Ontario Municipal Board

IN THE MATTER OF an appeal by Ted Cooper of By-law 2007-359 of the City of Ottawa relating to property municipally known as 613, 5585 and 5601 Hazeldean Road.

Witness Statement of Darlene Conway, P. Eng.

February 19, 2008

Background

1. I am a Professional Engineer, as designated by Professional Engineers Ontario. I work in the Planning, Transit and Environment Department of the City of Ottawa. I have been employed by the City of Ottawa since 2002. I have 20 years of experience in water resources and municipal engineering, both in the public and private sectors. A copy of my Curriculum Vitae is included as Exhibit A.

2. I currently sit on the Technical Advisory Committee for the Fernbank Community Design Plan (henceforth “Fernbank”) on behalf of the City of Ottawa, but provide this testimony as a private citizen.

3. The Fernbank lands are located on the west side of the Carp River, immediately upstream of Hazeldean Road. The portion of this development area draining to the Carp River is approximately 200 hectares, a location plan of which is provided in Exhibit B.

4. The development of the Fernbank lands was not accounted for in the hydrologic and hydraulic modeling undertaken for the Carp River Restoration Plan Class Environmental Assessment (henceforth “restoration project”). As such, the proponents of the Fernbank Community Design Plan were directed by the City to complete an impact analysis of the development of these lands on the restoration project. The results of this impact analysis would provide the necessary stormwater management criteria to be applied to the Fernbank

development to ensure no increased flood and erosion risk downstream of the development.

5. The impact analysis for the Fernbank lands would require the use of the modeling supporting the restoration project. The restoration project is a proposed rehabilitation of the Carp River from Hazeldean Road to just north of Richardson Sideroad (henceforth the “study reach”). The restoration project proposes a regrading of the channel and floodplain to effect a more “natural” watercourse and includes the filling and removal from the floodplain for development of approximately 28 hectares. Exhibit C provides the study reach and proposed fill areas.

   In anticipation of the submission of the required impact analysis for the Fernbank lands, I undertook to familiarize myself with the following Class Environmental Assessment documents (henceforth “Class EAs 1, 2 and 3”) supporting the restoration project in November 2007:

   i) Flow Characterization and Flood Level Analysis: Carp River, Feedmill Creek and Poole Creek (CH2MHill, October 2005) – Class EA 1;

   ii) Post-Development Flow Characterization and Flood Level Analysis for Carp River, Feedmill Creek and Poole Creek (CH2MHill, June 2006) – Class EA 2;

   iii) Kanata West Master Servicing Study Volumes 1 and 2 (Stantec, June 2006) – Class EA 3.

   These documents provide the technical support for the restoration project, including existing and post-development hydrologic and hydraulic modeling. “Existing” refers to 2005 land use conditions and post-development refers to the future build-out of most lands designated urban within the Official Plan (but, for instance, does not include development of the Fernbank lands).

   The hydrologic modeling simulates the runoff response of the watershed to rainfall events (how much water runs off), and the hydraulic modeling simulates resultant water levels within the receiving Carp River. Existing and post-development flows and water levels are compared to assess the impact of the proposed restoration project and floodplain filling. Another factor – the amount of storage within the study reach – is also calculated for existing and post-development conditions and compared. The amount of storage (or the volume of water) within the study reach influences the water levels and peak flows. For example, any reduction in storage from filling in the floodplain reduces the attenuation of flood flows and can result in increases in water levels and peak flows.

At the time of my review, the Class EAs had been approved by the City, Mississippi Valley Conservation, the Ministry of Natural Resources, and the Ministry of Transportation. The Minister of the Environment has yet to render his decision on four Part II Order requests that were submitted after the Class EAs were posted for the public review period in July 2006.

Review of Class Environmental Assessment Documents

6. From the review of the Class EAs, I have two major concerns:

   i) Design of the restoration project and associated post-development 100 year flood elevations has proceeded on the basis of uncalibrated/unvalidated modeling; and

   ii) The results of the post-development analyses indicated *reduced* flood levels compared to the 2005 existing condition levels.

