Birch Avenue Municipal Class EA

Drainage and Stormwater Management Report

Prepared for the City of Hamilton
by IBI Group
January 20, 2020

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1 Introduction

The City of Hamilton is undertaking a Municipal Class Environmental Assessment (MCEA) for the proposed improvements to Birch Avenue from Burlington Street East to Barton Street East. IBI Group has been retained by the City of Hamilton to complete a Schedule “B” EA under the Municipal Class EA (MCEA) process for the proposed improvements to Birch Avenue. The project limits are illustrated in **Figure 1**.

The City of Hamilton is undertaking the construction of the Hamilton Transit Maintenance and Storage Facility (MSF) at 80 Brant Street (with access off of Birch Avenue). Through the construction of this facility, changes will have to be made to Birch Avenue to accommodate the new user demands.

The stretch of Birch Avenue (between Burlington Street East and Barton Street East) currently has three lanes in one direction and has three rail bridges (Bridges 330, 331, and 332). To accommodate for transit vehicles, the road will be converted to two-way. **Figure 2** provides the location of three bridges.

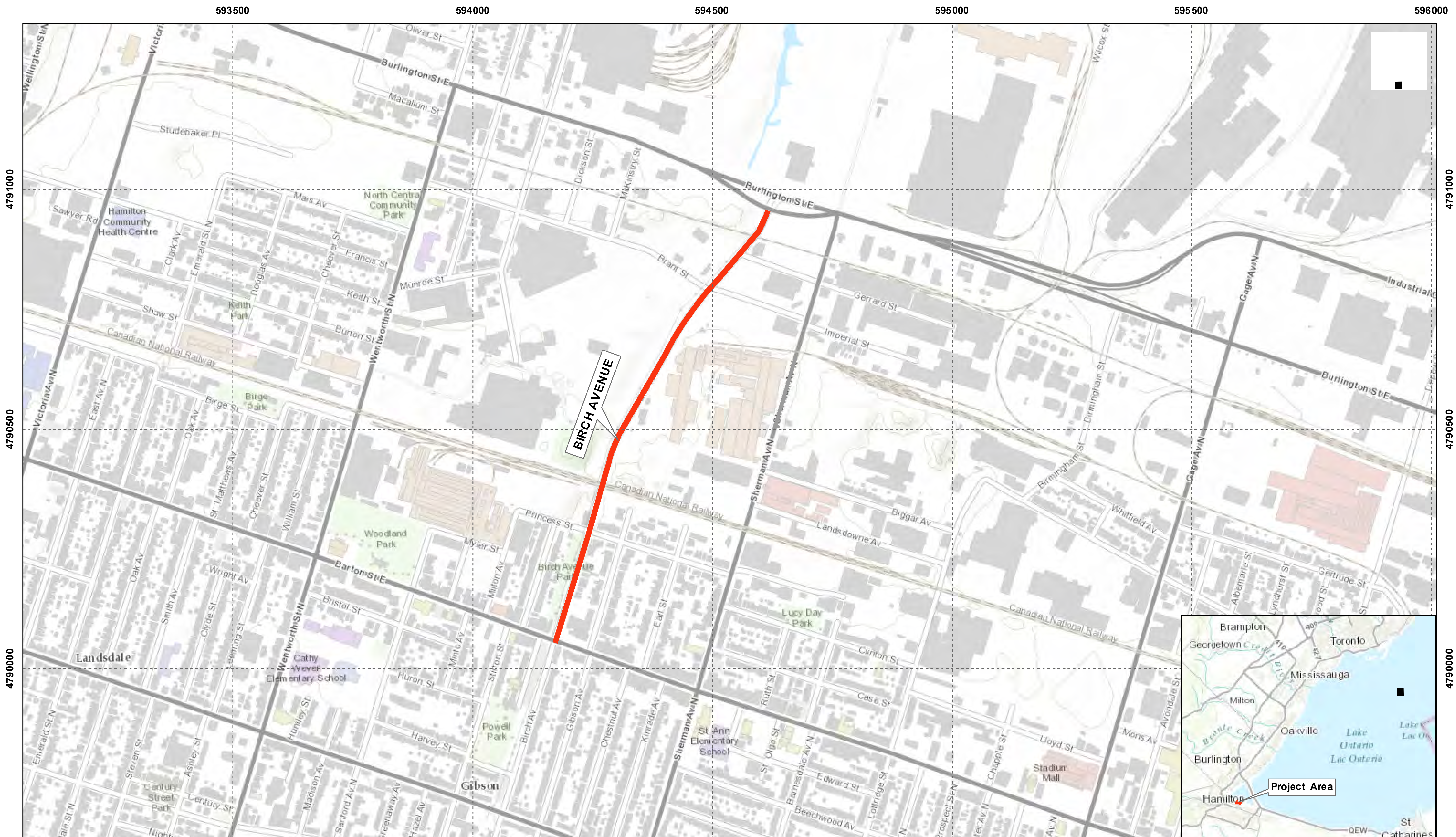
Changes in engineering standards, pertaining to road clearance under bridges, have made the bridges no longer compliant. Bridge 331 will be removed; however, a recommendation will be made through this EA study to address clearance issues under Bridges 330 and 332. The bridge clearance options of lowering the road will create challenges regarding stormwater management.

This Stormwater Management (SWM) Report is a supporting document to the Class EA for the proposed improvements to Birch Avenue. It serves to summarize the existing drainage conditions and proposed drainage and SWM Plan to mitigate the existing drainage issues along the Birch Avenue corridor. The overall focus of the study is to achieve a 2-year level of service for Birch Avenue between Barton Street East and Burlington Street East.

2 Study Scope

The following describes the tasks covered in the study to meet the stormwater management challenges identified for the preferred solution:

1. Delineate drainage area at the underpasses where bridges are located;
2. Establish design stormwater runoff rates;
3. Concepts to minimize runoff volume to be managed (minimizing drainage catchment, infiltration/diversion opportunities such as Low Impact Development technologies, etc.);
4. Establish required hydraulic capacity of pump station alternatives;
5. Forcemain route option;
6. Outfall/discharge location options, including combined sewer versus discharge to harbor;
7. Identify land/footprint requirements for stormwater infrastructure;
8. Pumping station and generator location options and property needs;
9. Wet well configuration, and
10. Constructability, maintenance/repair access, and cost of alternatives.



No.	REVISIONS	INITIAL	DATE	REFERENCE MATERIALS	ACTIVITIES

0 62.5 125 250 m

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BIRCH AVENUE
Key Plan

Figure- 1

Figure 2: The Location of Railway Bridges

3 Background Information

Previous studies and reports related to hydrology, hydraulics, stormwater management, and adjacent development plans were obtained from the City of Hamilton and reviewed, and are listed below:

- City of Hamilton, Stormwater Master Plan – Class Environmental Assessment Report (City-Wide), Prepared by Aquafor Beech Limited, May 2007
- Birch Avenue Stormwater Modelling and Flood Relief Study Report, City of Hamilton, prepared by McCormick Rankin, April 2013
- Technical Memo on Birch Avenue Sewer Capacity Analysis, prepared by GM BluePlan Engineering, February 2, 2017

- Draft Report for Flooding and Drainage Master Servicing Study, City of Hamilton, prepared by Aquafor Beech Limited, June 7, 2019
- Geotechnical Investigation Report for Proposed Watermain, Birch Street, Hamilton, Ontario, Prepared by Terraprobe, April 13, 1997
- City of Hamilton, Geotechnical Investigation Report for Proposed Road Reconstruction and Watermain Replacement, Birch Avenue, Hamilton, ON, Prepared by EXP Services Inc., dated November 13, 2018

4 Site Description

Within the project limits, Birch Avenue is principally a three-lane one-way urban arterial road with an additional turning lane at the intersection of Barton Street East. The existing right-of-way (ROW) generally varies from 13.0 m to 19.5 m. Sidewalk is available mostly on the east side of Birch Avenue. However, from the intersection of Barton Street East to approximately 415 m north, sidewalks are available on both sides of Birch Avenue. Birch Avenue is a straight roadway throughout the study corridor and follows a relatively flat topography. The topography within the project limits rises slightly toward the south and gently undulates at three low/sag points located at the railway crossings.

Given the urban context of the study area, natural heritage features are generally limited to ornamental plantings, manicured lawns, and grassed strips.

Within the project limits, there are no aquatic features (watercourses) or areas that would be designated as Areas of Natural and Scientific Interest (ANSI), Environmentally Sensitive Areas (ESA), or Provincially Significant Wetlands (PSW). Currently, there are three railway underpasses that exist on Birch Avenue between Princess Street and Burlington Street East.

4.1 Existing Land Use, Soils, Groundwater and, Physiography

The Birch Avenue study area primarily consists of industrial landuse; there is a steel factory along the east side, a City Works yard to the west (between Princess Street and Brant Street), and a hydro corridor adjacent to Birch Avenue on the west side.

The site is located within the Iroquois Plain physiographic region of Southern Ontario which stretches along the eastern and the southern shores of western Lake Ontario. The site is also situated within the former Sherman Inlet. In the early twentieth century, fill was imported from off-site sources to fill the Sherman Inlet and associated wetland. The results of the geotechnical investigation report “Geotechnical Investigation, Proposed Watermain, Birch Street, Hamilton, Ontario, prepared by Terraprobe, dated April 13, 1997, revealed that the depth of fill in the boreholes ranged from 0.6 m to 1.2 m along Birch Avenue. Organic silt to silty clay material present beneath the fill.

The groundwater levels measured in the open boreholes immediately following the drilling ranged from about 1 m to 3 m below the existing ground surface as reported in the above referenced Geotechnical Investigation report.

4.2 Existing Drainage Conditions

The study area falls within the Urban Hamilton watershed as shown on the Hamilton Conservation Authority’s watershed map. Drainage within the study area is principally influenced by topography, land cover, and grade changes along Birch Avenue. Within the project limit, Birch Avenue is a three-lane one-way urban roadway section with curbs, gutters, and pedestrian sidewalks. Stormwater resulting from minor storm events is conveyed by trunk storm relief sewer and discharged to Lake Ontario through the outlet located north of Burlington Street East. Major system flows within the roadway corridor are conveyed to existing outlets as roadway overland flow.

The Birch Avenue study area is situated primarily on an overland flow route. There are existing drainage and flooding issues along Birch Avenue. These issues include: large external drainage areas that contribute flows to the storm trunk relief sewer; external major overland flow through Birch Avenue; the invert elevation of the storm trunk relief sewer; and, the hydraulic effect of the Lake Ontario water levels on the sewer performance. The study area is located within the City's combined sewer servicing catchment area, and the storm relief sewer on Birch Avenue receives combined sewer overflows at different spots, including at the overflow location at Princess Street.

A review of topographic maps and the Digital Elevation Model (DEM) (provided by the City of Hamilton) was conducted and external catchment areas for each of the bridge underpasses were delineated for major and minor system flows. The catchment area map for the major system is shown on **Figure 3**. The catchment area is completely urbanized and serviced by combined and partially separated sewers.

The Birch Avenue trunk storm relief sewer extends from King Street (140 m west of Sherman Avenue), north on Sherman Avenue to Barton Street, west on Barton Street to Birch Avenue and north on Birch Avenue to the outlet located north of Burlington Street East. There are also storm sewer legs which extend west along Beechwood Avenue and Rosemont Avenue. The eastern sewer legs collect a significant amount of flow from the primary overland flow route which passes through residential properties between Sherman Avenue and Barnesdale Avenue. The catchment area map for minor system including storm sewer networks is presented on **Figure 4**.

There are no watercourses documented or observed during site investigations within the study area, so consequently there are no watercourse crossings within the drainage scope of work for the Birch Avenue improvements.

DWG. No. 001 presented in **Appendix A** depicts the existing condition drainage within the project limits, including existing infrastructure and landscaping, drainage area discretization, outlets, and the direction of overland flow routes.

BIRCH AVENUE CATCHMENT AREA

No.	REVISIONS	INITIAL	DATE	REFERENCE MATERIALS	ACTIVITIES

0 25 50 100 m

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Design Manager

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Public Works Department

BIRCH AVENUE
MAJOR CATCHMENT AREA

Figure-3

BIRCH AVENUE CATCHMENT AREA

4.3 Existing Drainage Elements

4.3.1 Storm Relief Sewer

Under existing conditions, runoff from Birch Avenue is primarily collected by catchbasins, conveyed by storm relief sewers, and finally discharged into Lake Ontario through the outlet located north of Burlington Street East.

The existing storm relief sewer along Birch Avenue is a concrete structure with the size of 1450 mm X 1800 mm, located under the sidewalk on the east side of Birch Avenue between Burlington Street East and Princess Street. On the south side of Princess Street along Birch Avenue, the size of the storm relief sewer changes to 1200 mm X 1550 mm. The slope of the storm relief sewer along Birch Avenue between Barton Street East and Burlington Street East varies from 0.05% to 0.4%. These low gradients reduce the sewer capacity significantly. The obvert of the sewer is above the road elevation, particularly within the road sags at the railway underpasses. The storm relief sewer is integral to the footings of each of the three railway bridge abutments.

4.3.2 Combined Sewer

The catchment area, located south of Princess Street, is serviced by the existing combined sewer system. The existing sewer along Birch Avenue also has a combined sewer which varies in size and gradient. The combined sewer between Wilson Street and Princess Street has a 600 mm X 900 mm non-circular section and the slope varies from 0.3% to 0.6%. Between Barton Street East and Princess Street, there is a parallel storm relief trunk sewer (1200 mm X 1314 mm) in addition to the 600 mm X 900 mm combined sewer. The storm relief sewer flows north towards Burlington Street East, while the combined sewer (600 mm X 900 mm) connects to the Princess Street combined sewer system and continues to flow east.

The combined sewer networks, located at the intersection of Birch Avenue and Princess Street, discharge wet weather flow into the Birch Avenue storm relief sewer through an overflow chamber located at the intersection of Birch Avenue and Princess Street. The low flow (sanitary flow) is conveyed east along Princess Street, through the combined sewer system. As a result, the storm and sanitary sewer system are completely separate along Birch Avenue from Princess Street to the outfall located north of Burlington Street East.

Princess Street intersection improvements were completed near Manhole HJ07E045 to prevent inflow of dry weather flow into the Birch storm trunk relief sewer by reinstalling an overflow weir. The location of the manhole is provided in **Figure 5**.

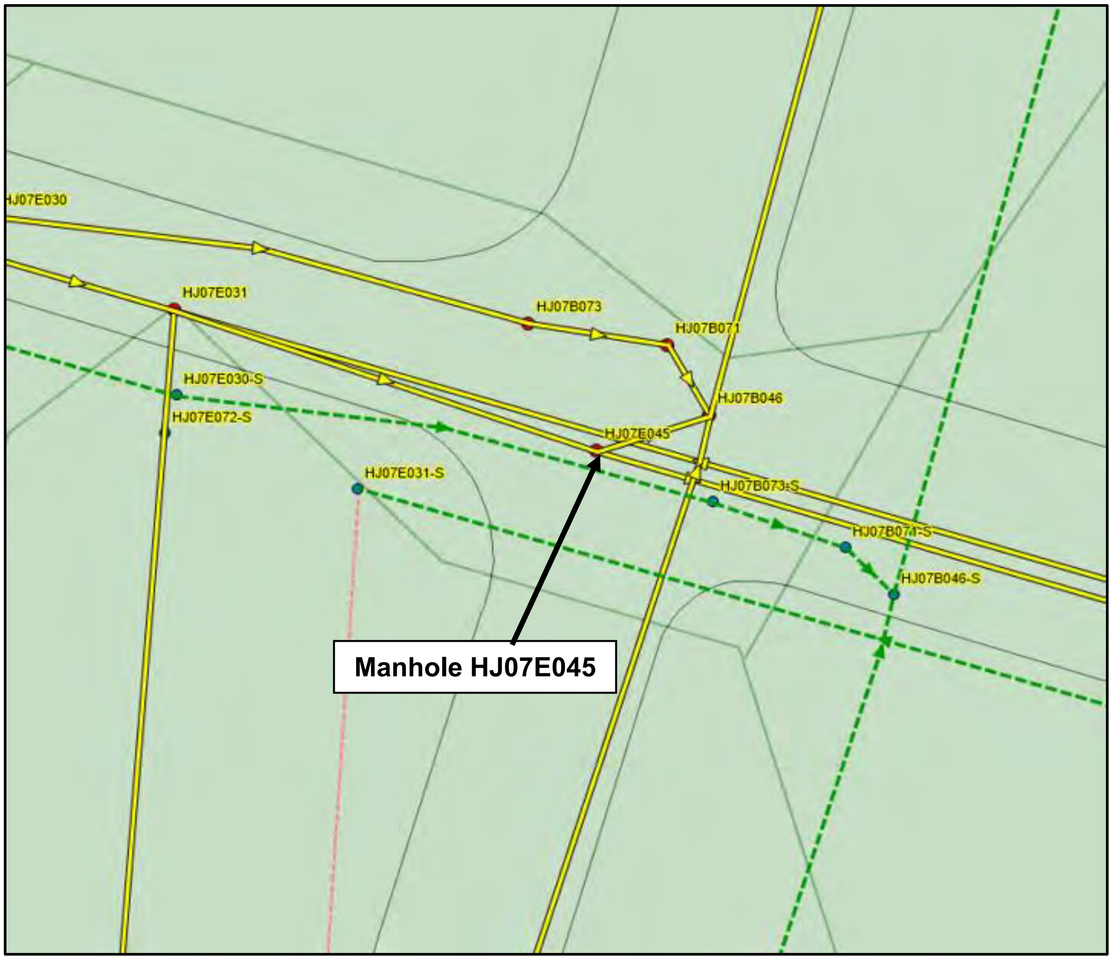


Figure 5: The Location of Manhole HJ07E045

4.3.3 **Sanitary Sewer**

There is an existing sanitary sewer that runs north along Birch Avenue to service Birch Avenue adjacent areas. This sanitary sewer starts at the railway crossing interchange located just north of Princess Street, continues north, and discharges into the Burlington Street East sanitary sewer system. The sanitary sewer size varies from 300 mm to 450 mm and the slope varies from 0.19% to 0.57%.

5 Flooding Issues

As mentioned previously, there are three low/sag points located along Birch Avenue at the three railway underpasses. The slope of the existing storm relief sewer along Birch Avenue, between Barton Street East and Burlington Street East, varies from 0.05% to 0.4%. These low gradients reduce the sewer capacity significantly. Therefore, it is well recognized that the capacity of the existing storm sewer on Birch Avenue is not adequate to convey the required design flows. This inadequate flow capacity of the storm sewer results in undesirable flooding and level of service at the three railway underpasses. Also, the obvert of the storm relief sewer at some locations is above the road elevation, particularly within the low/sag points at the railway underpasses.

Another significant factor for flooding, associated with the Birch Avenue storm relief sewer and roadway, is the level of Lake Ontario and its hydraulic effect on the sewer's outlet. Summer average lake level is approximately 75.0 m as shown in **Figure 6**. The top of road elevations at the railway underpass sags are 75.69 m, 76.0 m, and 76.40 m for the north, middle, and south railway crossings, respectively. The sewer inverts range between 74.29 m at Burlington Street East, 75.0 m just north of south railway underpass, 75.20 m at Princess Street, and 76.29 m at Barton Street. Therefore, the sewer invert is typically wet up to just north of the south railway underpass.

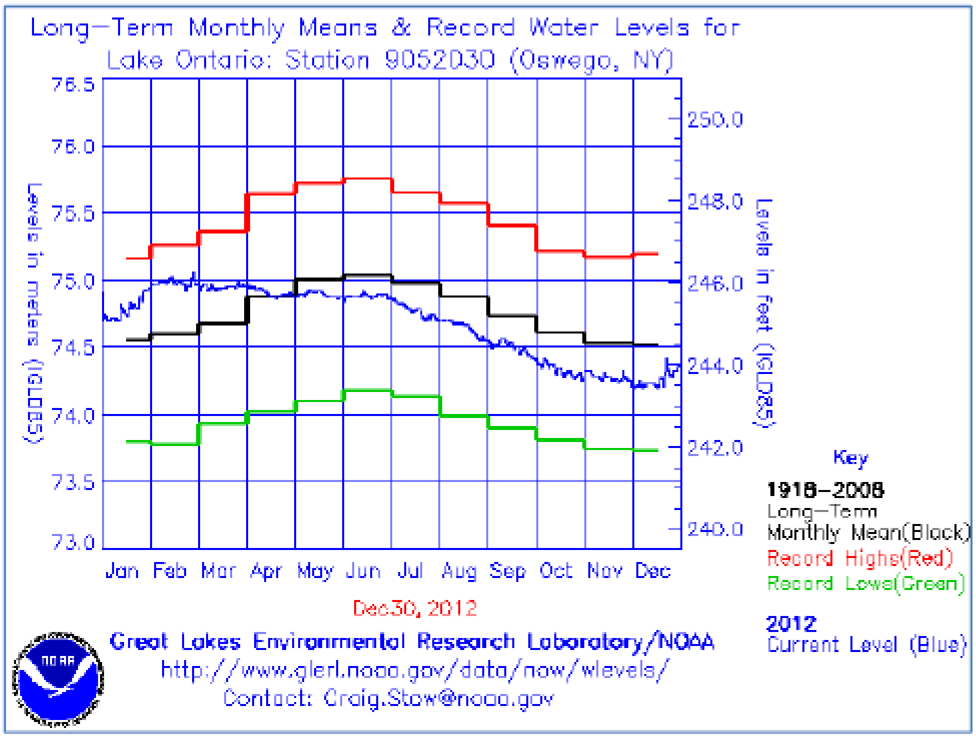


Figure 6: Lake Ontario Average Water Levels

6 Birch Avenue Improvements

A new Bus Maintenance and Storage Facility (MSF) is planned at Birch Avenue and Brant Street, and the City desires improvements to active transportation along the corridor. The Birch Avenue improvements, as part of this project, will include incorporating a multi-use path on the west side of Birch Avenue between Princess Street and Burlington Street East. The proposed improvement also includes localized intersection improvements along the entire corridor. Existing catchbasins will require minor adjustments or relocation where curb lines are to be shifted as part of the proposed design. The shift to two-way operations from Burlington Street East to Barton Street East provides the opportunity to address two existing issues along the corridor – low clearance at two railway crossing bridges and drainage issues. Both of these pose safety issues to road users and may impact the operation of the proposed MSF in adverse conditions.

