July 14, 2015

Elizabeth VanHooren
General Manager/Secretary Treasurer
Kettle Creek Conservation Authority
44015 Ferguson Line
St.Thomas, Ontario N5P 3T3

Dear Ms. VanHooren:

Re: Inner Harbour Flooding, Port Stanley Ontario

Purpose of this report is to review the flooding impacts of the infilling of Port Stanley harbour. The review will focus on the inner harbour area where new development is proposed. Our 2010 report (Kettle Creek Hydraulic Study, Riggs Engineering Ltd., June 2005, updated April 2010) assessed this issue considering the entire length of Kettle Creek through Port Stanley.

The Kettle Creek Conservation Authority uses the Hurricane Hazel standard with a 48 hour rainfall of 285 millimetres. Flooding in Port Stanley was first assessed by Cumming Cockburn in 1986[1]. Cumming Cockburn made further assessment in 1988[2] to establish a floodway which defines a no development area (floodway) consistent with the main flow of Kettle Creek and a flood fringe consisting of shallow areas of flooding where development may be permitted. The floodway concept only applies north of the lift bridge. The floodway concept was not extended below the lift bridge because flooding was contained within the harbour walls per the original floodplain mapping and no fringe areas were identified. The floodway concept applies to areas were flooding is contained within a river valley. The area surrounding the inner harbour can be classified as a river delta or beach accretion area with no valley walls. If the area beyond the main channel flooded, large spills would occur. Flow paths would form around obstacles and scoured rivulets. Obstructions such as buildings will exacerbate the situation, tending to increase flood levels. The floodway concept should not, therefore, apply to this type of delta area.

Riggs Engineering updated the floodplain mapping as part of the Hydraulic Studies report 2010. Riggs Engineering also looked at the impacts of not dredging the harbour on upstream flooding.

Harbour infilling is caused by sand deposits from Lake Erie and by river sediments carried by Kettle Creek. If no dredging takes place, the bed elevation raises and the hydraulic capacity reduces. The implications of not dredging were based on the inner

[1] Cumming Cockburn Limited (1986). Floodline mapping study for the Village of Port Stanley, submitted to the Kettle Creek Conservation Authority.
[2] Cumming Cockburn Limited (1988). Engineered Floodway Kettle Creek-Port Stanley, Canada – Ontario Flood Damage Reduction Program (FDRP), submitted to the Kettle Creek Conservation Authority.

and outer harbour areas filling to elevation 172.5 m. The potential additional flooding compared to a fully dredged situation (elevation 168.0 m) is shown on the attached

figure 1. A significant area of additional flooding occurs below the lift bridge. The extent of this flooding is shown on figure 1 down to the line of Lake Erie flooding. The Lake Erie flooding is due to high water levels and wave uprush. The full extend of the flooding cannot easily be defined because the area south of the Lake is relatively flat with no valley walls. Therefore when water overtops the harbour walls there is extensive spilling into the low areas before entering Lake Erie.

The 2010 assessment took a simplistic approach to the filling of the harbour with the assumption that the harbour fills to uniform levels. In reality filling is variable with deposits more concentrated in certain areas. Riggs Engineering carried out a sounding survey in 2014 on behalf of the Municipality of Central Elgin. We have reviewed 2014 sounding below the lift bridge and analyzed upstream flooding resulting from the new bed elevations. Dredging was last carried out in 2001. Thus a lengthy period of harbour infilling has ensued. Harbour elevations are shown on figure 2.

Our hydraulic model (HecRas) was updated to include the 2014 sounding data. The results for flooding of the inner harbour area are shown below.

Flood Levels Inner Harbour – 2014 Soundings

above lift bridge	176.6 m
below lift bridge	176.1 m
100 m south of lift bridge	176.1 m
200 m south of lift bridge	175.8 m
300 m south of lift bridge	175.2 m

The effect of additional rising of the river bed was checked. The increase in flood level was consistent with the increase in bed level e.g. an increase in bed level of 0.5 m increases flood levels by 0.5 m.

Prior to 2001 dredging was carried out on a regular basis to provide sufficient draft for large Great Lakes vessels.

The top of the harbour walls is between elevation 175.5 m and 175.8 m. More accurate elevations of the harbour walls will be surveyed by us and will be appended to this report. The critical area for flooding is below the lift bridge for about 200 m. Although the regional flood (Hurricane Hazel) will overtop the harbour wall under present conditions, the 100 year flood is contained within the harbour walls. The maximum 100 year flood level below the lift bridge is 174.4 m (Lake Erie at mean of 174.1 m). With a higher lake level (175.2 m) the 100 year flood increases to 175.3 m. The maximum level of the regional flood is not affected by lake level. As discussed in our 2010 report, flooding levels due to ice are not expected to be affected by dredge levels. However, the duration

of flooding is likely to be increased by the slower breakup and movement of ice below the lift bridge caused by a constricted channel.