7. i) **Uncalibrated/unvalidated modeling**: The hydrologic model used for the restoration project analyses (XPSWMM) is not a physically-based model. In order to provide a realistic representation of the runoff response of a watershed to a rainfall event, the model must be calibrated to actual measured events. Data from measured events are obtained from rainfall gauges and streamflow gauges. Once calibrated, that is, the various model parameters adjusted such that the simulated (modeled) response closely matches the observed response, the model is then validated by "testing" it

with additional (different) measured events. Key elements to be calibrated and validated for hydrologic modeling are total runoff volume (how much water runs off the land) and time to peak (the time it takes after runoff begins for the peak flow of the event to occur).

For the restoration project, level loggers (to continuously record water levels) were installed at three locations within the study reach: at Palladium Drive, Glen Cairn pond and Richardson Sideroad. For the period of monitoring (early September 2004 to the end of October 2004) only one event – that of September 9, 2004 - was available to attempt calibration of the modeling. However, only water levels, rather than flows derived from water levels, were used. Without observed flows, the runoff volume for this one observed event could not be determined and hence, the hydrologic model could not be calibrated for runoff volume.

From Figure 3-3 from Class EA 1, included as Exhibit D, it is evident that the simulated (modeled) water levels on the recession (or falling) limb of the event are significantly lower than the observed water levels at both Palladium Drive and the Glen Cairn pond. Attempts were made with the hydraulic model to improve the calibration by increasing the channel roughness (Manning's 'n' value) but this resulted in only a marginal water level increase and significant differences between observed and simulated water levels remain. The observed and simulated times to peak also differ in the order of six to nine hours. Overall, these results indicate that the modeling is not generating sufficient runoff volume and/or not reflecting the poorly drained character of the study reach. In other words, the simulated water levels recede much more quickly than the observed water levels.

8. The Ministry of Natural Resources Technical Guide: River and Stream Systems: Flooding Hazard Limit (MNR, 2002), henceforth “the Guide,” documents standardized approaches to manage flood susceptible lands across the Province. As noted on p. 8, the Guide also “assists in the approval

process and in explaining, or if necessary defending, the methodology when challenged." The Guide notes on p.26 (my emphasis), "

> The best test of a watershed model lies in its ability to adequately reproduce recorded flows from storms similar in magnitude to that of the selected flood. <u>It is not adequate for the purposes of the flood risk mapping program to blindly apply any model to a watershed without adequate testing for both calibration and verification of the model parameters.</u>

Further on p. 26 (my emphasis),

> Generally, hydrologic models are calibrated for a basin by successive attempts at reproducing recorded data while varying those parameters that are not fixed until an adequate reconstitution is developed. <u>This procedure is followed for several historical events so that model calibration is not based upon a single sample</u>. <u>If sufficient records exist on the stream, several recorded discharges should be run, independent of the calibration runs, to verify the model.</u> If there are no records on the stream in question, the model must be calibrated and tested on a similar adjacent watershed where the variable parameters can be assumed to match those of the basin under study.

And on p. 60, the Guide notes,

> For a single event model, five events of significant magnitude is recommended, this will prove invaluable for testing the accuracy of the calibration and should not be overlooked.

Excerpts from the Guide are provided in Exhibit E.

9. From the methodologies identified in the Guide, the modeling supporting the restoration project has not been calibrated: only one event was available, and even for this event, an observed runoff volume could not be determined. Likewise, with only one available event, validation was not possible.

10. The lack of adequate calibration and no validation is acknowledged in Class EA 1 as well by City staff who commented on this document. From a summary of comments provided at the front of Class EA 1 (not numbered), provided as Exhibit F, City staff commented:

    3rd page of comments: Calibration of the model is a major concern. The consultant has calibrated the model based on only **one event** and is only using **water levels.** There is no way of knowing if the flows are adequately modeled especially given that the results differ from previous models and that non-standard parameters are used in the analysis. The consultant recommends that further flow monitoring be undertaken to validate the model. It is our opinion that a calibrated model has not been prepared and additional flow monitoring is required to calibrate and validate the model.