The existing railway bridge located south of Brant Street is proposed to be removed and the low point located at this crossing will be improved to provide a positive roadway drainage for this location. Due to the low clearance at the existing south and north railway crossing bridges, the Birch Avenue road profile at those railway crossing locations is proposed to be lowered to increase the existing traffic clearance. **Appendix B** includes typical cross-sections which represent the proposed condition. In general, the proposed changes to the existing cross-section will have little impact to the overall pavement area and are not expected to significantly impact drainage along Birch Avenue within the project limits.

7 Hydrologic Analysis

A detailed hydrologic analysis was conducted to determine the peak flow rates for both minor and major storm events at the Birch Avenue low/sag points located at the two railway crossing locations (Bridge 332 and Bridge 330). The peak flow rates were determined using a PCSWMM model. The following sections provide a brief description of the hydrologic methods that are used for the flow calculations.

DWG. No. 002A, presented in **Appendix C,** depicts the proposed condition within the project limits, drainage area discretization, outlets, and the direction of overland flow routes. The existing internal and external catchment areas have been maintained in the proposed condition, as well as the existing outlet and drainage patterns.

7.1 Hydrologic Analysis Using PCSWMM Model

A dual drainage model was developed for Birch Avenue using PCSWMM to assess the performance of the existing major and minor drainage systems. It includes the sewer system (minor system designed for smaller storm events), the overland flow paths (major system for higher storm events), and the connection (manholes and catch basins) between the two systems. PCSWMM has the ability to carry out design and analysis of (i) new, (ii) existing, and (iii) combined new and old urban drainage systems where surface flows are routed over the land surface (major system, such as roads, swales, street sags, and storage areas) while part of the runoff simultaneously flows in the underground conveyances (minor system, such as sewer pipes and associated infrastructure).

7.1.1 **Modeling Overview**

The minor system's performance was assessed based on maximum hydraulic grade line in the sewer, and percent pipe full capacity. The major system was evaluated on the basis of ponding depths / extents, and flooding frequency.

The hydraulic and hydrologic data were collected and compiled into suitable formats, and were used to build the dual drainage system. The major system was then created parallel to the minor system. The major systems were assigned the road cross-sections at various points in accordance with as-built drawings and topography.

Overall, the dual drainage model boundary starts from Barton Street East and extends to Burlington Street East covering a 114.46 ha area, which consists of 172 sub-catchments, 71 conduits (including major and minor sewers and roads) and 73 junctions (manholes).The model layout is presented in **Figure 7.**

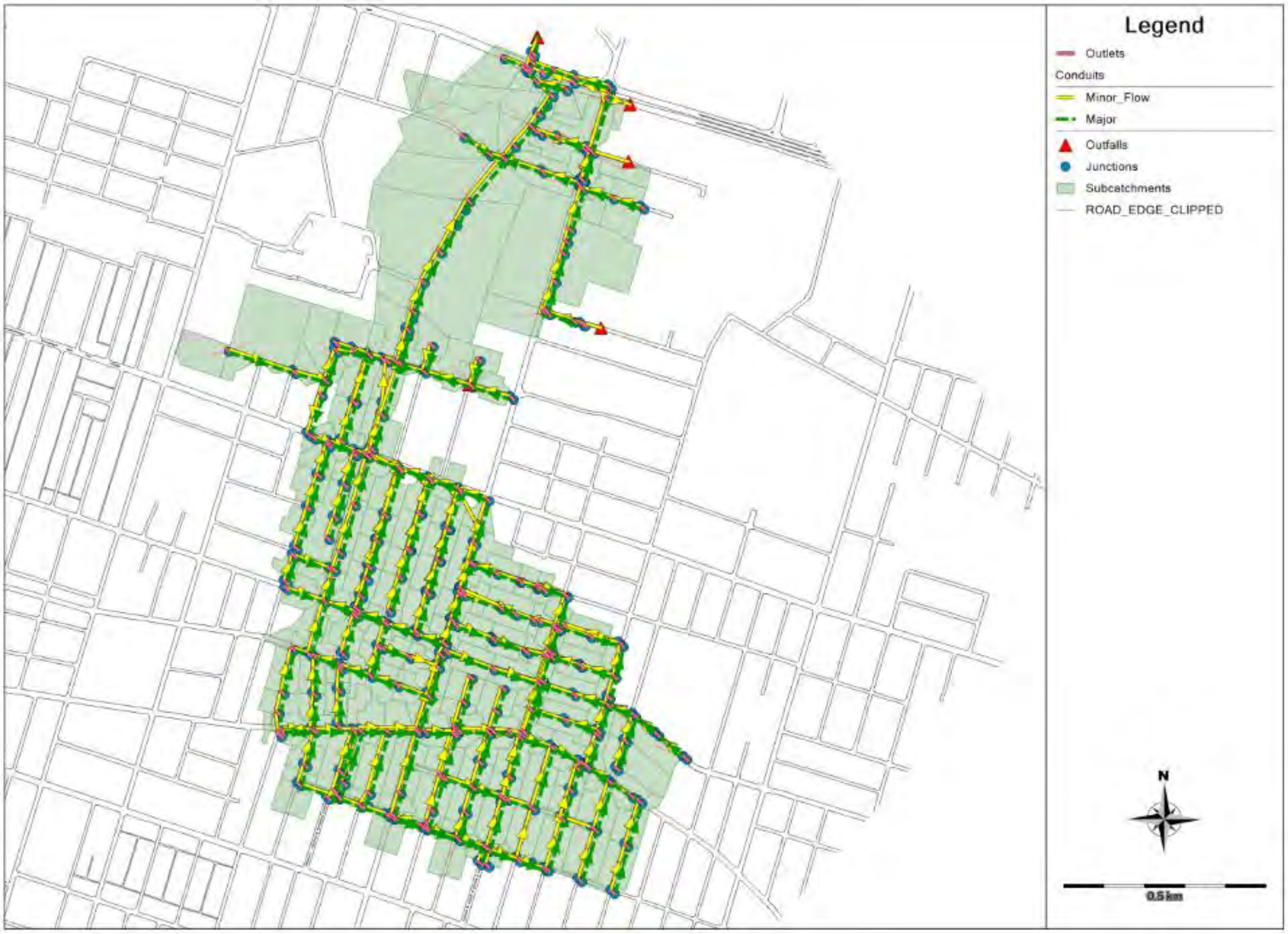


Figure 7: PCSWMM Model Layout

7.1.2 **Hydrology**

Surface hydrology includes determination of the flow rate, runoff volume, and timing (hydrograph) for a sub-catchment area by considering various factors, such as expected rainfall intensity (hyetograph), existing land use, sub-catchment delineation, infiltration, depression storage, Manning's roughness for pervious and impervious areas, percent directly connected impervious areas, and flow path length.

The City of Hamilton prescribed SCS Type II, 6 hour duration hyetograph for Mount Hope station to be used as design storm for computing runoff flow rates. The hyetograph is shown in **Appendix D**.

The average imperviousness of each sub-catchment was calculated as an area-weighted average. The different land uses in GIS data were reviewed against the aerial photo to confirm the percent impervious.

Based on different land use types, Manning's roughness coefficient of 0.013 was assigned to represent the concrete surface of road pavement and sewers. Manning's roughness coefficient of 0.24 was applied for pervious area, such as park and open space.

Typical depression storage values of 2.5mm and 5mm were assumed for impervious and pervious areas, respectively. The Horton Infiltration method was used to simulate infiltration in the model.

The dual drainage model was run for all storm events up-to the 100-year storm events. A summary of peak flows for different storm events at the two railway crossing locations are presented in **Table 1**.

Table 1: Summary of Peak Flows by PCSWMM Model

ANALYSIS POINT	TOTAL AREA (HA)	STORM EVENT	EXISTING STORM SEWER PEAK FLOW (M^3/SEC)	OVERLAND PEAK FLOW (M^3/SEC)	TOTAL FLOW (M^3/SEC)
South Railway Crossing (332)	80.18	2-Year	4.29	0.28	4.57
		5-Year	5.05	0.33	5.38
		10-Year	5.08	0.34	5.42
		25-Year	5.14	0.34	5.48
		50-Year	5.17	0.34	5.51
		100-Year	5.19	0.33	5.52
North Railway Crossing (330)	112.12	2-Year	3.55	1.14	4.69
		5-Year	3.87	2.25	6.12
		10-Year	4.06	2.51	6.57
		25-Year	4.21	2.67	6.88
		50-Year	4.31	2.71	7.02
		100-Year	4.39	2.70	7.09

7.2 Birch Avenue Existing Sewer Capacity

As mentioned previously, the existing storm relief sewer along Birch Avenue is a concrete box section with varying size and slopes. The PCSWMM model provided maximum flow conveyance capacity of the storm relief sewer and is presented in following **Table 2**.

Table 2: Conveyance Capacity of Existing Storm Relief Sewer

LOCATION	SEWER SIZE (MM X MM)	SLOPE (%)	FLOW CONVEYANCE CAPACITY (M^3/SEC)
Between Barton Street and Princess Street	1200 X 1550	0.4	3.66
Between Princess Street and Brant Street	1450 X 1800	0.4	4.28
	1450 X 1800	0.1	3.28
	1450 X 1800	0.08	3.03
Between Brant Street and North Railway Crossing	1450 X 1800	0.18	3.45
Between North Railway Crossing and Burlington Street East	1875 X 1800	0.05	3.63

As seen in **Table 2** above, the existing storm relief sewer has different flow conveyance capacity depending on the corresponding size and slope of the storm sewer. The minimum flow conveyance capacity of 3.03 m^3/sec has occurred between Princess Street and Brant Street. Therefore, the existing storm relief sewer along Birch Avenue does not have enough conveyance capacity to convey 2-year storm flow at certain locations within the study area.

8 Drainage Design Options

The current flooding, due to major and minor storm events at the underpasses and adjacent roadway areas, will further be impacted by the proposed road improvements.

8.1 Road Improvement Options

The proposed roadway improvements will change Birch Avenue from a one-way to a two-way road and will improve the active transportation facilities along the corridor. If the existing roadway profile and low clearance at the two railway crossing locations are maintained, these will remain posing safety issues to road users and may impact the operation of the proposed MSF.

Lowering the Road at Two Railway Underpass

The proposed Birch Avenue road improvements will require lowering the road profile to provide adequate bridge clearances at the south and north underpasses. The following road lowering options are being considered at the two underpasses:

Option 1: Maintain Existing Condition

Option 2: Lowering Road by 0.3 m

Option 3: Lowering Road by 0.6 m

Table 3: Road Lowering for the Bridge Clearance at South and North Underpasses

LOCATION	STORM EVENT	FLOODING DEPTH (M)		
		Option 1: (Maintain Existing Condition)	Option 2: (Lowering Road by 0.3m)	Option 3: (Lowering Road by 0.6m)
South Railway Crossing (332)	2-Year	0.53	0.68	0.83
	5-Year	0.53	0.69	0.83
North Railway Crossing (330)	2-Year	0.72	0.85	0.97
	5-Year	1.02	1.16	1.30

The above options of profile-lowering will significantly increase the flooding depth at both underpasses. **Table 3** provides impacts on flooding depths resulting from the three options.

The obvert of the storm relief sewer is approximately 500 mm and 400 mm above the road surface at the south and north railway crossings, respectively, and therefore significantly above the road at the two railway underpasses.

The most significant factor for flooding associated with the Birch Avenue storm relief sewer and roadway is the level of Lake Ontario and its hydraulic effect on the sewer's outlet. Summer average lake level is approximately 75.0 m as shown in **Figure 6**. The top-of-road elevations at the railway underpass sags are 75.69 m and 76.40 m for the north and south railway crossings, respectively. The existing middle underpass is not discussed in this report as the City has confirmed that the railway crossing will be removed and the sag will be eliminated.

With the lowering of the road, it will not be possible to capture and discharge all major flows solely through a gravity sewer. The lowering of the road profile below the Lake Ontario water level will make storm pumping inevitable. The sewer inverts range between 74.29 m at Burlington Street East, 75.0 m just north of the south railway underpass, 75.20 m at Princess Street, and 76.29 m at Barton Street. Therefore, the sewer invert is typically wet up to just north of the south railway underpass.

A 2-year level of protection is targeted for the storm system. This would provide emergency vehicle access during the 2-year design storm (The MTO Highway Drainage Design Standards, January 2008, SD-7 for Depressed Roadways and Underpasses indicates that the maximum depth of flooding in a road sag should be 30 cm measured from the crown of the roadway to ensure that emergency vehicles can access or traverse a depressed roadway).

The analysis of alternatives is provided in **Table 4** where each of the alternatives is summarized and includes the following information:

- Road lowering options (the alternatives considered);
- Flooding depth;
- Level of service;
- Pumping;
- Constructability;
- Drainage/pumping outlet;
- Impact on existing storm sewer and,
- Road lowering preference.

Based on the above analysis of alternatives, the preferred alternative is to lower the road between 0.3m and 0.6m so as to achieve the desired bridge clearance.

8.2 Potential Peak Flow Reduction Measures

A number of potential peak flow reduction measures were considered in order to reduce the underpass pumping rates required to address flooding on Birch Avenue. A description of each measure is described below.

1. "Do Nothing" Alternative

If the existing roadway profile and low clearance at the two railway crossing locations are maintained, these will remain posing safety issues to road users and may impact the operation of the MSF. Since there are potential negative consequences associated with the "Do Nothing" alternative it cannot be considered a reasonable or acceptable course of action.

2. Low Impact Development (LID) Measures

This measure includes the provision of an underground infiltration system upstream of the south and north underpasses. The current catchbasins upstream of the south underpass (Bridge No. 332), located along the west curb line of Birch Avenue, will be disconnected

Table 4: Analysis of Alternatives
Birch Avenue Municipal Class Environmental Assessment
Drainage and Stormwater

Alternative ID	Flooding Depth	Level of Service	No of Railroad Crossings	Pumping*	Constructability/ Property*	Secondary Benefit of Pumping	Outlet to Harbour	Existing Storm	Preference
Maintain As Is (Do Nothing)	*Max Flood Depth at South Underpass, 332:* 2-year: 0.53 m 5-year: 0.53 m *Max Flood Depth at North Underpass, 330:* 2-year: 0.72 m 5-year: 1.02 m	Less than 2-year level of service.	3 Underpasses.	No. *South sag:* 76.40m *North sag:* 75.69m Lake: 75.0m	-	-	-	Exposed by 0.5 m	-
Lower Road Profile by 0.30m (Provide 0.3 m additional clearance to bridge, construct pumping station, provide LID underneath 3 m wide MUP.)	*Max Flood Depth at South Underpass, 332:* 2-year: 0.68 m 5-year: 0.69 m *Max Flood Depth at North Underpass, 330:* 2-year: 0.85 m 5-year: 1.16 m	2-year level of service. 2 year-flood frequency moderate (50% chance any given year).	2 Underpasses (crossing 331 will be eliminated).	Yes. South sag: 76.10m North sag: 75.39m Lake: 75.0m	Property required, pumping station, 1 km long forcemain and access to pump house	Provides relief to upstream areas.	No, existing can be utilized.	Exposed by 0.8 m	Preferred: underpass elevations are still above lake levels, exposed sewer depth is lesser, frequent pumping is avoidable, & will not require backwater flow preventer.
Lower Road Profile by 0.60 m (Provide 0.6 m additional clearance to bridge, construct pumping station, provide LID underneath 3 m wide MUP.)	*Max Flood Depth at South Underpass, 332:* 2-year: 0.83 m 5-year: 0.83 m *Max Flood Depth at North Underpass, 330:* 2-year: 0.97 m 5-year: 1.30 m	2-year level of service. 2 year-flood frequency moderate (50% chance any given year).	2 Underpasses (crossing 331 will be eliminated).	Yes. South sag: 75.80m North sag: 75.09m Lake: 75.0m North sag will go lower than the recorded highs of the Lake.	Property required, pumping station, 1 km long forcemain, access to pump house, and backwater flow preventor	Provides relief to upstream areas.	No, existing can be utilized.	Exposed by 1.1 m	Not preferred: Underpass elevations are below recorded highs in the Lake, frequent pumping required, exposed sewer depth is higher, & will require backwater flow preventer.
Lower Road Profile by 1.3m (Provide 0.6 m additional clearance to bridge, construct pumping station, provide LID underneath 3 m wide MUP.)	*Max Flood Depth at South Underpass, 332:* 2-year: 1.13 m 5-year: 1.13 m *Max Flood Depth at North Underpass, 330:* 2-year: 0.70 m 5-year: 1.01 m	-	-	South sag: 75.10m North sag: 74.39m Lake: 75.0m North sag will be lower than the normal lake level. Both will be lower than the recorded highs of the Lake.	-	-	-	Exposed by 1.8 m (entire storm trunk is exposed.)	Not Recommended.

Lowering road profile by 1.3m was not carried forward as it had significant impact on intersections and vertical curve.

The recorded water height levels in the Lake are more than 75.5 m in summer.

The size of the existing Storm Sewer is 1450 m (W)x 1800m (D).

The last leg of existing STM, d/s of Burlington St. and just u/s of Harbor outlet, has an additional capacity of 1.7m3/s.

Flooding Depths are more than 300 mm that makes pumping inevitable.

Birch Ave. Stormwater Modelling and Flood Relief Study, May 2013 recommended a combination of a new sewer along Sherman Ave. and divert Barton St. STM relief for Birch to Sherman Ave (Total Cost $11m).

In option 3, catch basins at sags will not be able to drain to the existing STM (75.8-1.3=74.5m i.e. below the invert of exist STM 75.094m). This will result in frequent pumping.

*Refer to Table 7 of the SWM report

From the existing storm line and a combination of catchbasins and side-inlets is proposed to capture major flows conveyed along the west gutter of Birch Avenue. The intent is to capture maximum road flow by increasing inlet capacity and providing maximum storage volume in chambers; this will reduce peak flow through infiltration and attenuation, thus reducing the pumping requirement at the underpasses during the 2-year storm event. The design of the storage facility would reduce outflows to an acceptable peak flow to minimize the impact on the Birch Avenue trunk sewer downstream. This option would effectively reduce pumping requirements at both underpasses, thereby reducing pumping infrastructure costs. The proposed design will be able to divert a flow of 1.26 m^3/sec to infiltration chambers.

The geotechnical investigation report "Geotechnical Investigation, Proposed Watermain, Birch Street, Hamilton, Ontario, prepared by Terraprobe, dated April 13, 1997", revealed that the groundwater levels measured in the open boreholes, immediately following the drilling, ranged from about 1 m to 3 m below the existing ground surface. According to the above-referenced report, depth of fill in the boreholes ranged from 0.6 m to 1.2 m along Birch Avenue. Organic silt to silty clay material is present beneath the fill which has an approximate infiltration rate of 10 mm/hour (reference: http://www.fao.org/3/S8684E/s8684e0a.htm) and is suitable for implementation of the underground infiltration chambers within the project area.

The LID system is proposed from the south underpass to Burlington Street East. The infiltration chambers can be installed underneath the proposed 3 m wide multi-use path on the west side of Birch Avenue. The measure will reduce the amount of major overland flow that enters the underpasses and will reduce the pumping cost. The LID will provide some hydraulic benefits; however, it will not alleviate the underpass flooding completely.

The proposed LID measure will reduce the rates of runoff to the outlets and provide a high level of treatment through the capture of both particulate and dissolved constituents. These types of facilities reduce water temperature impacts and enhance groundwater recharge. The proposed chambers will provide 1500 m^3 and 3400 m^3 of storage at the south and north underpass locations respectively. The locations of the proposed infiltration chambers are shown on **DWG. No. 002A in Appendix C**.

Due to limited space availability in the hydro corridor, this alternative was deemed infeasible. A 15 m buffer of horizontal clearance is required around each Hydro One structure to preserve the work zone required for line maintenance and to ensure the geotechnical stability of the towers. In addition, any underground installations on the hydro corridor must be designed to withstand the loading conditions created by heavy maintenance vehicles that may be used by Hydro One. The 15 m buffer zones, relative to the hydro corridor boundary, reveal that the construction of a storm relief line/infiltration chambers within this hydro corridor is not feasible. As such, this option is not recommended and is not discussed further.

3. Increased Capacity along Existing Storm Sewer Alignment

An option to upgrade the existing Birch Avenue storm sewer to provide additional hydraulic capacity was assessed. Due to the physical constraints of the sewer's existing location, enlarging the sewer vertically (rise/height) was deemed infeasible for the following reasons:

- The average water level in Hamilton Harbour (Lake Ontario) is above the invert of the sewer throughout the majority of the study area. Therefore, lowering the sewer will not provide an appreciable increase in sewer capacity, and
- The obvert of the sewer is at the road surface from Burlington Street East to just north of the south railway underpass and significantly above the road sag elevations at the underpasses. As such, providing additional capacity above the existing sewer will not benefit the surface flooding problem on Birch Avenue.

The concrete box sewer size can be increased horizontally (width); however, this will involve changes to the current road cross-section at the underpasses. The east wall of the sewer forms an integral part of the overhead railway bridge abutments. Increasing the width of the sewer will result in reduced traffic lane width on the east side of the road. The proposed sewer alignment is presented in **DWG 002B** as an Option 2 in **Appendix E**. The potential road modifications to the east will impact the existing hydro poles.