Recommendations

Given that the overtopping of the harbour walls can occur at present and will worsen as the harbour fills in, new development for the inner harbour area can only be considered if dredging is to be carried out. If dredging is not carried out the inner harbour area will flood and new development cannot be permitted. Dredging should be sufficiently deep to trap sediments over an extended period. This is more economical than frequent dredging to higher elevations. If dredging is carried out to the 2001 depth (167.1), a period of 10 to 15 years can be assumed before further dredging is necessary. Over the long term, the volume removed would not change, regardless of the frequency of dredging (what goes in must come out).

In order to assess future dredging a general guideline to channel elevations is needed. Based on the 2014 soundings, the elevation pattern shown on the following table could be used. However, there may be variability in the pattern, in which case detailed soundings will be required. The maximum channel bed elevation is based on a flood elevation of 176.0, which results in minor overtopping and spillage.

There is a degree of uncertainly in predicting harbour infilling, both spatially and temporally. Also, it may not always be possible to carry out dredging in a timely manner. In view of these considerations it is recommended that new development incorporate flood proofing. An elevation of 176.5 m is suggested for the inner harbour below the lift bridge. This elevation is similar to that required to protect from wave uprush (176.8 m).

Avoiding flood damages and allowing future development will require a commitment by the municipality to carry out dredging. Such commitment could be in the form of a council resolution.

Maximum Channel Elevations

at exit of outer harbour	169.5 m
at exit of inner harbour channel	170.0 m
250 m north of exit of inner harbour channel	170.3 m
500 m north of exit of inner harbour channel	170.5 m

Conclusions

Flooding in Port Stanley is affected by harbour dredging. If dredging is not carried out, flooding is exacerbated. In the inner harbour area there is potential for overtopping the habour walls and considerable spillage on both sides of the channel. Soundings done in 2014 show critical creek-bed elevations have now been reached. Spillage in a delta area does not lend itself to a floodway concept. The flood risk is a barrier to future development. Monitoring of creek bed elevations would trigger channel cleanout when required. The frequency of dredging can be considerably reduced by deep excavation.

Dredging is required to avoid flooding problems and should be supported by a council resolution. Flood proofing of new development to 176.5 m is recommended.

