. These costs are included as on-going operation costs and are included in our annual estimate of \$110,000/yr/site, which is based on historical data from the Barton and Superior sites. One item which highlights the impact of the FERC license requirements regarding dam safety is establishment of the inflow design flood (IDF), or spillway design flood as it is sometimes termed, for FERC sites. Under the State of Michigan jurisdiction, the spillway design flood is defined as a 200 year flood for high hazard dams such as the Argo and Geddes sites. This is a little less than 10,000 cfs for these sites. Under FERC guidelines, the inflow design flood must meet Probable Maximum Flood (PMF) criteria, which has been estimated to be approximately 23,000 cfs. Neither the Argo nor the Geddes dams have adequate spillway capacity to meet the PMF flows. In this case, FERC allows the applicant to perform an incremental hazard evaluation to determine if the inflow design flood can be established at a flow lower than the PMF. This study was performed for both the Barton and Superior sites, which resulted in an IDF of 0.6 and 0.7 PMF respectively. It is anticipated that this study will be required at both the Argo and Geddes sites should they be developed. While FERC does not require this study to be performed as part of the license process (it is typically performed as part of the initial Part 12 Safety Inspection Report) it would be prudent for the City to undertake this study in order to determine if indeed the IDFs can be lowered within the existing spillway capacity. If not substantial expense could be incurred to increase the spillway capacity at each site. Further study is needed to determine how this could best be accomplished; however, it is possible that this could involve millions of dollars at each site.

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**APPENDIX A
Flow Data**

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**USGS
Flow Data**

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**APPENDIX B
Manufacturer Quotes**

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Canadian Hydro Components, Ltd.

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**HTS, Inc.
(Ossberger)**

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VA Tech Hydro

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**APPENDIX C
Site Layout**

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**APPENDIX D
Power Production Tables**

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**HTS, Inc.
(Ossberger)**

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**APPENDIX E
Historical Power Production
(Barton and Superior)**

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**APPENDIX F
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**APPENDIX G
MDNR/MDEQ Study Guide**