With the road design Option 2, it is feasible to increase the capacity of the storm relief sewer along its existing alignment by increasing the width of sewer from 1.45 m to 2.4 m. The hydraulic analysis suggests a new concrete box sewer of 2.4 m X 1.8 m size is feasible.

When compared with the existing conveyance capacity of the storm relief sewer, the proposed 2.4 m X 1.8 m storm sewer will increase the flow conveyance capacity from 4.29 m^3/s and 3.55 m^3/s to 4.78 m^3/s and 4.42 m^3/s at the south and north railway underpasses, respectively, for the 2-year storm event and will reduce the pumping rates moderately.

4. Diversion of Flow to New Sherman Avenue Storm Relief Sewer at Princess Street

This measure includes redirecting a portion of Birch Avenue storm flows to Sherman Avenue. A schematic showing the extent of these changes is presented in **Figure 8**. **Table 5** provides a summary of results from the diversion of flows to the new Sherman Avenue storm relief sewer at Princess Street.

Table 5: Storm Sewer Flow Conveyance Improvements

LOCATION	STORM EVENT	PROPOSED (2.4 M X 1.8 M) STORM SEWER (EXISTING STORM UPGRADE UNDER BIRCH AVENUE)			FLOW DIVERSION TO NEW SHERMAN AVENUE STORM RELIEF SERWE		
		Storm Sewer Flow (m^3/sec)	Overland Flow (m^3/sec)	Depth (m)	Storm Sewer Flow (m^3/sec)	Overland Flow (m^3/sec)	Depth (m)
South Railway Crossing (332)	2-Year	4.78	0.21	0.47	0.72	0.00	0.015
	5-Year	5.82	0.30	0.53	0.97	0.00	0.057
North Railway Crossing (330)	2-Year	4.42	0.67	0.60	2.39	0.026	0.079
	5-Year	4.50	1.74	0.97	2.89	1.57	0.635

This option will convey Birch Avenue flows to the new Sherman Avenue storm relief sewer as presented in **Table 5**. The option is considered hydraulically effective, technically feasible, and will reduce the pumping rates at the underpasses significantly.

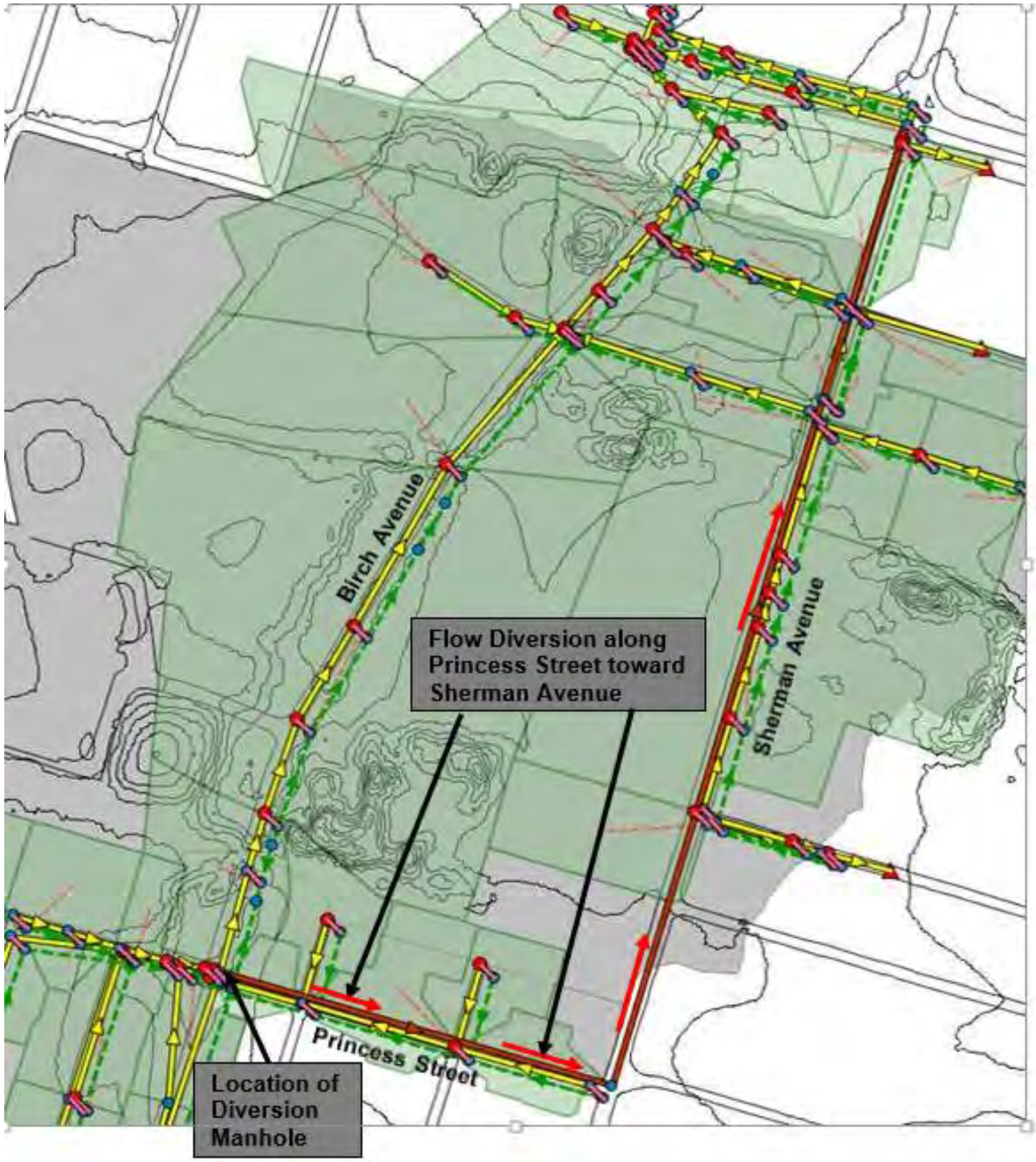


Figure 8: Proposed Flow Diversion at Princess Street toward Sherman Avenue

8.3 Pumping Stations

The proposed Birch Avenue improvements include potential upgrades to existing Canadian National Railway (CNR) bridges and changes to road profiles. The lowering of the road profile below lake level will make pumping inevitable. Three options have been examined to address the flooding issues, based on 0.6 m road lowering that best meets the requirement for bridge clearance.

Option 1: Maintain the Existing Storm Relief Sewer

This measure will involve the construction of two separate pumping stations – one at each of the south and north underpasses. The pumps would lift wet weather flow from the Birch Avenue storm relief sewer to a new forcemain. Each pumping station would include a wet well and a forcemain that would connect to the existing trunk storm sewer at Burlington Street East. There is additional capacity downstream of the manhole (MH 39), just before the existing storm outlet at the harbor; therefore, the forcemain would not require a new outlet to the harbor. The forcemain alignment is shown in **DWG 002** in **Appendix C**. The pumping rates for each of the options are provided in **Table 6**.

There is some open-space in City-owned land immediately west of the hydro corridor and north of the south underpass. The land within the Birch Avenue Dog Park, on the west side of Birch Avenue, may be suitable for the construction of a pump station for the south underpass. A geotechnical study will be required to assess the construction feasibility as the dog park is an old landfill site.

At the north underpass, the pumping station is proposed in the northwest quadrant of the Birch Avenue and Burlington Street East intersection. The locations of the pumping stations are provided in **DWG 002** in **Appendix C**. The cost of the pumping stations at the north and south underpasses is provided in **Table 7.**

Option 2: Birch Avenue Storm Sewer Upgrade

The potential upgrades to the existing Birch Avenue storm sewer will reduce the pumping rates by 100 l/s and 200 l/s at the south and north underpasses, respectively. However, this will not reduce the size of the pumping station significantly when compared with Option 1 above. The pumping rates are presented in **Table 6**. The cost of the pumping stations at the north and south underpasses is provided in **Table 7.**

Option 3: New Sherman Avenue Storm Relief Sewer

The option of a new Sherman Avenue storm relief sewer will reduce the pumping requirement significantly. The PCSWMM hydraulic analysis indicated that the diversion of Birch Avenue flows to Sherman Avenue will reduce pumping rates significantly to 26 l/s and 43 l/s for the south and north underpasses, respectively.

With this option, the south and north pumping stations can be combined and constructed in the northwest quadrant of the Birch Avenue and Burlington Street East intersection. This will result in cost savings on property requirements, forcemain installation, pumps, and generator requirements while taking into consideration the operational and maintenance costs. The Option 1 forcemain alignment can be followed to install a gravity pipe from the south wet well to the north wet well. The underground south wet well will still be needed to capture and convey the storm flows. The cost of a pumping station at the north and south underpasses is provided in **Table 7.**

Table 6 presents optional pumping rates for the three alternatives.

Table 6: Optional Pump Rates

OPTION	MITIGATION MEASURE	STORM EVENT	REQUIRED PUMP CAPACITY AT SOUTH RAILWAY CROSSING (#332) (m^3/sec)	REQUIRED PUMP CAPACITY AT NORTH RAILWAY CROSSING (#330) (m^3/sec)
1	Existing condition (maintain existing storm relief sewer)	2-Year	0.28	0.78
2	Birch Avenue sewer upgrades (with 2.4 m X 1.8 m storm sewer)	2-Year	0.18	0.58
3	Flow diversion to new Sherman Avenue storm relief sewer	2-Year	0.026	0.043

Note: 5-year storm flows are large and not practical to pump

8.4 Storm Drainage Pumping System

A cast-in-place concrete wet pit/well will be provided. The wet well sizing for each of the options is provided in **Table 8**. Two access hatches will be provided for access inside the pit, complete with access ladders and safety platforms as per OPSD 404.20 requirements. A separate smaller access hatch will be provided for floats access.

Three submersible pumps, one stand-by, will each pump the storm water in the vicinity of the lake at the proposed location. Pumps will be provided with a control panel, floats, and SS guide rails. Discharge piping from each pump will be tied to a common header inside the station. Alarms for pump failure and high water level inside the pit will be sent to a Supervisory Control and Data Acquisition (SCADA) system.

For pump maintenance an appropriate monorail/hoist will be provided.

Refer to sketch SK-M-001 in **Appendix F** for more details on the station equipment layout, sump pit, and pumps for each of the options.

The wet well will be located below grade level and is sized to provide adequate storage of stormwater between pump starts. The surface area of each wet well measure is provided in **Table 8**. **Appendix F** provides details of the wet well configurations.

Heating and Ventilation System

The ventilation rate for the pumping station will be 4 air changes per hour. Fresh air intake louvres and exhaust fans will be interlocked and controlled by a room thermostat to maintain the maximum temperature of 38 deg. C inside the space. Heating will be provided by two electric unit heaters in order to maintain a pumping station temperature above 9 deg. C (adjustable).

The temperature inside the pumping station is to be monitored. Low and high temperature alarms will be connected to the SCADA.

Table 7: Birch Avenue Alternative Remedial Measures to Reduce pumping

Alternative ID	LID Measures	Maintain Existing Storm Relief Sewer	Replace and Upgrade Existing Storm Relief Sewer	New Sewer along Sherman Avenue
Description	Provide underground infiltration chambers from Barton Street East to Burlington Street East to divert Birch Avenue roadway runoff, to detain major overland flows, and infiltrate stormwater.	Maintain existing storm sewer	Replace existing storm sewer with a new storm relief sewer on Birch Avenue from Princess Street to Burlington Street East	Construct a new storm relief sewer along Sherman Avenue. Redirect Birch Avenue flows at Princess Street to new Sherman Avenue storm relief sewer.
Requires Pump	Yes (to drain underpasses)	Yes (to drain underpasses)	Yes (to drain underpasses)	Yes (to drain underpasses)
Outlet to Harbour	Use existing	Use existing	Use existing with upgrade	New
# Railroad Crossings	2 (middle crossing is assumed to be eliminated)	2 (middle crossing is assumed to be eliminated)	2 (middle crossing is assumed to be eliminated)	2 (middle crossing is assumed to be eliminated)
Length of the Proposed Measure	~ 900 m	-	~ 810 m	~ 1 km
Estimated Capital Cost	$1M (2.5mx1.5m)	-	$6M (2.4mx1.8m)	$7M (1.8mx1.8m) includes Princess Diversion
Constructability	Conflicts with Hydro One corridor, 15m of horizontal clearance is required; additional property requirements on west side of Birch Avenue.	-	1. Requires current 1.8m sidewalk to be widened to 2.5m. 2. Modifications at bridges are required, as the current sewer is integral part of bridge structures. 3. Impact to traffic lane width on east side, if bridges are not replaced. 4. Impact on hydro poles on east side of Birch Avenue.	Anticipated crossings: • 10 Sewers(300 to 2250mm) • 13 Water mains (150 to 600mm) • 6 Gas lines (size 32 to 200 I.P) • 3 Bell lines • 6 Hydro ducts
Hydraulic Modeling Results	Will reduce the pumping requirment by 1.26 m^3/s	Large pumping rates (280lps and 780lps)	It does not provide much relief to pumping at north underpass, as the new sewer will start from Princess Street. Provides 5-year level of service to Birch Avenue (no additional benefit)	Benefits study area but does not provide 5-year level of service due to additional flow from upstream areas.
Secondary Benefit	Reduces pumping at underpasses	-	Reduces pumping at underpasses	Reduces pumping at underpasses, Provides relief to upstream areas. Pumping stations can be combined. Forcemain between south and north pumping stations can be replaced by a gravity sewer.
Pumping Cost	$5M	$7M	$6.5M	$3.5M
Annual Pump Operating Cost	$170,000	$217,500	$191,000	$92,000
Size of Pumping Station	12m x 15m (North), 12m x 15m (South)	12m x 15m (South), 15m x 20m (North)	12m x 15m (South), 15m x20m (North)	11m x 8m (North)
Comments	Not Feasible	Feasible	Feasible	Preferred
Preference	○	◑	◑	◕

M: Million

General

Piping and valves will be labelled and tagged.

Generator Area, Noise Control and Sizing

The control room will house a diesel generator to provide back-up power in the event of an interruption in power supply. Fresh air will be provided to the room via a louvre and a damper combination (Silex Engine Silenser). Although the station is in an industrial area and involves stormwater pumping, the provision for odour control of the wet well exhaust will be considered in detailed design. The generator sizing is provided in **Appendix G**

Table 8 provides a summary of pumping station details for different options.

Table 8: Pumping Station Details

OPTION	PUMPING STATION	LOCATION	FLOW RATE (lps)	PUMP TYPE	WET WELL	PUMPING STATION SIZE	COMMENT
1	South Pumping Station (332)	Dog Park or existing parking lot adjacent to dog park	280	XFP306M-CB2-60HZ	6 m X 4 m	12 m X 15 m	A geotechnical study will be required to assess the construction feasibility as the dog park is an old landfill site
	North Pumping Station (330)	Northwest quadrant of Birch Avenue and Burlington Street intersection	780	XFP 400M-CH2-60 HZ	6 m X 6 m	15 m X 20 m	
2	South Pumping Station (332)	Dog park or existing parking lot adjacent to dog park	180	XFP-300-J-CH2-60HZ-	6 m X 4 m	12 m X 15 m	A geotechnical study will be required to assess the construction feasibility as the dog park is an old landfill site
	North Pumping Station (330)	Northwest quadrant of Birch Avenue and Burlington Street intersection	580	XFP 351M-CH3 60 HZ	6 m X 6 m	15 m X 20 m	
3	South Pumping Station (332)	Pumping station not required	26	-	4 m X 4 m	-	-
	North Pumping Station (330)	Northwest quadrant of Birch Avenue and Burlington Street intersection	43	XFP151E-CB2-60HZ	8 m X 4 m	11 m X 8 m	Combined pumping flow will be 69 lps

8.5 Dewatering Costs

Based on preliminary estimates, the dewatering costs may vary from $50,000 to $65,000 depending on the location. It is recommended that the City budgets $55,000 for dewatering costs. However, the actual cost will be determined and budgeted for during detailed design. Details of the dewatering costs are provided in **Appendix H**.

9 Conclusions and Recommendations

This report documents the drainage and stormwater management aspects associated with the existing and proposed flooding conditions at the Birch Avenue underpasses. It describes the existing and proposed drainage conditions within the study limits and outlines the proposed drainage and SWM Plan to manage flooding along the Birch Avenue. The findings of this study are summarized as follows:

- The Birch Avenue study area is located on a primary overland flow route with large external drainage areas contributing flows to the storm trunk relief sewer.
- Within the Birch Avenue roadway corridor, runoff from minor storm events is conveyed by the existing storm relief sewer. Due to the limited flow conveyance capacity of the existing storm relief sewer, all major storm flows are conveyed by road.
- Currently there are three low/sag points located along the Birch Avenue at the railway crossing locations. These low points and adjacent areas currently experience flooding.
- The existing railway bridge located south of Brant Street (331) is proposed to be removed and the low point located at this crossing location will be eliminated to provide a positive roadway drainage.
- The storm relief sewer inverts range from 74.29 m at Burlington Street East, 75.0 m just north of the south railway underpass, 75.20 m at Princess Street and 76.29 m at Barton Street East. Summer average water level of Lake Ontario is approximately 75.0 m which has adverse hydraulic effects on the existing storm relief sewer flow conveyance.
- The proposal to lower the road at the south (332) and north (330) underpasses, to achieve required bridge clearances, will result in additional ponding at the bridge crossing locations and pumping will be inevitable to eliminate the flooding at these locations.
- The preferred alternative is to lower the road between 0.3 m to 0.6 m to achieve the desired bridge clearance under the north and south underpasses.
- Pumping is proposed at the south (332) and north (330) underpasses to lift excess wet weather flows from the Birch Avenue storm relief sewer. The 5-year storm event is relatively large and not practical to pump.
- The pumped water will be conveyed through a proposed force main. The last leg of storm relief sewer at Burlington Street East has enough capacity to discharge the pumped flow directly in the harbour.
- Three pumping options were evaluated. The option of flow diversion to a new Sherman Avenue storm relief line was considered most economical and preferred option. This preferred option achieves 2-year level of service.
- A geotechnical investigation should be undertaken to evaluate and confirm the subsurface conditions in the area.

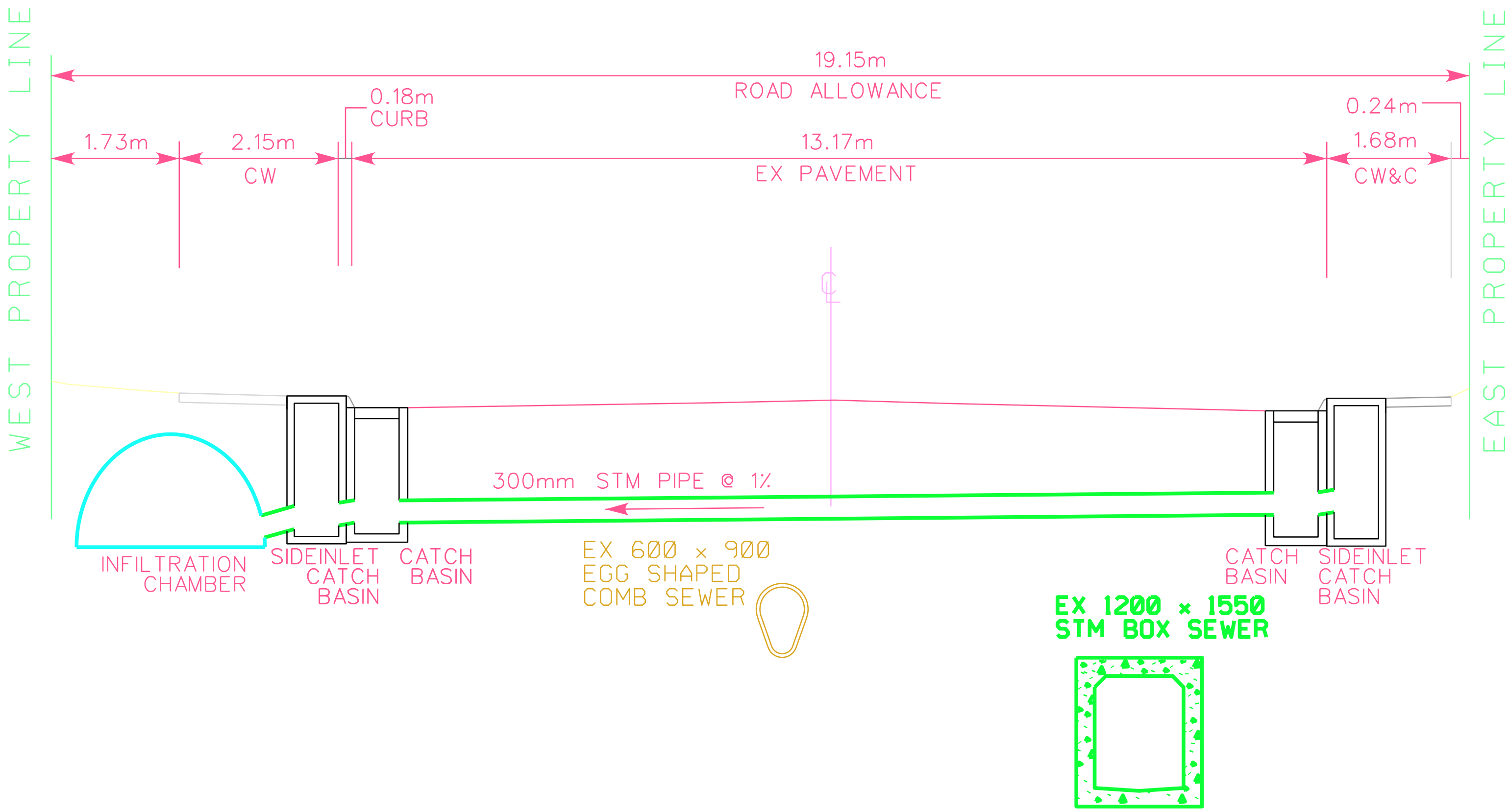
Appendix A

EXISTING CONDITION DRAWING

BIRCH AVE LAYOUT

Appendix B

TYPICAL CROSS SECTIONS



TYPICAL CROSS-SECTION
NTS

Appendix C

PROPOSED CONDITION DRAWING

BIRCH AVE LAYOUT
LID MEASURES :OPTION 1
PUMPING STATION LOCATIONS : FOR OPTION1, OPTION2 & OPTION3

No.	REVISIONS	INITIAL	DATE
⚠	No Revisions		

REFERENCE MATERIAL
Road Plan : 97-H-14, 96-H-11, 88-H-1, 68-H-33, 68-H-100
Sewer Plans : 88-S-6, 10-S-53, B-130-S3, P-23-S1,78-S-56
Water Plans : 88-W-16
Misc. Plan: 62R-14437, 05-M-14
Geodetic Bench Mark Index No. 4-06 Elevation=82.438