Yours truly,

Peter Crook, P. Eng.
Senior Engineer

Figures 1-2

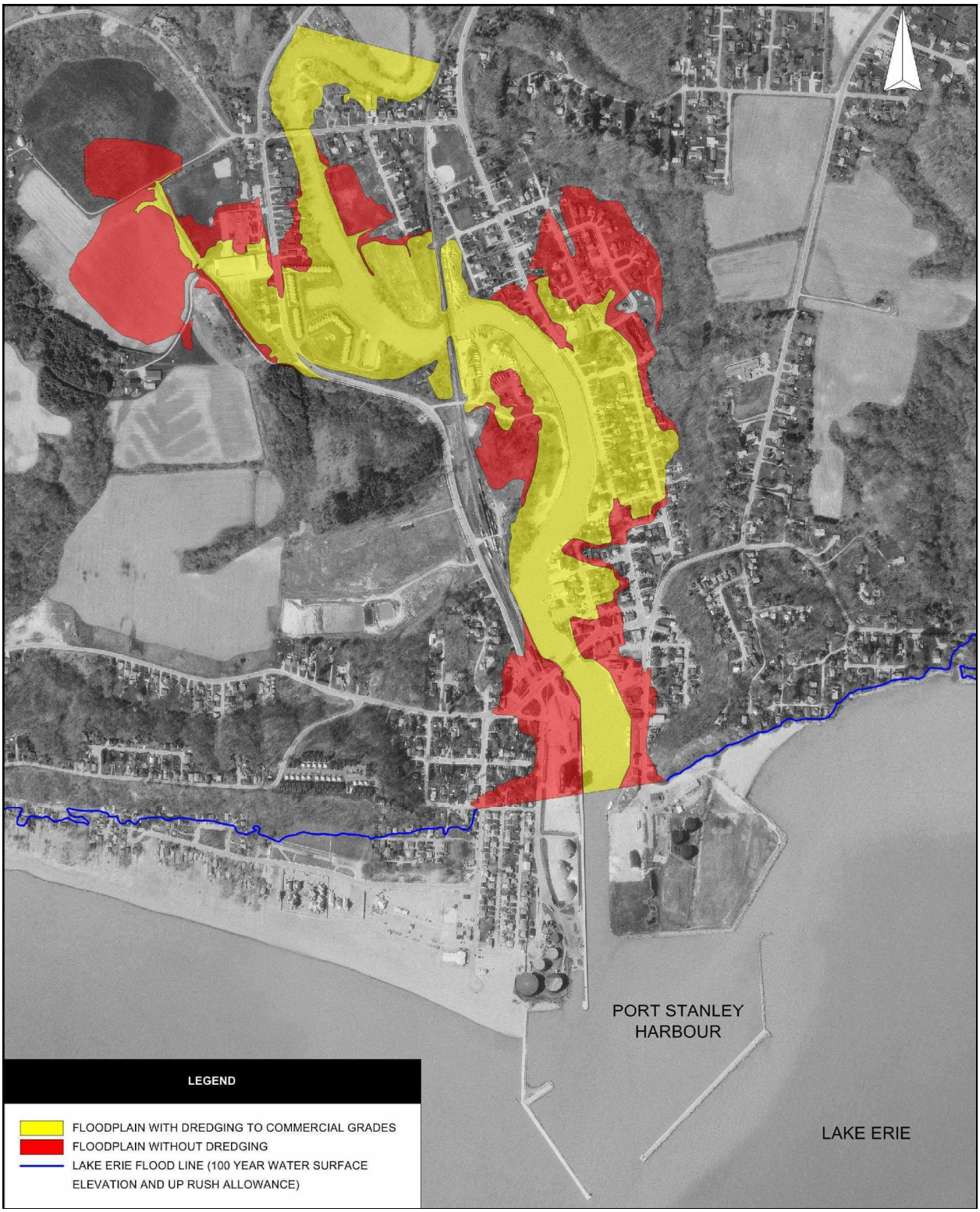

FIGURE 1. FLOODPLAIN COMPARISON DREDGING VS NO- DREDGING

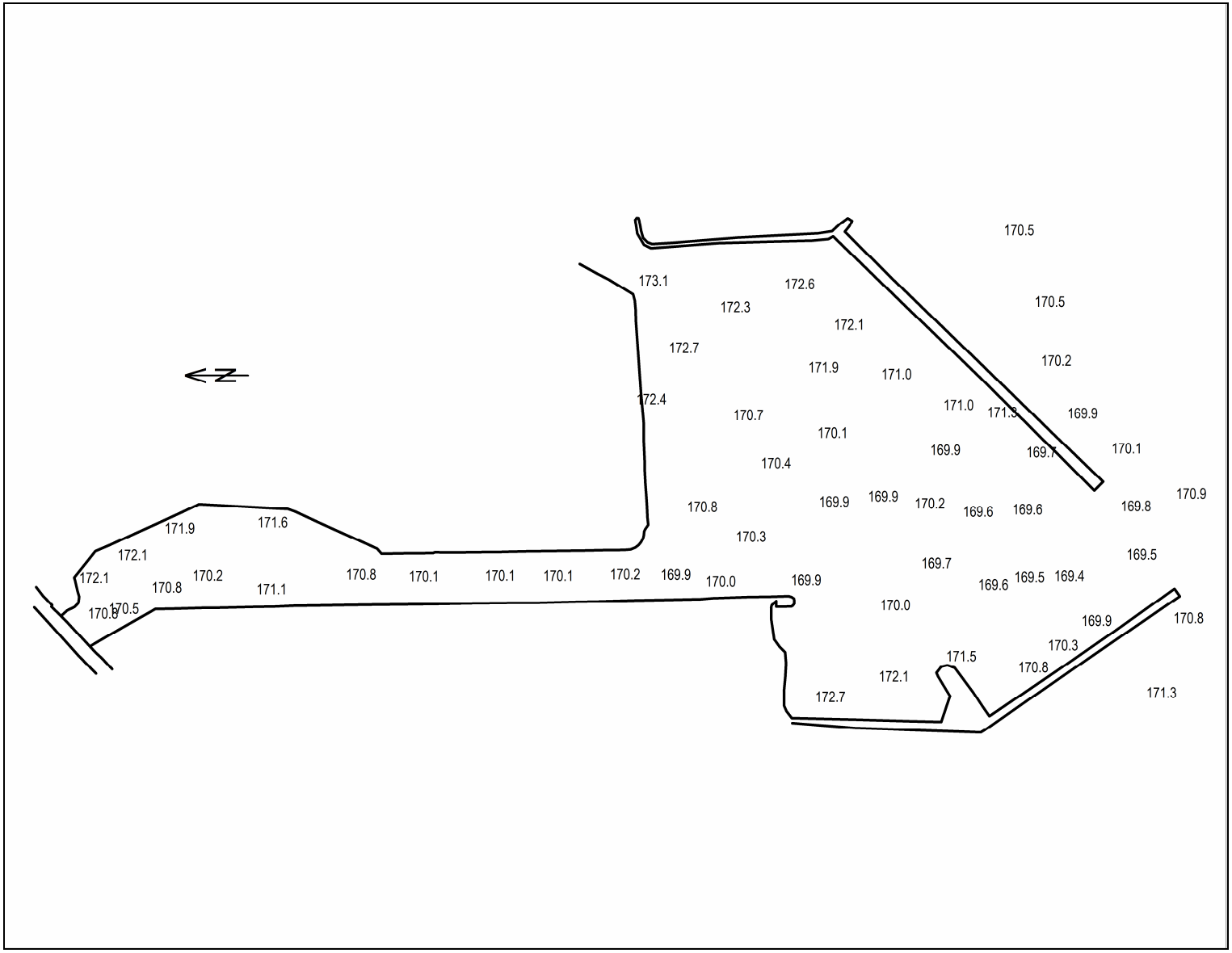

FIGURE 2. 2014 HARBOUR SOUNDINGS