Q/C IN ACCORDANCE WITH ASCE STANDARD 38-02
All Utilities depicted are at unless otherwise noted.
Ⓓ information derived from existing records
Ⓒ information obtained from field survey combined with Ⓓ information
Ⓑ information obtained in field and indicates horizontal position of subsurface utility
Ⓐ precise horizontal and vertical location of utility obtained by exposure and measurement
Dimensions shown on this plan are in millimetres unless otherwise noted

SCALE
0 5m 10m 20m
1:500

Project Manager (Design)
NAME
Manager of Design

Hamilton
Public Works Department

BIRCH AVENUE
Proposed Conditions
DWG NO-002A

Appendix D

THE SCS TYPE II E HOUR HYETOGRAPH

TABLE 5.1
6 HOUR SCS DISTRIBUTION DESIGN STORM HYETOGRAPHS
MOUNT HOPE

Time Step (min)	Rainfall Intensity (mm/hr)					
	2	5	10	25	50	100
10	1.59	2.26	2.70	3.26	3.68	4.09
20	1.59	2.26	2.70	3.26	3.68	4.09
30	1.59	2.26	2.70	3.26	3.68	4.09
40	2.38	3.39	4.06	4.90	5.51	6.14
50	2.38	3.39	4.06	4.90	5.51	6.14
60	2.38	3.39	4.06	4.90	5.51	6.14
70	2.38	3.39	4.06	4.90	5.51	6.14
80	2.38	3.39	4.06	4.90	5.51	6.14
90	2.38	3.39	4.06	4.90	5.51	6.14
100	3.97	5.65	6.76	8.16	9.19	10.23
110	3.97	5.65	6.76	8.16	9.19	10.23
120	3.97	5.65	6.76	8.16	9.19	10.23
130	4.76	6.78	8.11	9.79	11.03	12.28
140	4.76	6.78	8.11	9.79	11.03	12.28
150	4.76	6.78	8.11	9.79	11.03	12.28
160	23.82	33.90	40.56	48.96	55.14	61.38
170	42.88	61.02	73.01	88.13	99.25	110.48
180	61.93	88.14	105.46	127.30	143.36	159.59
190	8.73	12.43	14.87	17.95	20.22	22.51
200	8.73	12.43	14.87	17.95	20.22	22.51
210	8.73	12.43	14.87	17.95	20.22	22.51
220	3.97	5.65	6.76	8.16	9.19	10.23
230	3.97	5.65	6.76	8.16	9.19	10.23
240	3.97	5.65	6.76	8.16	9.19	10.23
250	3.18	4.52	5.41	6.53	7.35	8.18
260	3.18	4.52	5.41	6.53	7.35	8.18
270	3.18	4.52	5.41	6.53	7.35	8.18
280	2.38	3.39	4.06	4.90	5.51	6.14
290	2.38	3.39	4.06	4.90	5.51	6.14
300	2.38	3.39	4.06	4.90	5.51	6.14
310	1.59	2.26	2.70	3.26	3.68	4.09
320	1.59	2.26	2.70	3.26	3.68	4.09
330	1.59	2.26	2.70	3.26	3.68	4.09
340	1.59	2.26	2.70	3.26	3.68	4.09
350	1.59	2.26	2.70	3.26	3.68	4.09
360	1.59	2.26	2.70	3.26	3.68	4.09

Appendix E

PROPOSED CONDITIONS DRAWING (OPTION 2 &3)

BIRCH AVE LAYOUT
OPTION 2 & 3

No.	REVISIONS	INITIAL	DATE
⚠	No Revisions		

REFERENCE MATERIAL
Road Plan : 97-H-14, 96-H-11, 88-H-1, 68-H-33, 68-H-100
Sewer Plans : 88-S-6, 10-S-53, B-130-S3, P-23-S1,78-S-56
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Ⓑ information obtained in field and indicates horizontal position of subsurface utility
Ⓐ precise horizontal and vertical location of utility obtained by exposure and measurement
Dimensions shown on this plan are in millimetres unless otherwise noted

SCALE
0 5m 10m 20m
1:500

Project Manager (Design)
NAME
Manager of Design

Hamilton
Public Works Department

BIRCH AVENUE
Proposed Conditions
DWG NO-002B

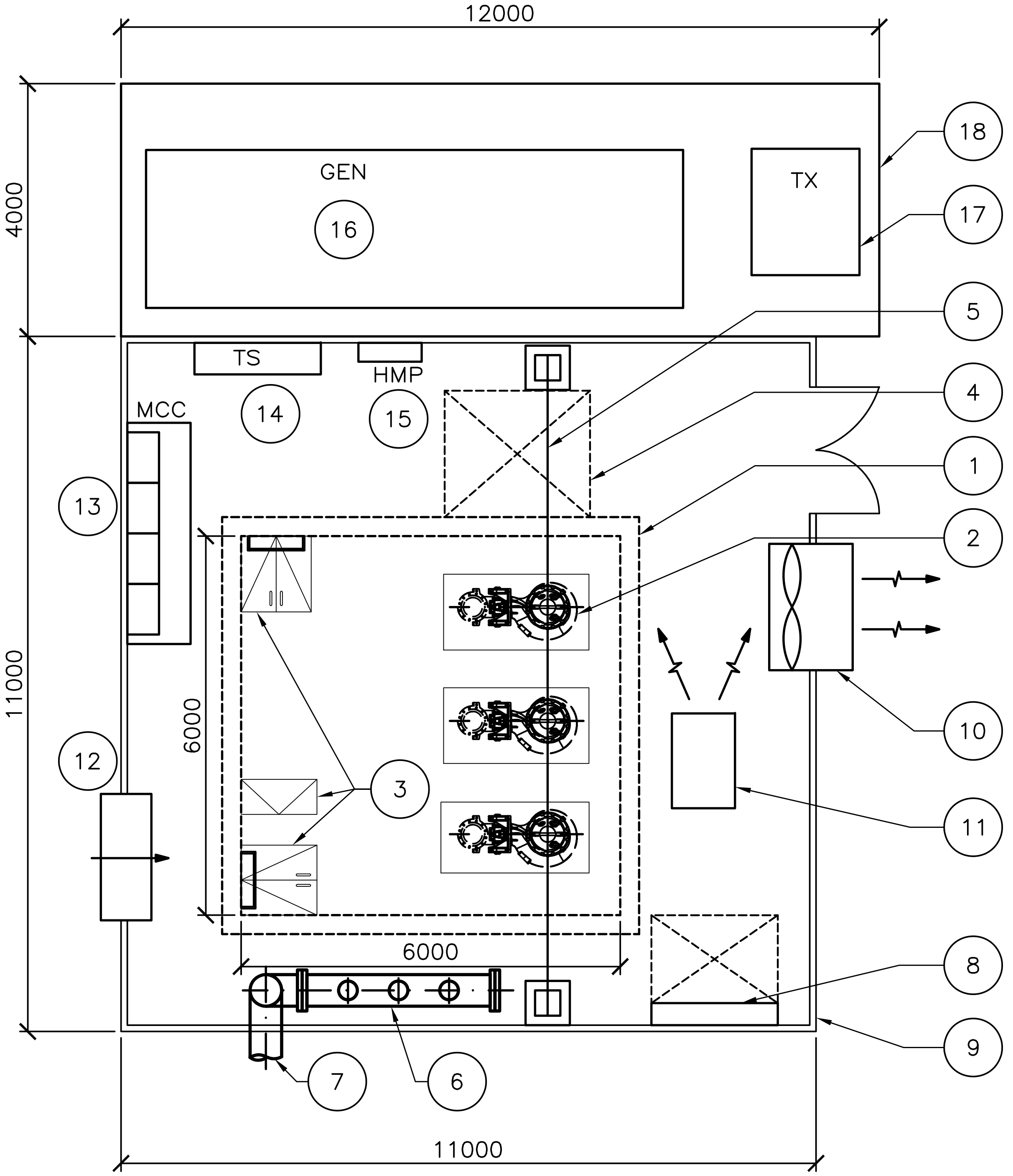
Appendix F

PUMP STATION EQUIPMENT LAYOUTS

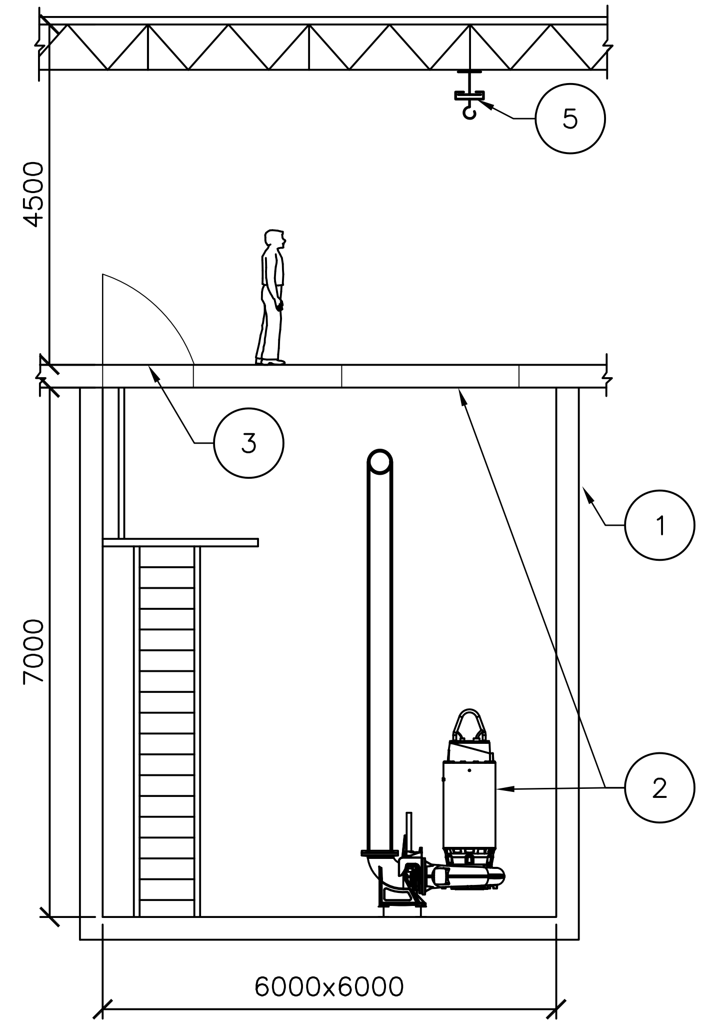
SOUTH PUMPING STATION : OPTION 1 & 2

LEGEND:

1. WET PIT
2. SUBMERSIBLE PUMP AND REMOVABLE ACCESS HATCH (TYP.)
3. MAINTENANCE ACCESS HATCH
4. PUMPS LANDING AREA
5. 3 TON PUMPS HOIST
6. PUMPS DISCHARGE HEADER
7. UNDERGROUND PUMPED STORM LINE TO LAKE
8. PUMPS CONTROL PANEL
9. INSULATED PREFABRICATED BUILDING WITH SLOPED ROOF
10. EXHAUST FAN
11. ELECTRIC UNIT HEATER
12. FRESH AIR INTAKE LOUVRE
13. MCC
14. TRANSFER SWITCH
15. HYDRO METERING PANEL
16. EMERGENCY GENERATOR C/W ENCLOSURE
17. TRANSFORMER
18. CONCRETE PAD



PLAN VIEW



SUMP PIT ELEVATION

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Date	Issued For	Rev.
2019-10-10	EA STUDY	A

Client CITY OF HAMILTON ONTARIO

Project ENVIRONMENTAL ASSESSMENT STUDY

Drawing Title
PROPOSED OPTION
STORM PUMPING STATION
AT BRIDGE 332

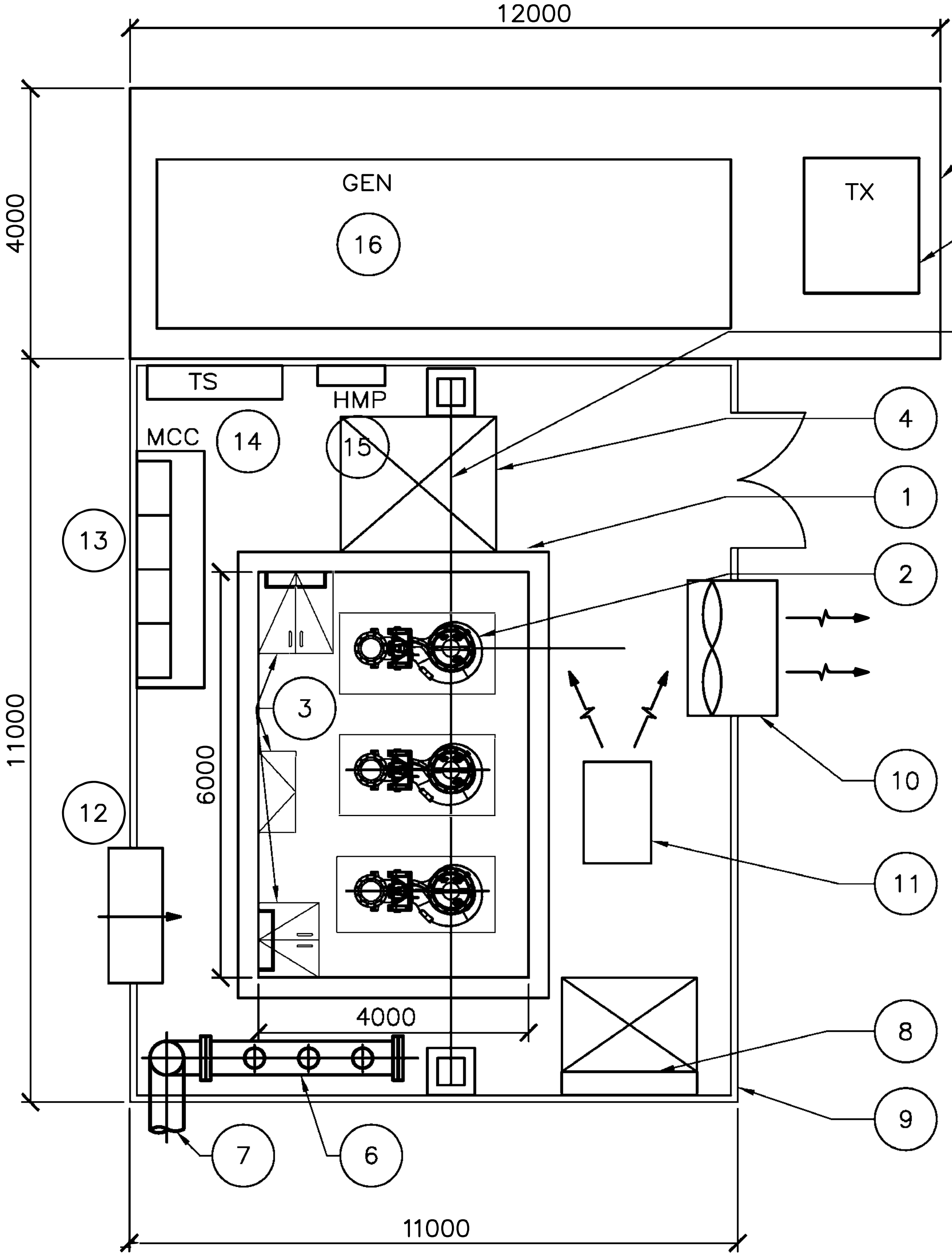
Project No. 121767

Drawing No. SK-M-001

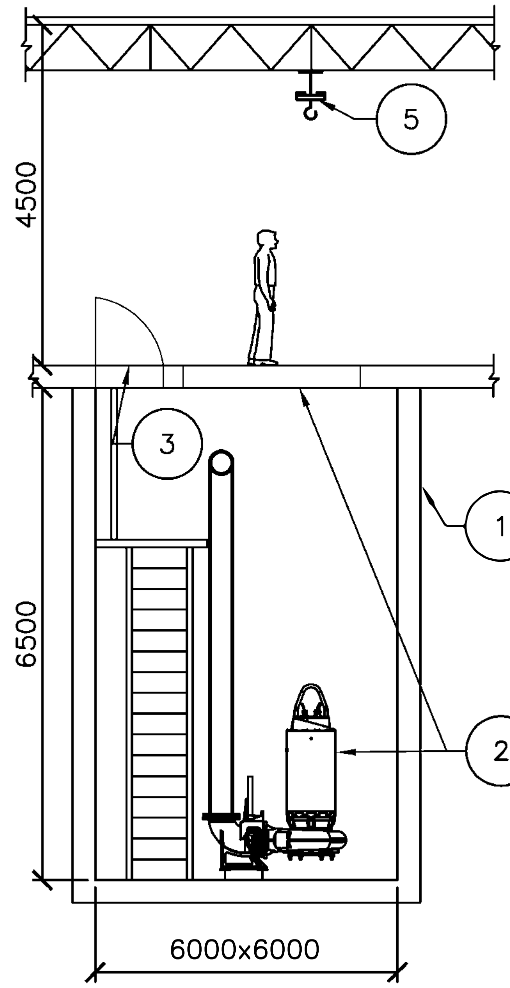
NORTH PUMPING STATION : OPTION 1 & 2

LEGEND:

1. WET PIT
2. SUBMERSIBLE PUMP AND REMOVABLE ACCESS HATCH (TYP.)
3. MAINTENANCE ACCESS HATCH
4. PUMPS LANDING AREA
5. 3 TON PUMPS HOIST
6. PUMPS DISCHARGE HEADER
7. UNDERGROUND PUMPED STORM LINE TO LAKE
8. PUMPS CONTROL PANEL
9. INSULATED PREFABRICATED BUILDING WITH SLOPED ROOF
10. EXHAUST FAN
11. ELECTRIC UNIT HEATER
12. FRESH AIR INTAKE LOUVRE
13. MCC
14. TRANSFER SWITCH
15. HYDRO METERING PANEL
16. EMERGENCY GENERATOR C/W ENCLOSURE
17. TRANSFORMER
18. CONCRETE PAD



PLAN VIEW



SUMP PIT ELEVATION

Date	Issued For	Rev.
2019-10-10	EA STUDY	A

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Client CITY OF HAMILTON ONTARIO

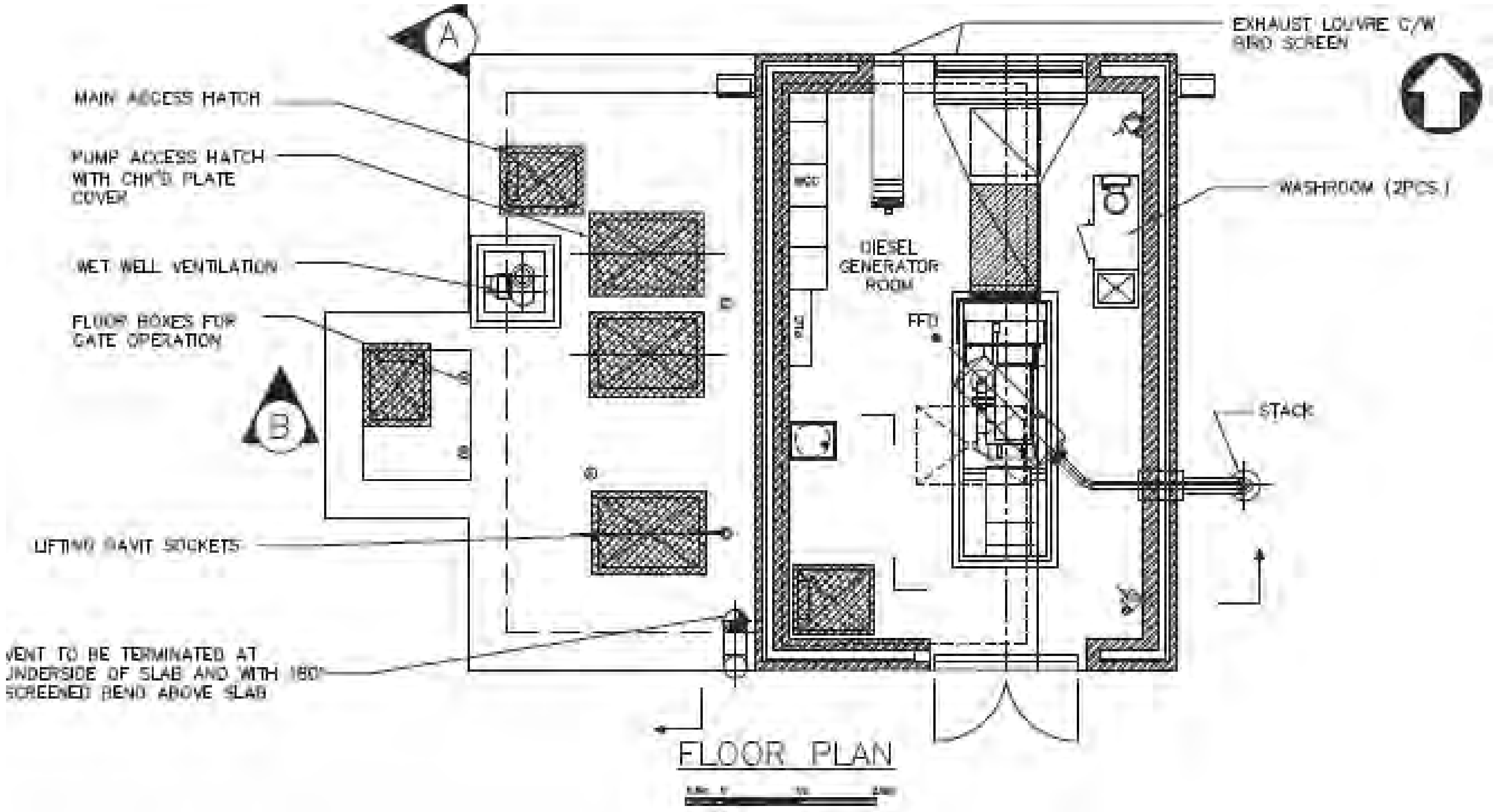
Project ENVIRONMENTAL ASSESSMENT STUDY

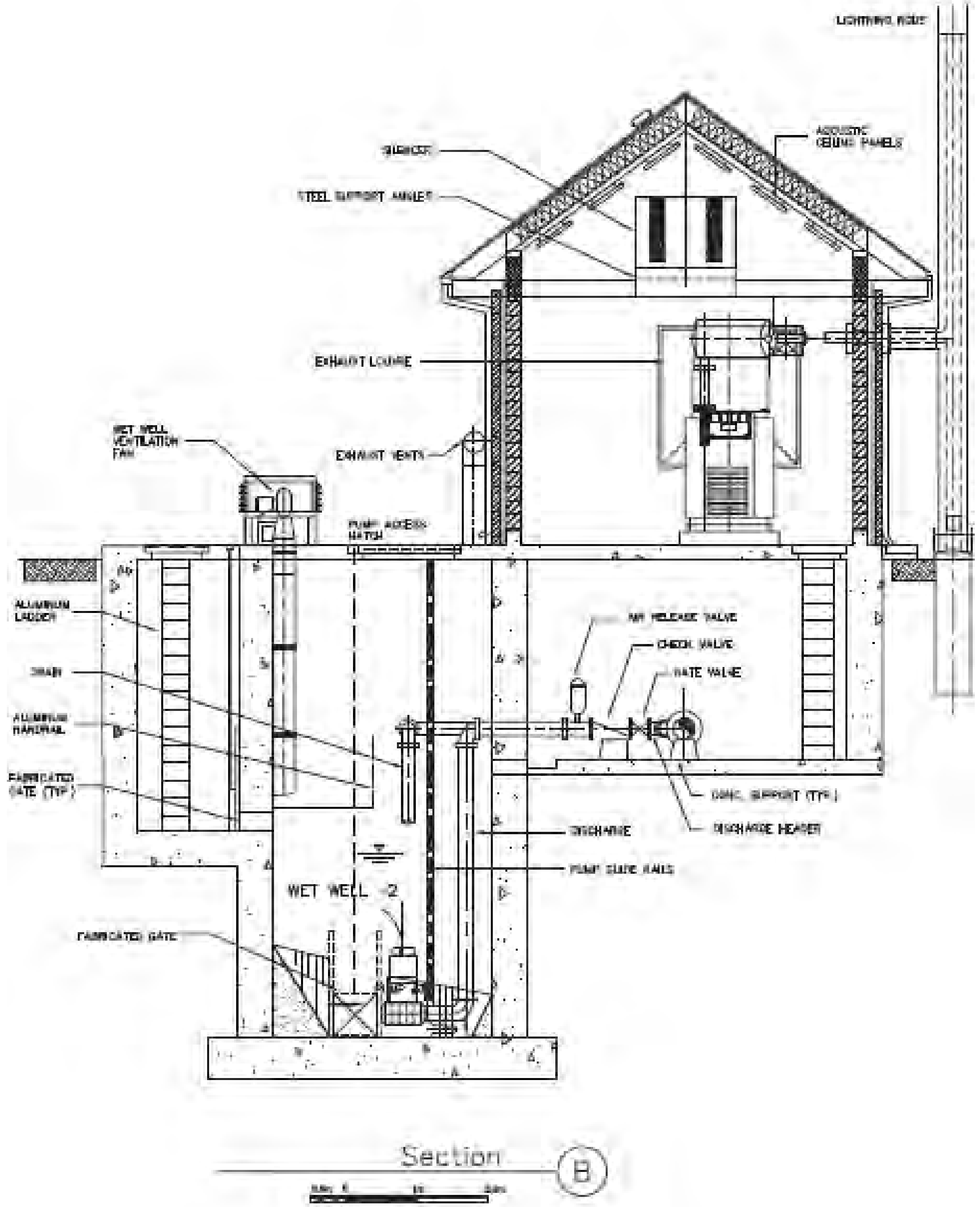
Drawing Title
PROPOSED OPTION
STORM PUMPING STATION
AT BRIDGE 330

Project No.
121767

Drawing No.
SK-M-002

PUMPING STATION : OPTION 3
(COMBINED NORTH & SOUTH)





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Date	Issued For	Rev.
2019-10-10	EA STUDY	A

Client CITY OF HAMILTON ONTARIO

Project ENVIRONMENTAL ASSESSMENT STUDY

Drawing Title
PROPOSED OPTION
STORM PUMPING STATION
AT BRIDGE 330

Project No.
121767

Drawing No.
SK-M-002

PUMP DESIGN

No: M-02.3087 - 04	2
Dat/Nam.: 02.06.2016 / K. Srb	
Cad Code: M_023087	
Technical changes reserved Änderungen vorbehalten Sous réserve de modifications	

XFP 306M-CB2

Dimension sheet PE6 WET WELL Installation

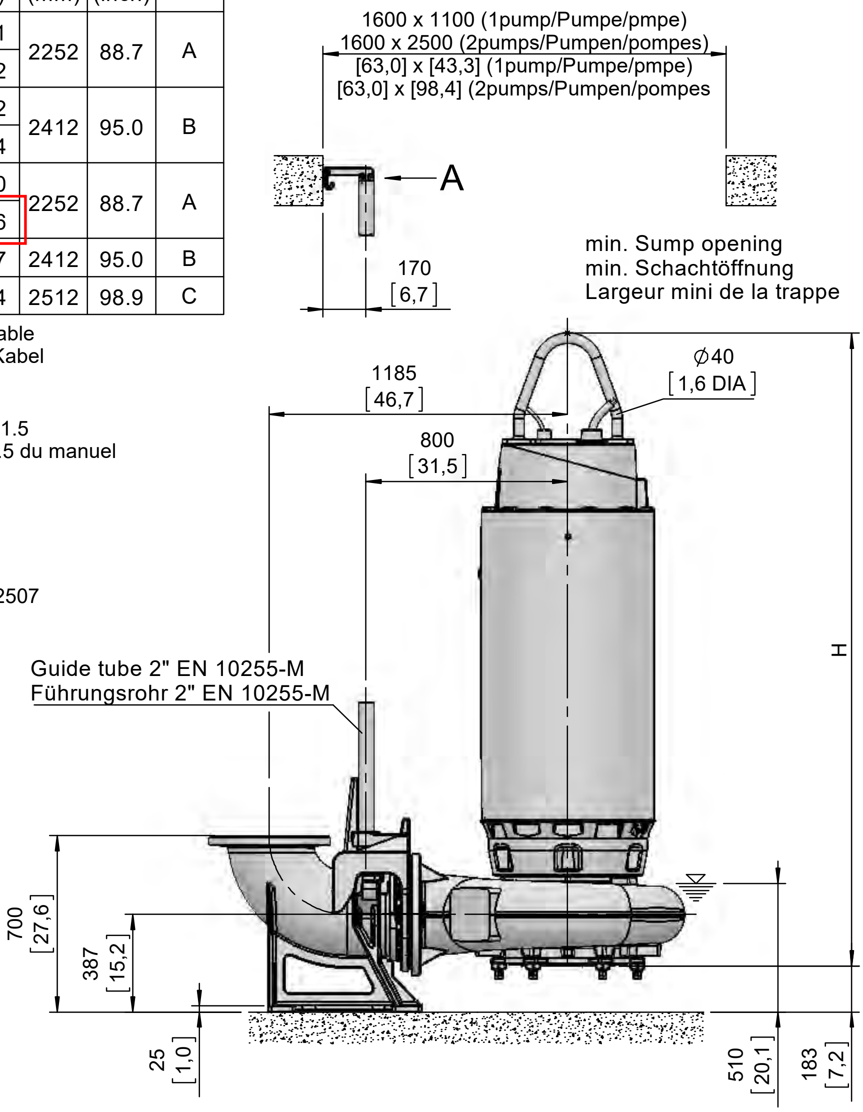
Maßblatt PE6 Nassinstallation

Plan d'encombrement PE6 installation submersible

SULZER

Type Typ Type 50Hz	Type Typ Type 60Hz	Weight Gewicht Poids MK (~kg)	(~lb)	H (mm)	(inch)	Size
PE 1320/4-M		2150	4741	2252	88.7	A
PE 1600/4-M	PE 1850/4-M-60	2255	4972			
PE 2000/4-M	PE 2200/4-M-60	2595	5722	2412	95.0	B
PE 2500/4-M	PE 2800/4-M-60	2700	5954			
	PE 1250/6-M-60	2195	4840	2252	88.7	A
	PE 1500/6-M-60	2275	5016			
	PE 1850/6-M-60	2570	5667	2412	95.0	B
	PE 2200/6-M-60	2750	6064	2512	98.9	C

Weight: Includes pump, slider bracket and 10m cable
Gewicht: Beinhaltet Pumpe, Halterung und 10m Kabel
Poids: Pompe, coulisseau et 10m de câble
For different cable length see IOM, chapter 1.5
Für abweichende Kabellänge siehe EBA, Kapitel 1.5
Pour des longueurs supérieures, voir la section 1.5 du manuel
For hex.-woodscrew 0,4*2,8 plug 0,5 DIA
Für Skt.-Holzschr.10*70 Dübel Ø12mm
Pour vis à bois hexagonale 10*70 trou de 12mm
Installation instructions "pedestal" 1 597 2507
Installationsanweisung "Fußstück" 1 597 2507
Instruction d'installation du "pied d'assise" 1 597 2507



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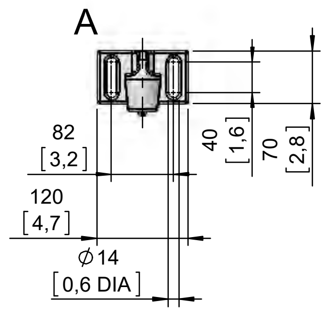
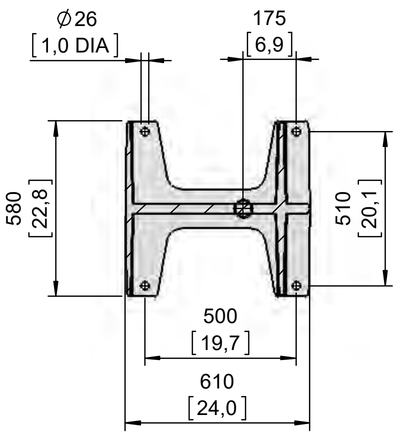
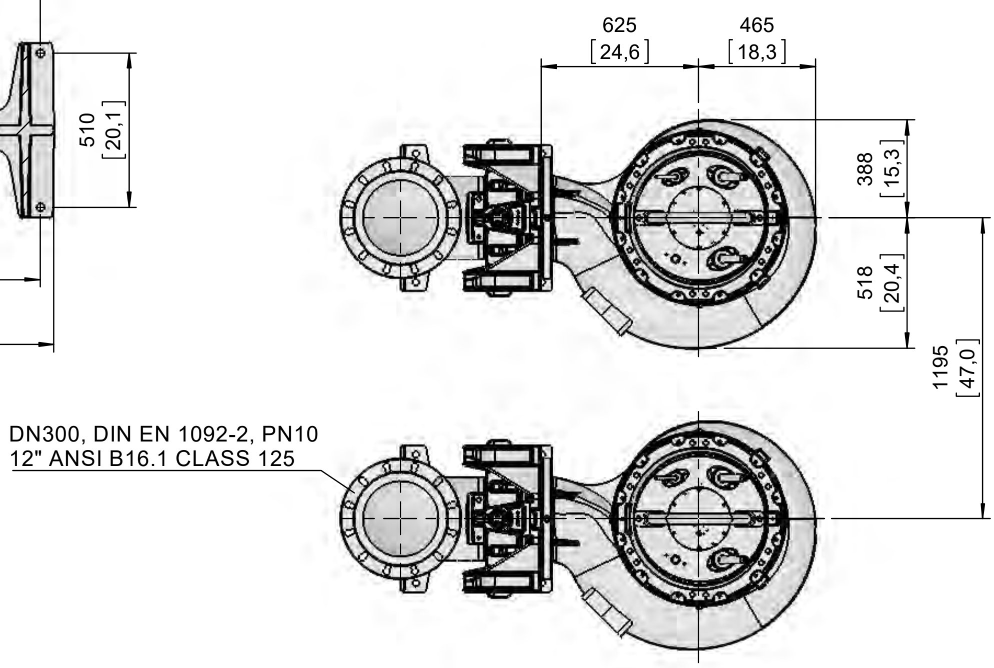




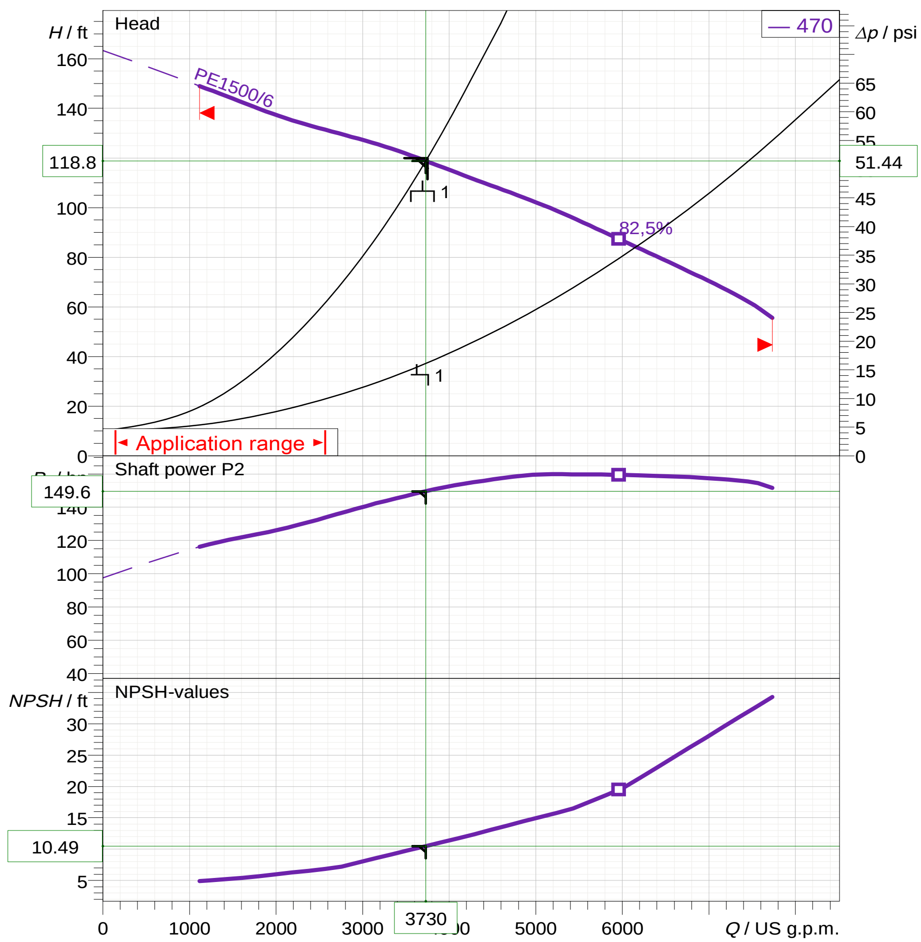


[mm / inch]

MK = Mit Kühlmantel
With cooling jacket
Avec enveloppe de refroidissement

SULZER

XFP 306M-CB2 60 HZ



Testnorm
ISO9906:2012,HI 11.6/14.6 Gr2B

2019-10-09

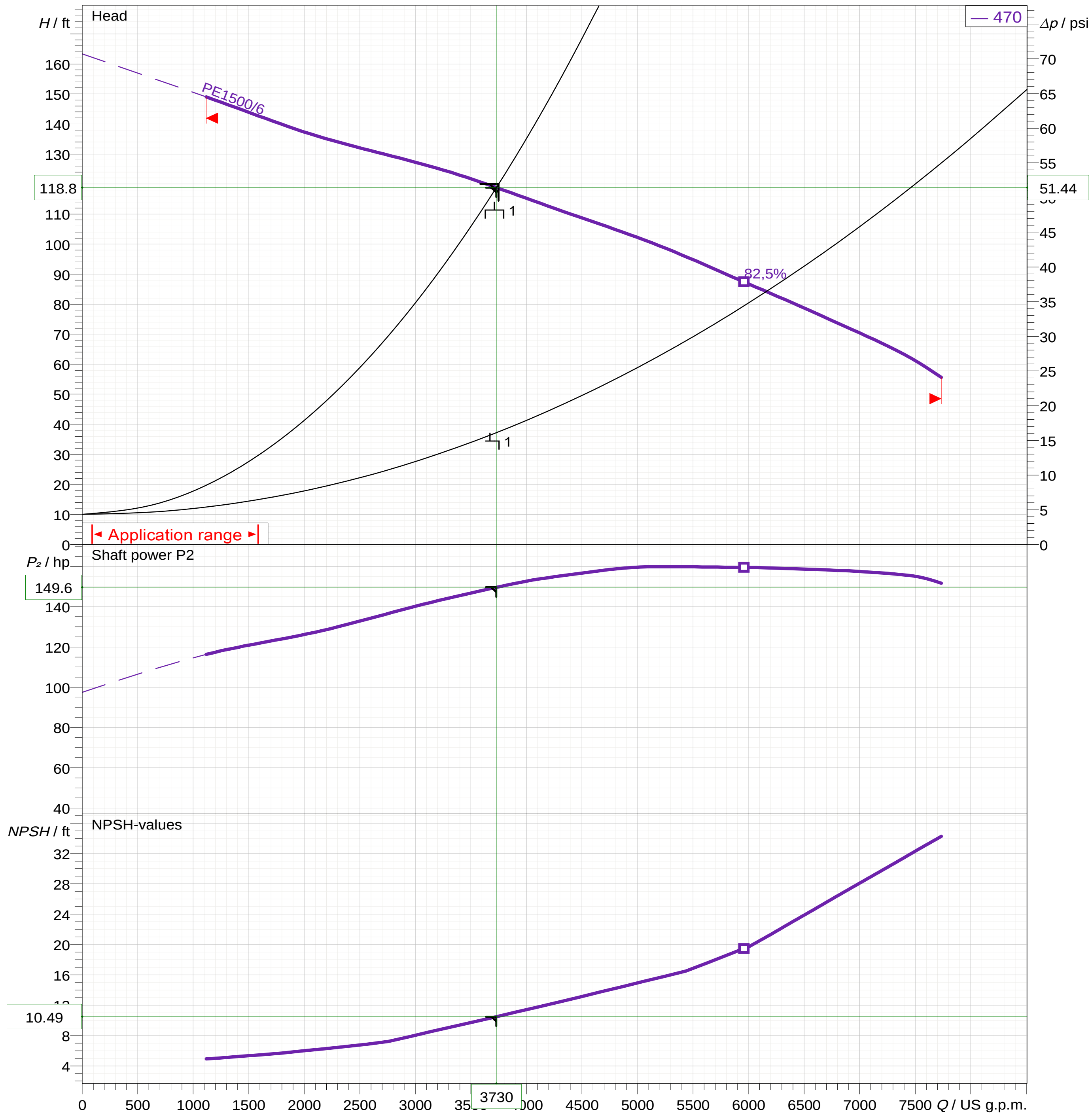
Operating data specification			
Flow	3730 US g.p.m.	Power input	156 hp
Efficiency	74,8 %	Head	119 ft
NPSH	10,5 ft	Rated power	150 hp
Temperature	68 °F	Fluid	Water
No. of pumps	2	Nature of system	Single pumps as parallel circuit

Pump data			
Type	XFP 306M-CB2 60 HZ	Make	SULZER
Series	XFP PE4-PE7	Impeller	Contrablock Plus impeller
N° of vanes	2	Impeller size	18 2/3inch
Free passage	4,13 x 4,72 inch	Suction flange	DN300
Discharge flange	DN300	Type of installation	wet well vertical installation 2"
Moment of inertia	41,1 lb ft²		

Motor data			
Rated voltage	600 V	Frequency	60 Hz
Rated power P2	201 hp	Nominal Speed	1180 rpm
Number of poles	6	Efficiency	95,6 %
Power factor	0,811	Rated current	186 A
Starting current	1380 A	Rated torque	892 lbf ft
Starting torque	2410 lbf ft	Degree of protection	IP 68
Insulation class	H(140)	No. starts per hour	10

Curve number	# Pump performance curves ## XFP 306M-CB2 60 HZ	SULZER
Reference curve XFP 306M-CB2 60 HZ		

					Discharge DN300	Frequency 60 Hz
Density 62,32 lb/ft³	Viscosity 1,082E-5 ft²/s	Testnorm ISO9906:2012,HI 11.6/14.6 Gr2B			Rated speed 1193 rpm	Date 2019-10-09
Flow 3730 US g.p.m	Head 119 ft	Shaft power 150 hp	Power input 156 hp	Rated power P2 201 hp	Hydraulic efficiency 74,8 %	NPSH 10,5 ft



Impeller size	N° of vanes	Impeller	Solid size	Revision
18 2/3inch	2	Contrablock Plus impeller	4,13 x 4,72 inch	

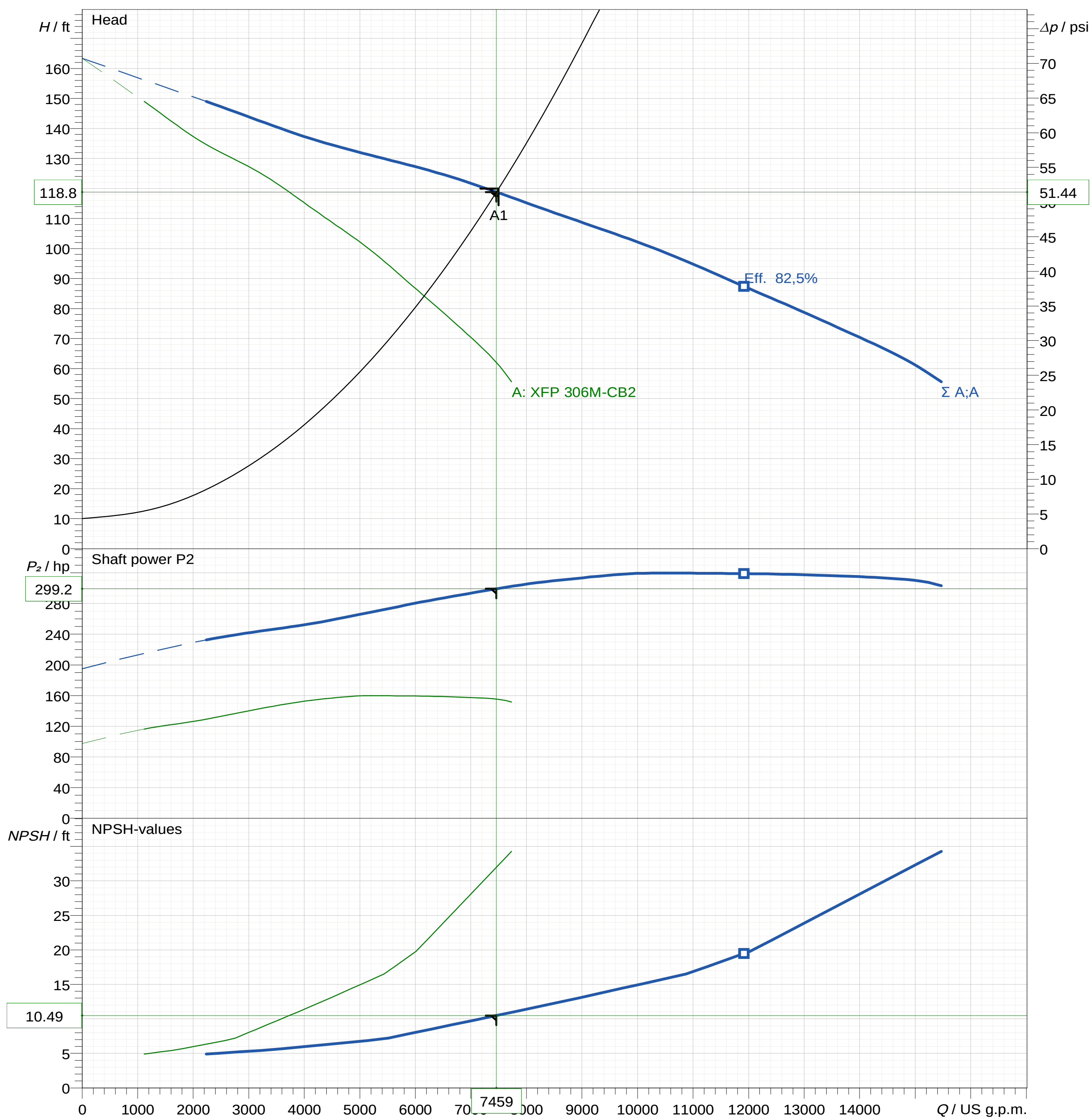
Spaix® 4, Version 4.3.12 - 2019/06/25 (Build 259)
Data version Sept 201

Curve number	Pump performance curves
Reference curve XFP 306M-CB2 60 HZ	XFP 306M-CB2 60 HZ

	Discharge	Frequency
	DN300	60 Hz

Density	Viscosity	Testnorm	Rated speed	Date
62,32 lb/ft³	1,082E-5 ft²/s	ISO9906:2012,HI 11.6/14.6 Gr2B	1193 rpm	2019-10-09

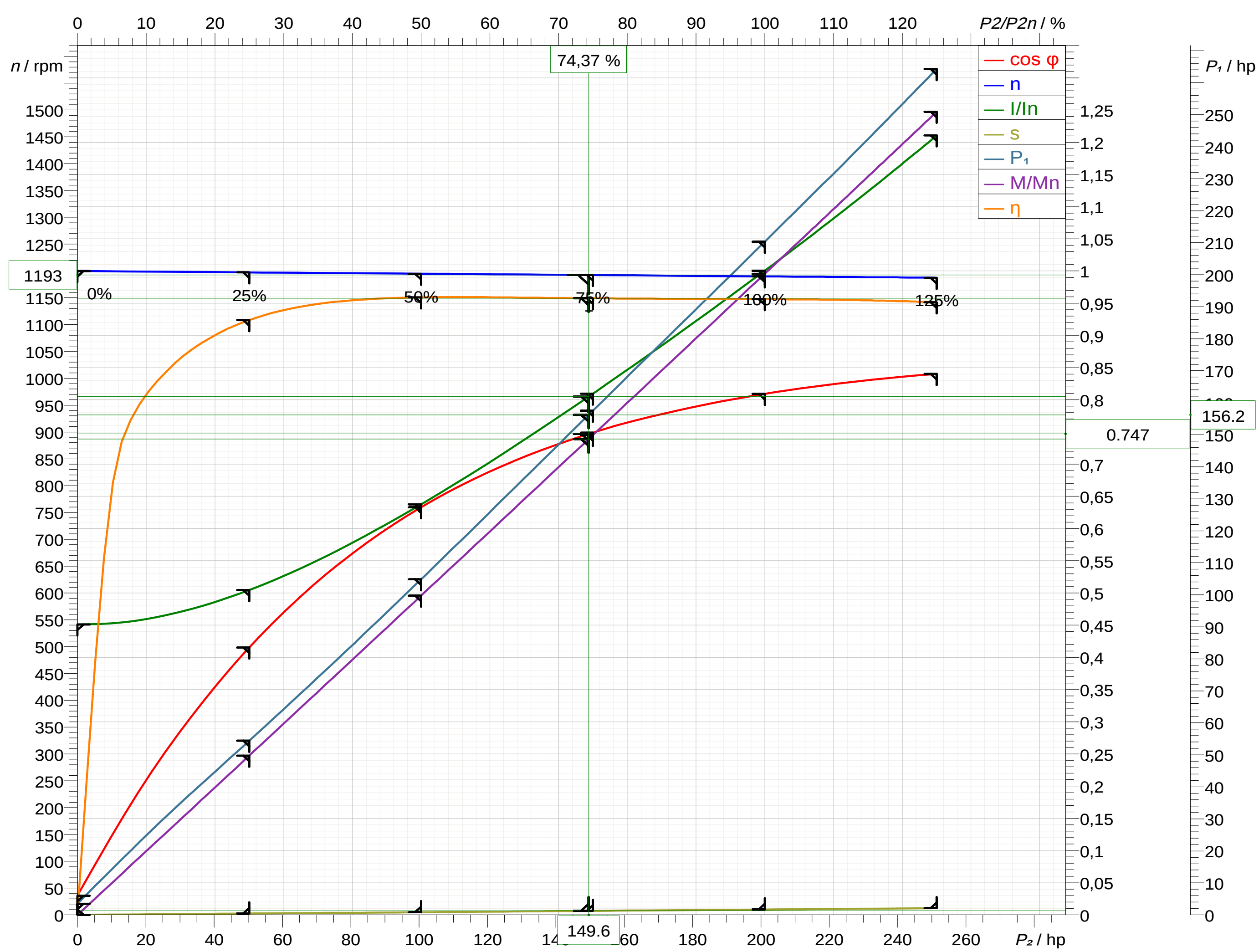
Flow	Head	Shaft power	Power input	Rated power P2	Hydraulic efficiency	NPSH
7459 US g.p.m.	119 ft	150 hp	156 hp	201 hp	74,8 %	10,5 ft



Impeller size	N° of vanes	Impeller	Solid size	Revision
18 2/3inch	2	Contrablock Plus impeller	4,13 x 4,72 inch	

Frequency 60 Hz	PE6	**Motor performance curve** PE1500/6

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
201 hp	1	1180 rpm	6	600 V	2019-10-09

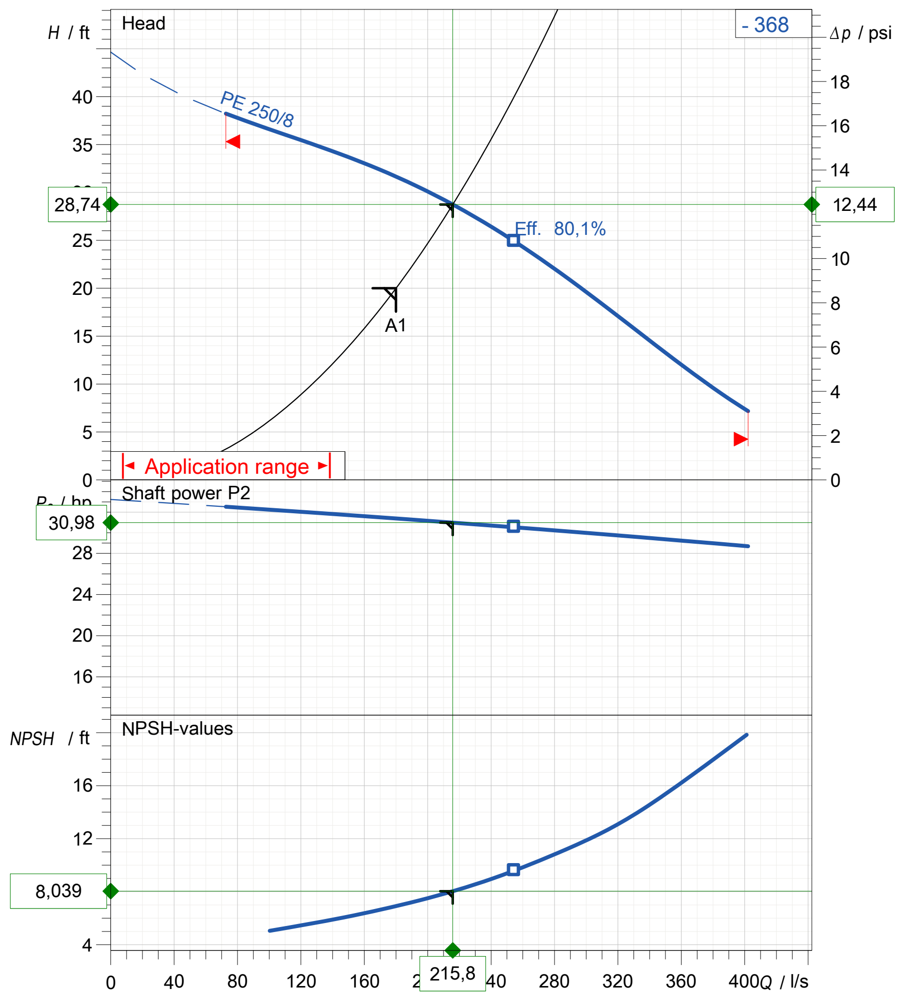


Symbol	No load	25 %	50 %	75 %	100 %	125 %
P_2 / hp	0	50,29	100,6	150,9	201,2	251,4
P_1 / hp	3,486	54,43	104,9	157,5	210,3	264,3
η / %	0	92,39	95,91	95,76	95,63	95,15
n / rpm	1200	1198	1195	1192	1190	1188
cos φ	0,02975	0,4152	0,6331	0,7491	0,8093	0,8402
I / A	84,08	94,06	118,8	150,9	186,5	225,7
s / %	0	0,2083	0,4167	0,625	0,8333	1,042
M / lbf ft	0	220,6	442,1	664,5	887,8	1112

Tolerance according to VDE 0530 T1 12.84 for rated power

Starting current	Starting torque	Moment of inertia	No. starts per hour
1380 A	2410 lbf ft	90,4 lb ft²	10

XFP 300J-CH2 60 HZ



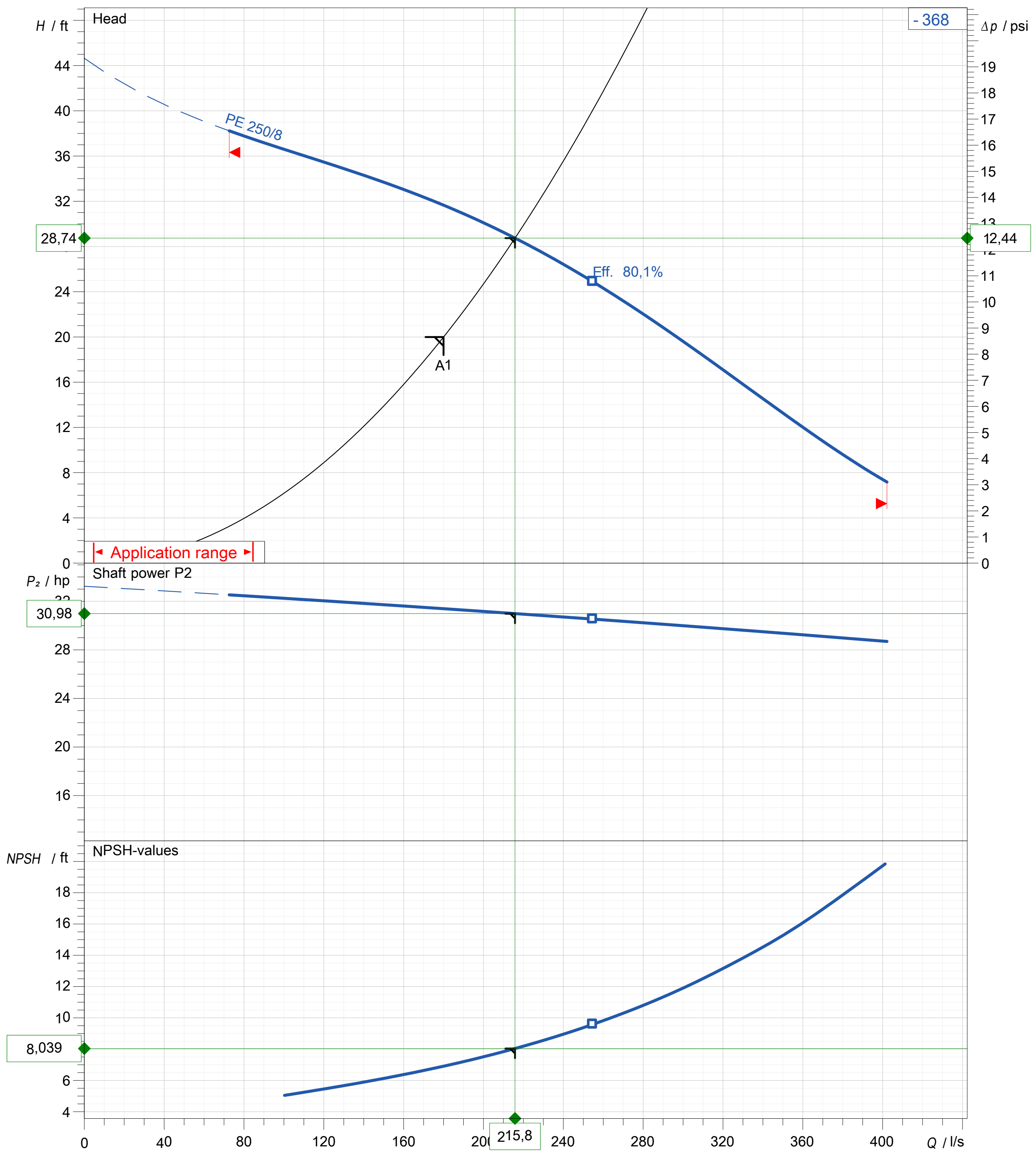
Testnorm
ISO9906:2012,HI 11.6/14.6 Gr2B

2019-11-07

Operating data specification		Power input	33,9 hp
Flow	215,8 l/s	Head	28,7 ft
Efficiency	77,8 %	Rated power	31 hp
NPSH	8,04 ft	Fluid	Water
Temperature	68 °F	Nature of system	Single head pump
No. of pumps	1		
Pump data			
Type	XFP 300J-CH2 60 HZ	Make	SULZER
Series	XFP PE4-PE7	Impeller	2-vane channel impeller
N° of vanes	2	Impeller size	368 mm
Free passage	110 x 127 mm	Suction flange	DN300
Discharge flange	DN300	Type of installation	
Moment of inertia			wet well vertical installation 2"
Motor data			
Rated voltage	480 V	Frequency	60 Hz
Rated power P2	33,5 hp	Nominal Speed	884 rpm
Number of poles	8	Efficiency	91,4 %
Power factor	0,741	Rated current	43,4 A
Starting current	221 A	Rated torque	199 lbf ft
Starting torque	378 lbf ft	Degree of protection	IP 68
Insulation class	H(140)	No. starts per hour	10

Curve number	Pump performance curves	
Reference curve XFP 300J-CH2 60 HZ	XFP 300J-CH2 60 HZ	SULZER

					Discharge	Frequency
					DN300	60 Hz
Density	Viscosity	Testnorm			Rated speed	Date
62,32 lb/ft³	1,082E-5 ft²/s	ISO9906:2012,HI 11.6/14.6 Gr2B			885,6 rpm	2019-11-07
Flow	Head	Shaft power	Power input	Rated power P2	Hydraulic efficiency	NPSH
215,8 l/s	28,7 ft	31 hp	33,9 hp	33,5 hp	77,8 %	8,04 ft

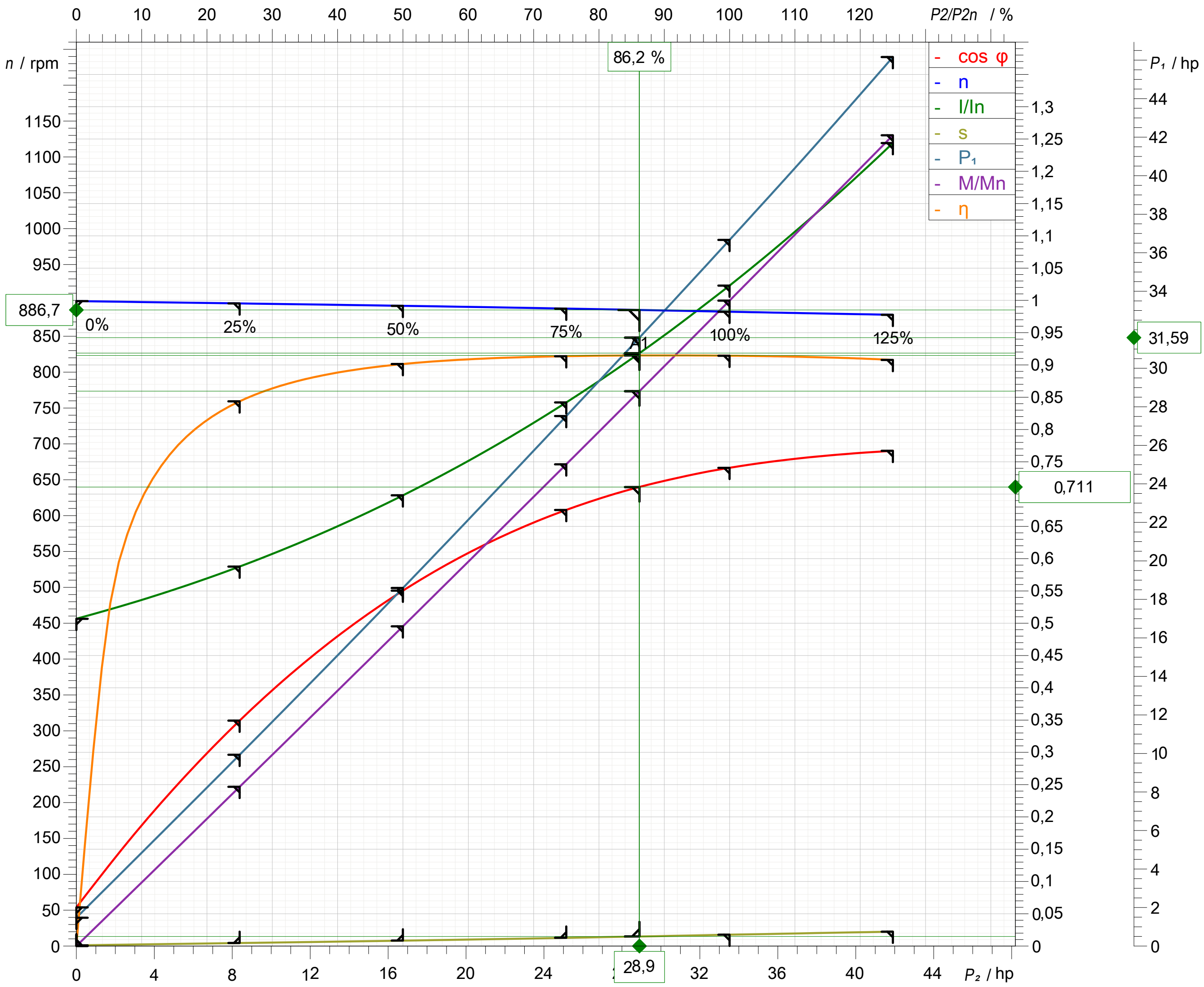


Impeller size	N° of vanes	Impeller	Solid size	Revision
368 mm	2	2-vane channel impeller	110 x 127 mm	

Spaix® 4, Version 4.3.12 - 2019/08/29 (Build 267)
Data version Sept 2019

Frequency 60 Hz	PE4	**Motor performance curve** PE 250/8	SULZER

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
33,5 hp	1,3	884 rpm	8	480 V	2019-11-07



Symbol	No load	25 %	50 %	75 %	100 %	125 %
P_2 / hp	0	8,381	16,76	25,14	33,53	41,91
P_1 / hp	1,471	9,934	18,59	27,52	36,67	46,16
η / %	0	84,37	90,15	91,36	91,43	90,78
n / rpm	899	895,8	892,4	888,6	884,2	880
cos φ	0,05995	0,3493	0,5505	0,6755	0,7407	0,7671
I / A	22	25,51	30,3	36,54	44,4	53,98
s / %	0,1063	0,4687	0,8404	1,271	1,754	2,227
M / lbf ft	0	49,14	98,66	148,6	199,1	250,1

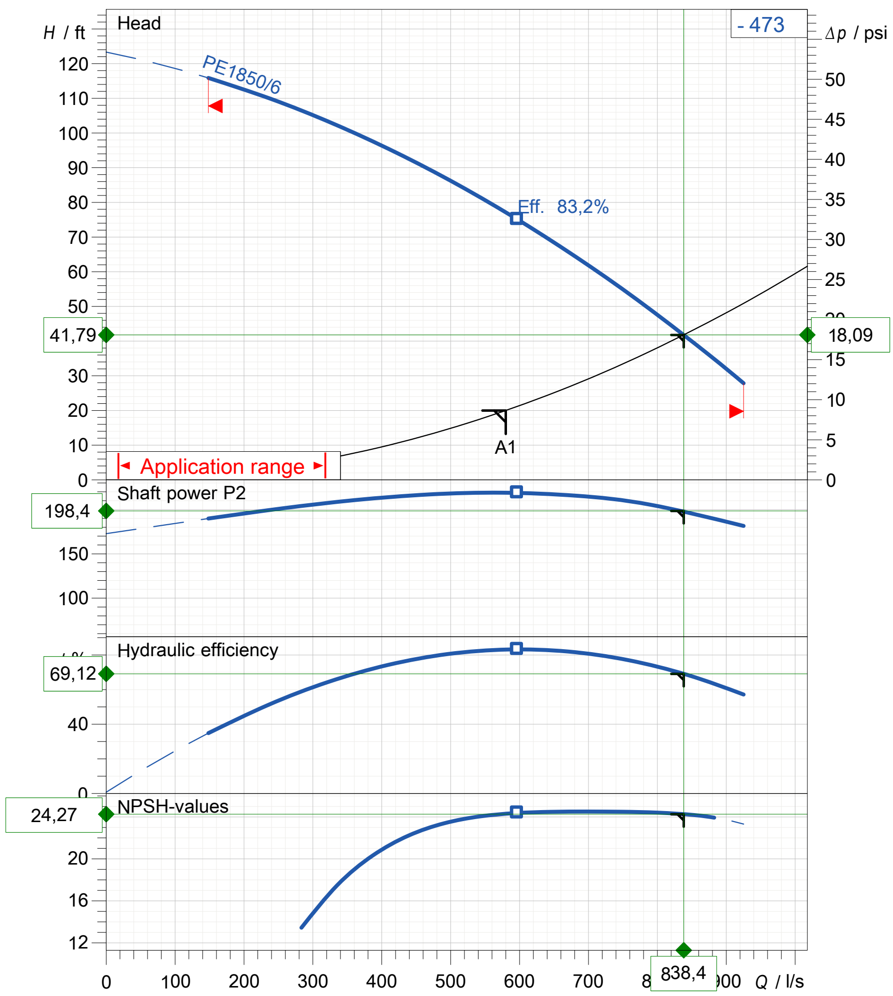
Tolerance according to VDE 0530 T1 12.84 for rated power

Starting current	Starting torque	Moment of inertia	No. starts per hour
221 A	378 lbf ft	13,6 lb ft²	10

Spaix® 4, Version 4.3.12 - 2019/08/29 (Build 267)
Data version Sept 2019

SULZER

XFP 400M-CH2 60 HZ



Testnorm
ISO9906:2012,HI 11.6/14.6 Gr2B

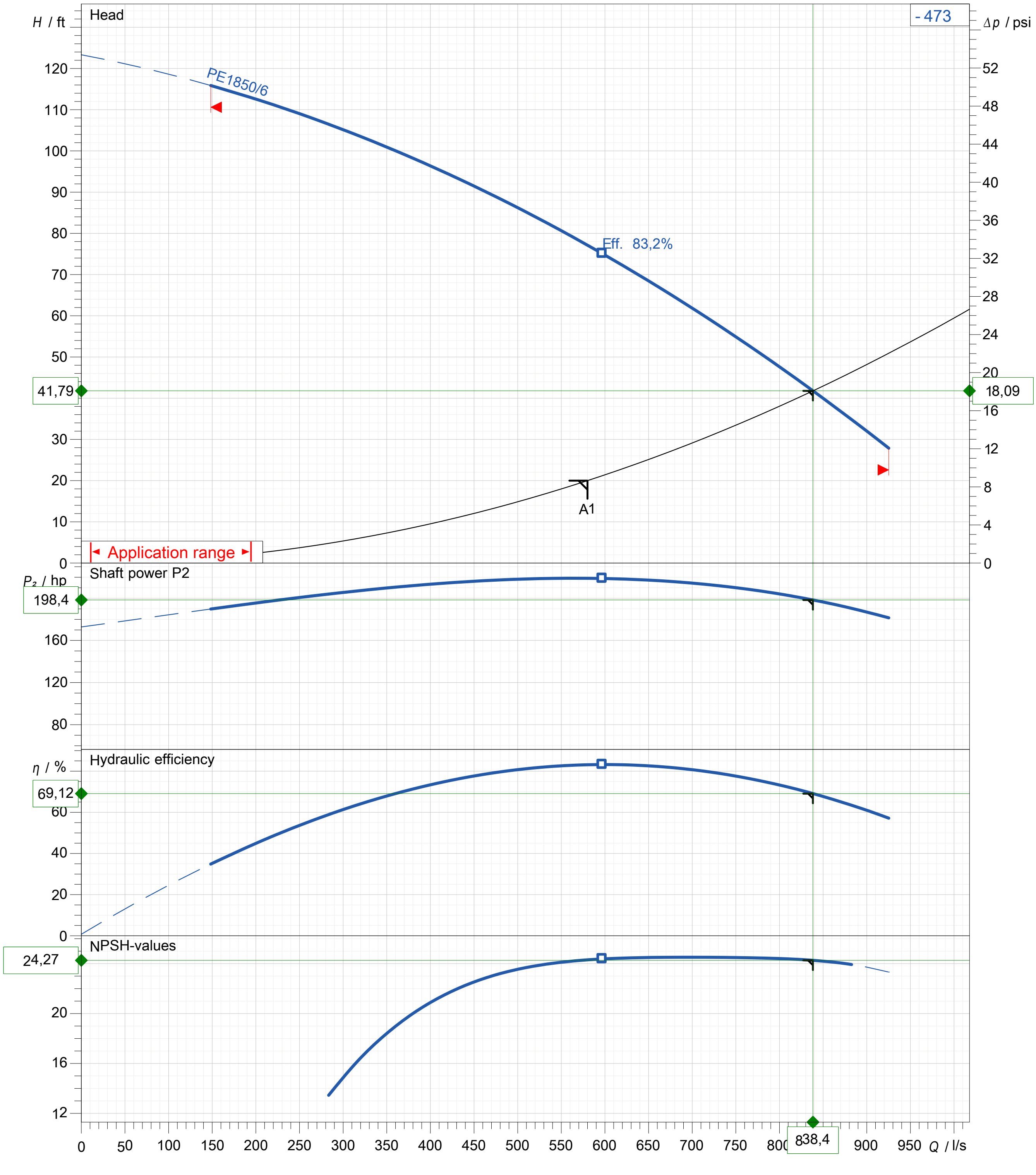
2019-11-07

Operating data specification			
Flow	838,4 l/s	Power input	207 hp
Efficiency	69,1 %	Head	41,8 ft
NPSH	24,3 ft	Rated power	198 hp
Temperature	68 °F	Fluid	Water
No. of pumps	1	Nature of system	Single head pump
Pump data			
Type	XFP 400M-CH2 60 HZ	Make	SULZER
Series	XFP PE4-PE7	Impeller	2-vane channel impeller
N° of vanes	2	Impeller size	473 mm
Free passage	180 x 150 mm	Suction flange	DN400
Discharge flange	DN400	Type of installation	wet well vertical installation 2"
Moment of inertia	38,7 lb ft²		
Motor data			
Rated voltage	480 V	Frequency	60 Hz
Rated power P2	248 hp	Nominal Speed	1180 rpm
Number of poles	6	Efficiency	95,8 %
Power factor	0,838	Rated current	277 A
Starting current	2080 A	Rated torque	1100 lbf ft
Starting torque	2860 lbf ft	Degree of protection	IP 68
Insulation class	H(140)	No. starts per hour	10

Curve number	Pump performance curves
Reference curve XFP 400M-CH2 60 HZ	XFP 400M-CH2 60 HZ

SULZER

					Discharge DN400	Frequency 60 Hz
Density 62,32 lb/ft³	Viscosity 1,082E-5 ft²/s	Testnorm ISO9906:2012,HI 11.6/14.6 Gr2B			Rated speed 1193 rpm	Date 2019-11-07
Flow 838,4 l/s	Head 41,8 ft	Shaft power 198 hp	Power input 207 hp	Rated power P2 248 hp	Hydraulic efficiency 69,1 %	NPSH 24,3 ft



Impeller size	N° of vanes	Impeller	Solid size	Revision
473 mm	2	2-vane channel impeller	180 x 150 mm	

Spaix® 4, Version 4.3.12 - 2019/08/29 (Build 267)
Data version Sept 2019

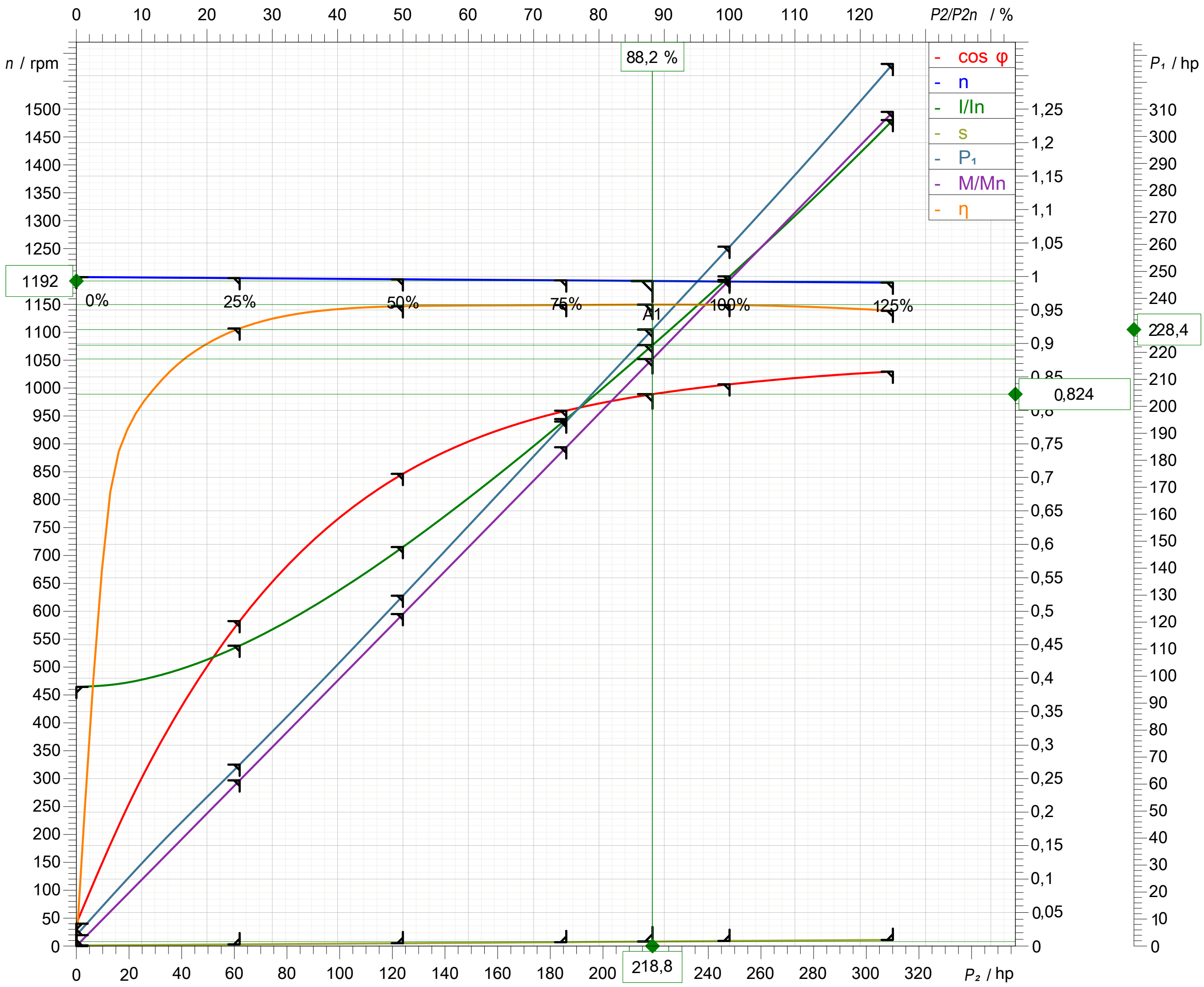
Frequency 60 Hz	PE6

Motor performance curve

PE1850/6

SULZER

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
248 hp	1	1180 rpm	6	480 V	2019-11-07

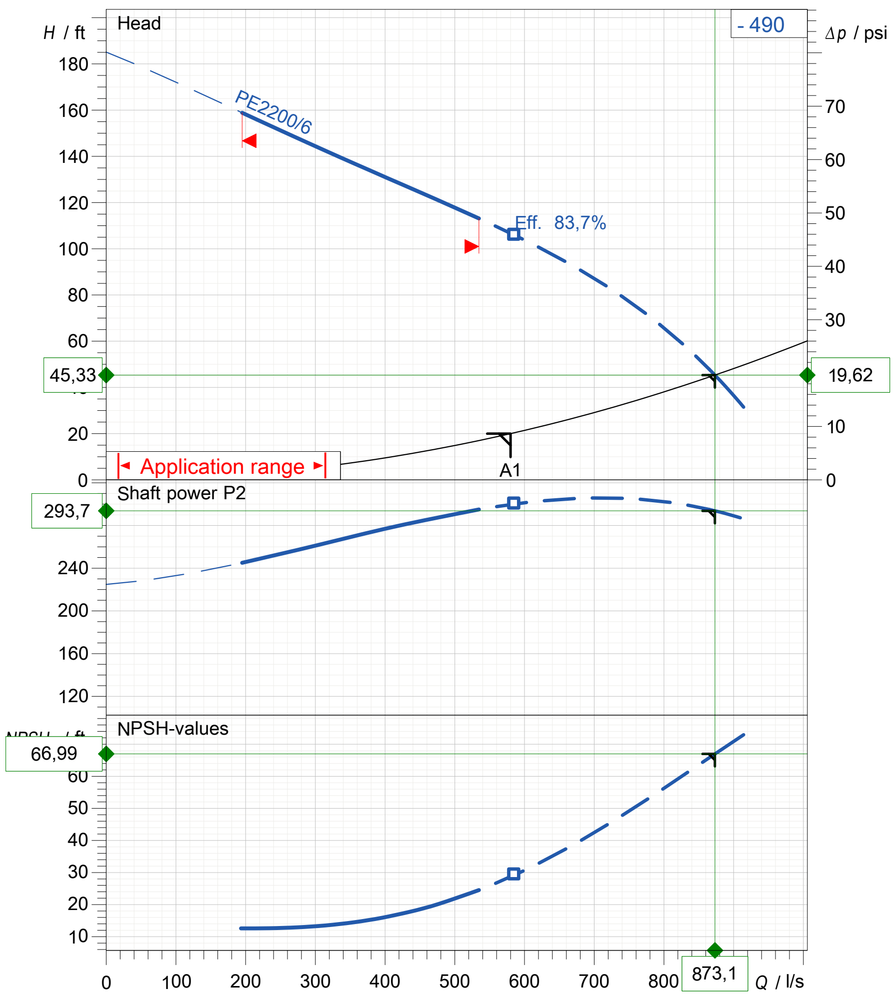


Symbol	No load	25 %	50 %	75 %	100 %	125 %
P_2 / hp	0	62,02	124	186,1	248,1	310,1
P_1 / hp	4,007	67,24	129,8	194,4	259,1	326,9
η / %	0	92,24	95,56	95,73	95,74	94,88
n / rpm	1199	1197	1195	1193	1191	1189
cos φ	0,03353	0,4854	0,7053	0,7996	0,8389	0,858
I / A	107,2	124,3	165,1	218	277	341,7
s / %	0,08333	0,25	0,4167	0,5833	0,75	0,9167
M / lbf ft	0	272,2	545,2	819,2	1094	1370

Tolerance according to VDE 0530 T1 12.84 for rated power

Starting current	Starting torque	Moment of inertia	No. starts per hour
2080 A	2860 lbf ft	207 lb ft²	10

XFP 351M-CH3 60 HZ



Testnorm
ISO9906:2012,HI 11.6/14.6 Gr2B

2019-11-07

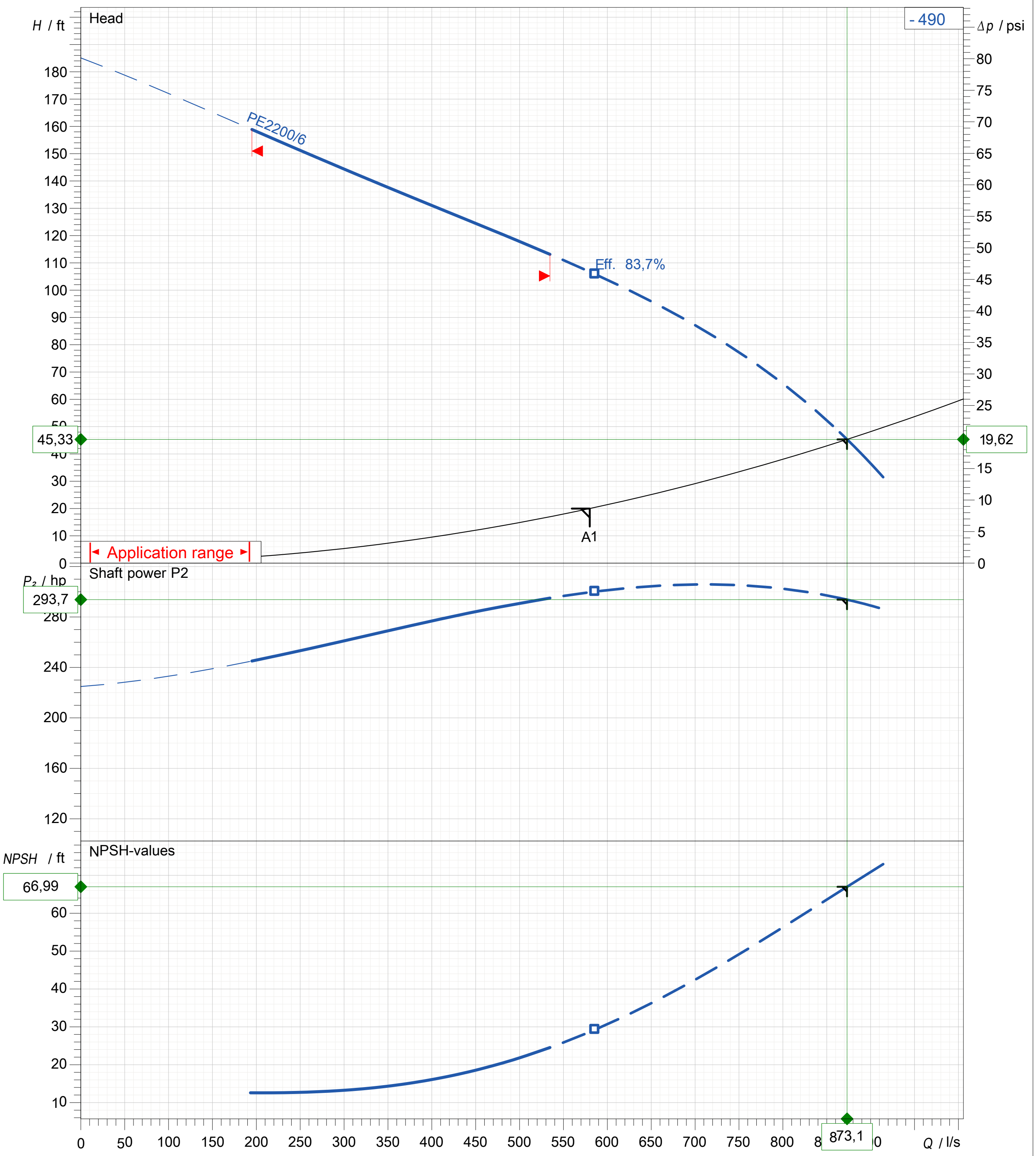
Operating data specification			
Flow	873,1 l/s	Power input	306 hp
Efficiency	53,3 %	Head	45,3 ft
NPSH	67 ft	Rated power	294 hp
Temperature	68 °F	Fluid	Water
No. of pumps	1	Nature of system	Single head pump

Pump data			
Type	XFP 351M-CH3 60 HZ	Make	SULZER
Series	XFP PE4-PE7	Impeller	3-vane channel impeller
N° of vanes	3	Impeller size	490 mm
Free passage	150 x 110 mm	Suction flange	DN350
Discharge flange	DN350	Type of installation	wet well vertical installation 2"
Moment of inertia	37,7 lb ft²		

Motor data			
Rated voltage	480 V	Frequency	60 Hz
Rated power P2	295 hp	Nominal Speed	1190 rpm
Number of poles	6	Efficiency	95,8 %
Power factor	0,819	Rated current	337 A
Starting current	2900 A	Rated torque	1310 lbf ft
Starting torque	3920 lbf ft	Degree of protection	IP 68
Insulation class	H(140)	No. starts per hour	10

Curve number	Pump performance curves
Reference curve XFP 351M-CH3 60 HZ	XFP 351M-CH3 60 HZ

					Discharge DN350	Frequency 60 Hz
Density 62,32 lb/ft³	Viscosity 1,082E-5 ft²/s	Testnorm ISO9906:2012,HI 11.6/14.6 Gr2B			Rated speed 1193 rpm	Date 2019-11-07
Flow 873,1 l/s	Head 45,3 ft	Shaft power 294 hp	Power input 306 hp	Rated power P2 295 hp	Hydraulic efficiency 53,3 %	NPSH 67 ft

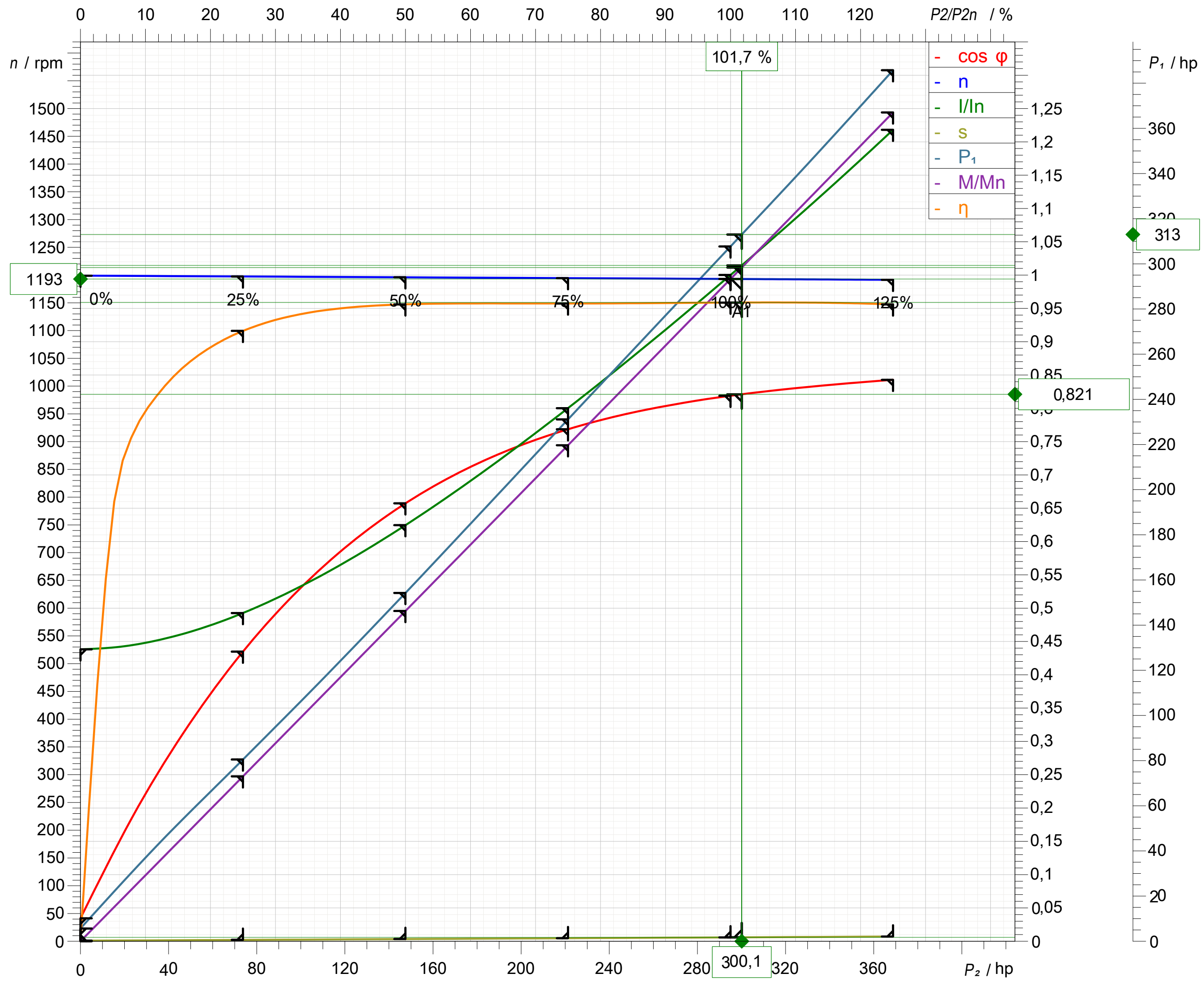


Impeller size	N° of vanes	Impeller	Solid size	Revision
490 mm	3	3-vane channel impeller	150 x 110 mm	

Spaix® 4, Version 4.3.12 - 2019/08/29 (Build 267)
Data version Sept 2019

Frequency 60 Hz	PE6	Motor performance curve PE2200/6	SULZER

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
295 hp	1	1190 rpm	6	480 V	2019-11-07



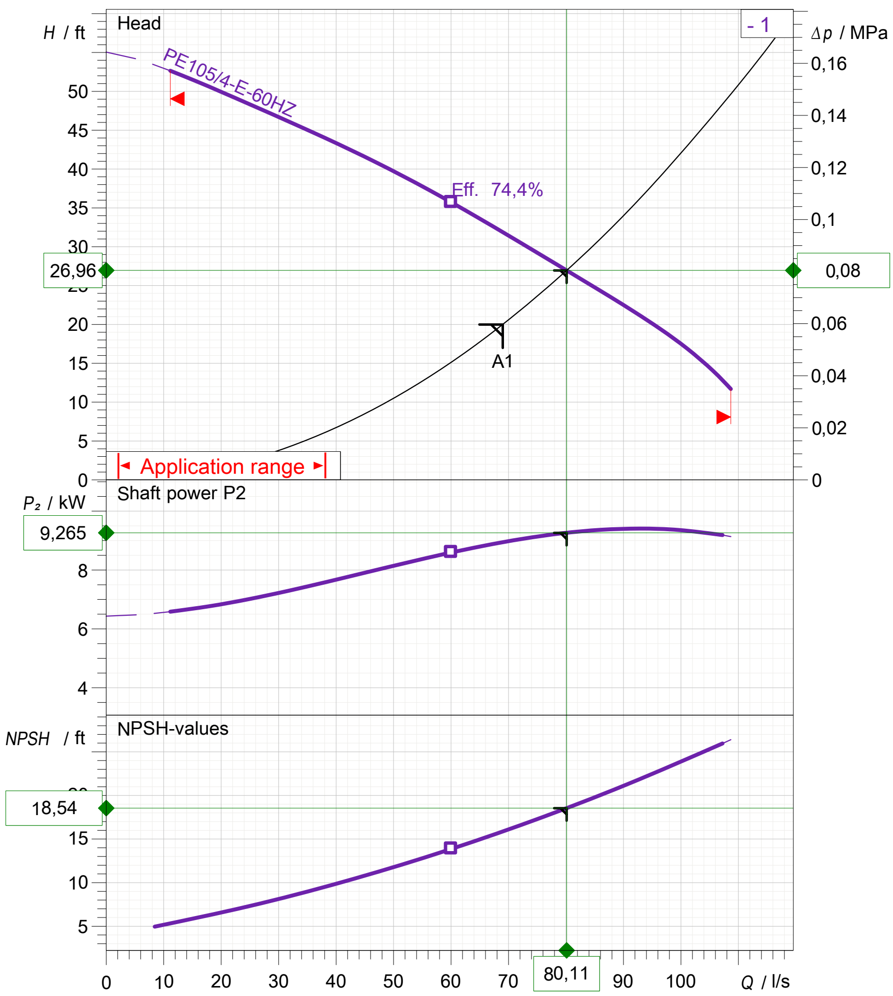
Symbol	No load	25 %	50 %	75 %	100 %	125 %
P_2 / hp	0	73,76	147,5	221,3	295	368,8
P_1 / hp	5,671	80,5	154,3	231,1	307,7	385,8
η / %	0	91,63	95,61	95,74	95,87	95,6
n / rpm	1199	1198	1196	1194	1193	1192
cos φ	0,03444	0,4348	0,6574	0,7686	0,8189	0,8429
I / A	147,7	166,1	210,5	269,7	337	410,5
s / %	0,08333	0,2083	0,3333	0,4583	0,5833	0,7083
M / lbf ft	0	323,5	647,8	972,9	1299	1626

Tolerance according to VDE 0530 T1 12.84 for rated power

Starting current	Starting torque	Moment of inertia	No. starts per hour
2900 A	3920 lbf ft	247 lb ft²	10

SULZER

XFP151E CB2 60HZ (wet pit)



Testnorm

ISO9906:2012,HI 11.6/14.6≤10kW

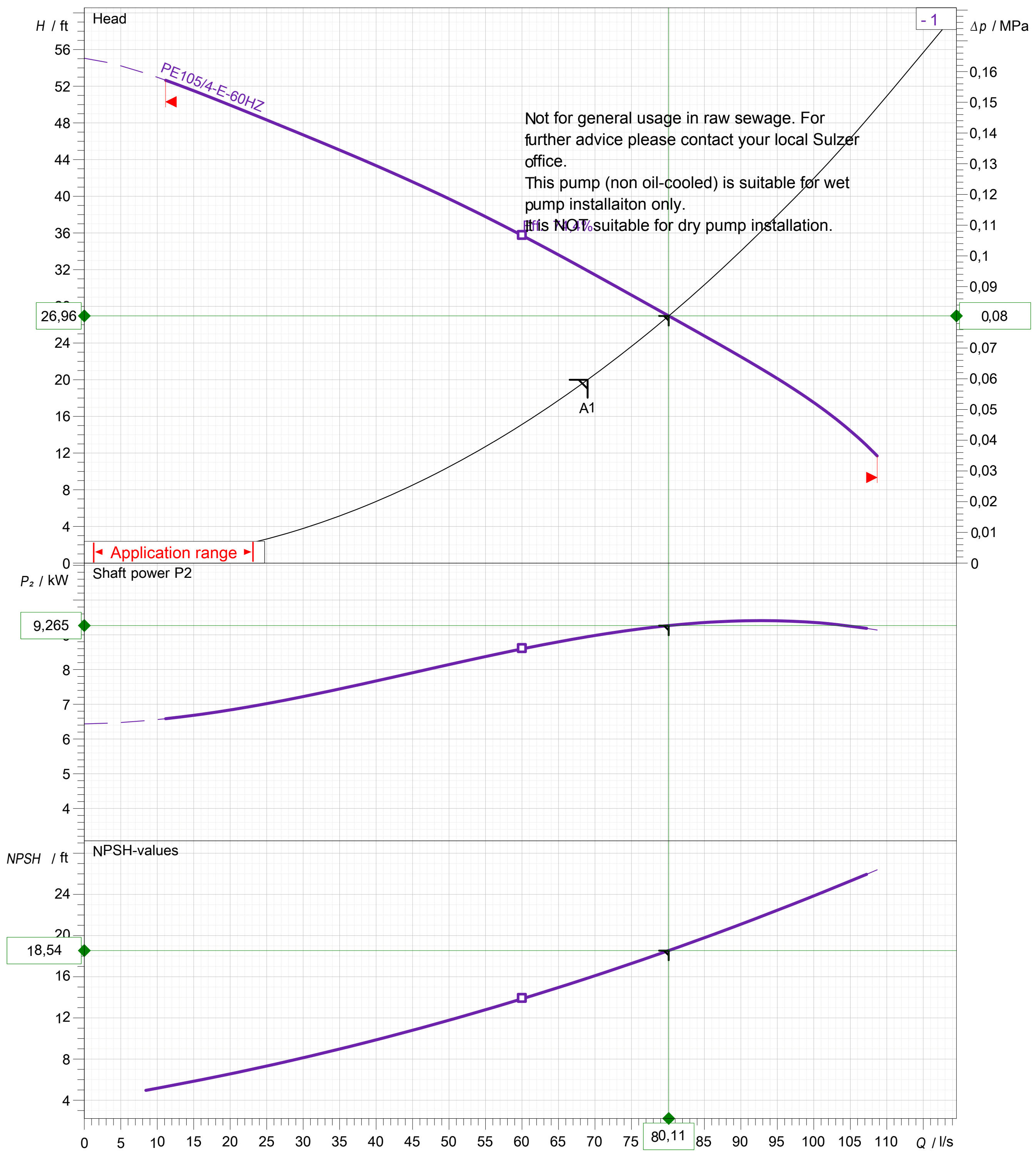
Not for general usage in raw sewage. For further advice please contact your local Sulzer office.
This pump (non oil-cooled) is suitable for wet pump installaiton only.
It is NOT suitable for dry pump installation.

2019-11-08

Operating data specification			
Flow	80,11 l/s	Power input	10 kW
Efficiency	69,7 %	Head	27 ft
NPSH	18,5 ft	Rated power	9,26 kW
Temperature	20 °C	Fluid	Water
No. of pumps	1	Nature of system	Single head pump
Pump data			
Type	XFP151E CB2 60HZ (wet pit)	Make	SULZER
Series	XFP PE1-PE3	Impeller	Contrabloc impeller, 2 vane
N° of vanes	2	Impeller size	230 mm
Free passage	76,2 mm	Suction flange	DN150
Discharge flange	DN150	Type of installation	Wet Well installation with pedestal
Moment of inertia	0,0236 kg m²		
Motor data			
Rated voltage	460 V	Frequency	60 Hz
Rated power P2	10,5 kW	Nominal Speed	1750 1/min
Number of poles	4	Efficiency	92,4 %
Power factor	0,81	Rated current	17,7 A
Starting current	106 A	Rated torque	57,2 Nm
Starting torque	118 Nm	Degree of protection	IP 68
Insulation class	H	No. starts per hour	15

Curve number	Pump performance curves
Reference curve XFP151E CB2 60HZ	XFP151E CB2 60HZ (wet pit)

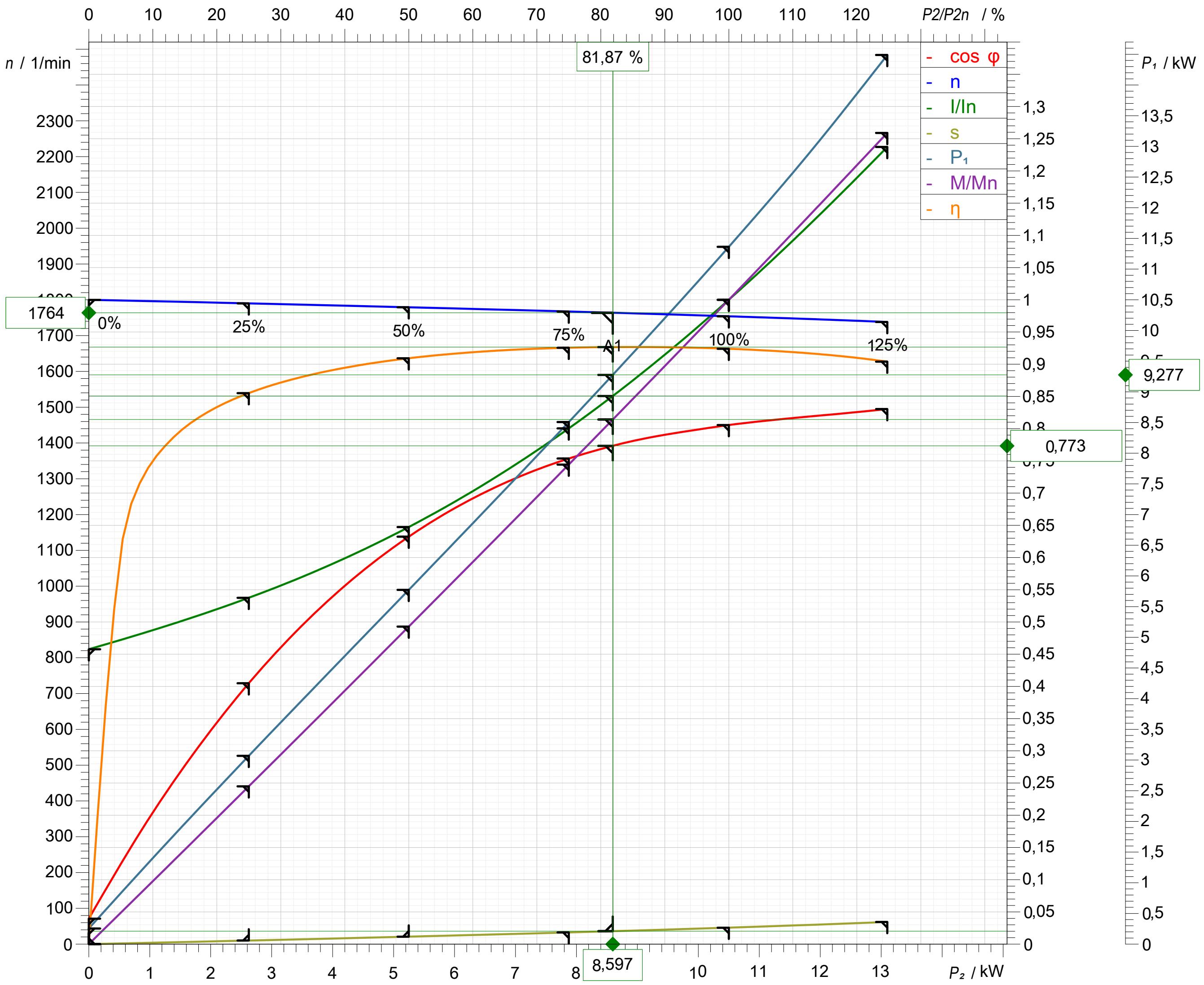
					Discharge	Frequency
					DN150	60 Hz
Density	Viscosity	Testnorm			Rated speed	Date
998,3 kg/m³	1,005 mm²/s	ISO9906:2012,HI 11.6/14.6≤10kW			1760 1/min	2019-11-08
Flow	Head	Shaft power	Power input	Rated power P2	Hydraulic efficiency	NPSH
80,11 l/s	27 ft	9,26 kW	10 kW	10,5 kW	69,7 %	18,5 ft



Impeller size	N° of vanes	Impeller	Solid size	Revision
230 mm	2	Contrabloc impeller, 2 vane	76,2 mm	

Frequency 60 Hz	PE2	**Motor performance curve** PE105/4-E-60HZ	SULZER

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
10,5 kW	1,3	1750 1/min	4	460 V	2019-11-08



Symbol	No load	25 %	50 %	75 %	100 %	125 %
P_2 / kW	0	2,625	5,25	7,875	10,5	
P_1 / kW	0,2553	3,069	5,774	8,508	11,36	
η / %	0	85,52	90,93	92,56	92,4	
n / 1/min	1800	1790	1779	1767	1754	
cos φ	0,03956	0,4049	0,6324	0,7537	0,8057	
I / A	8,1	9,514	11,46	14,17	17,7	
s / %	0,0007998	0,5572	1,163	1,819	2,56	
M / Nm	0	14	28,18	42,55	57,17	

Tolerance according to VDE 0530 T1 12.84 for rated power

Starting current	Starting torque	Moment of inertia	No. starts per hour
106 A	118 Nm	0,0449 kg m²	15

Spaix® 4, Version 4.3.12 - 2019/08/29 (Build 267)
Data version Sept 2019

Appendix G

GENERATOR SIZING

Generator Sizing Details:

Pump Flow	Pump Type	Generator Sizing		Cost
Litre/sec.		HP	Alternator	
235	SULZER XFP306M-CB260HZ-235lps	250HP	600kW	$155K
381	SULZER XFP301M-CH260HZ_381lps	400HP	800kW	$380K
780	XFP_400M-CH2__60_HZ 780lps 20ft head	350HP	800kW	$250K
180	XFP_300_J_CH2_60HZ_180lps 20ft	50HP	125kW	$70K
580	XFP_351M-CH3__60_HZ_580 20ft	400HP	800kW	$380K
26	XFP_80C_CB1_60HZ_(wet_pit) 26lps 20ft	-	-	-
43	XFP150G_CP_60HZ_(wet_pit_dry_pit) 43lps 6m 20ft	-	-	-
69	XFP151E_CB2_60HZ_(wet_pit) 69lps 20ft	20HP	50kW	$45K

Appendix H

DEWATERING COSTS

Dewatering Estimate:

Item	Quantity	Unit	Labour	Total Labour	Material	Total Material	Equipment	Total Equipment	Total
150 mm Dewatering Header Pipe	55	LM	15	825	20	1100			
50 mm Well Point Riser Pipe	420	LM	16	6846	14	5670			
250 mm Discharge Pipe	50	LM	14	715	27	1325			
Swing Joints W/Valves	36	Each	6	205	68	2448			
Self Jetting Tips	36	Each	5	180	63	2268			
Wellpoint Screened Tips	36	Each	6	205	33	1188			
Discharge Stones	4	CUM	12	47	32	128			
Main Wellpoint System Pump - Electric	1	Each	270	270			1650	1650	
Backup Wellpoint Pump - Electric	1	Each	270	270		1650	1650	1650	
Pump Operator (Paret Time)	5	Week	900	4500					
Installation Accessories	1	LS	1500	1500	1950	1950			
Subtotal - Labour									$15,564
Subtotal - Material									$17,727
Subtotal - Equipment									$3,300
Labour Burden	32	%							$5,136
Material Tax	13	%							$2,305
SUBTOTAL									$44,031
General Contractor & Indirect Costs	15	%							$6,605
Escalation	10	%							$4,403
Total Cost									$55,039