4th page of comments: The report recommends that monitoring of the Carp River be continued to better calibrate the model, however development design is currently proceeding using this model. It is recommended that design not proceed based on flows from this analysis.

11. A sensitivity analysis of various model parameters was undertaken. However, this provided no insight into the problems with the lack of calibration noted above, in particular, the lack of an observed runoff volume to calibrate to. The Guide also notes on p. 66 that,

The purpose of model testing and sensitivity analysis is to assess the impact of variations or uncertainties in the various calibrated model parameters on flood profiles. The relative importance of the variables is determined by changing one variable, within prescribed limits, and conducting simulations with all other variables held constant.

This indicates that a sensitivity analysis is not a substitute for calibration, but is a recommended procedure to be undertaken once calibration has been achieved.

12. The post-development analysis, documented in Class EA 2, proceeded on the basis of the uncalibrated/unvalidated existing condition modeling as documented in Class EA 1 without obtaining additional streamflow monitoring as had been recommended.

13. To summarize, the existing condition modeling was not calibrated or validated and so does not meet the requirements of the Guide. I am in agreement with the City staff quoted above that this modeling, in its current state, cannot be used for purposes of design, including the delineation of existing and/or future floodplain limits.

14. ii) **Results of post-development analyses**: Notwithstanding the lack of calibration and validation, post-development analyses proceeded by adjusting

the existing conditions modeling to reflect full build-out of the Official Plan (excluding Fernbank) and the proposed restoration project and floodplain encroachments. Results of these analyses indicated that post-development flood levels were reduced notwithstanding the significant urbanization proposed, the recommended stormwater management criteria which did not require post-development to pre-development peak flow controls, and that the floodplain was being reduced in width through large sections of the study reach as a result of the proposed filling. The results of the post development analyses documented in Class EA 2 are provided as Exhibit G.

15. In December 2007/early January 2008, I reviewed the hydrologic modeling provided by CH2MHill in Class EA 1 and that provided by Stantec in Class EA 3. The hydraulic modeling reviewed was that forwarded by e-mail to the City from Totten Simms Hubicki on December 19th, 2007, which included both the modeling prepared for the Class EA documents as well as a later detailed design version of the modeling (dated February/April 2007).

16. The hydrologic modeling produced hydrographs at various locations along the reach. A hydrograph is a time series of flows that reflects the runoff response of the watershed for a given rainfall event. The total area under a hydrograph curve represents the total runoff volume for that event.

17. I first compared the total pre-development runoff volume for the study reach (i.e, to Richardson Sideroad) to the total post-development runoff volume. I noted that the post-development runoff was significantly less than the pre-development runoff, a physical impossibility (unless, large drainage areas were diverted or significant volumes infiltrated and neither was the case). Exhibit H provides the total runoff volume comparison. I then discovered that due to a number of coding errors, the model was unable to read the hydrographs from the Kanata West development. This error resulted in the future flood levels being documented in the Class EAs as lower than 2005 existing condition levels.

18. I corrected the coding error that precluded the Kanata West hydrographs from being read and re-ran the model for three different scenarios:

A1(corrected): which assumed full build-out of all designated urban lands within the Official Plan (excluding Fernbank) and the existing channel and floodplain of the Carp River;

E(corrected): the preferred solution identified in Class EA 1, which assumed full build-out of all designated urban lands within the Official Plan and the restored channel of the Carp River with proposed encroachments from filling; and

C FinalV3 (corrected): the detailed design version of the preferred solution E (that is, detailed design work has proceeded on the restoration project).

For all three scenarios, with all hydrographs read by the model, flood levels generally increased over 2005 existing condition levels. For scenario E (corrected) flood levels generally matched 2005 levels, with some increases in the order of 0.09 to 0.12 meters over 2005 levels. However, the detailed design version C Final V3, showed much higher increases (in the order of 0.2 to 0.3 meter) over 2005 levels. All corrected scenarios showed significant increases over the levels for the same scenarios documented in Class EA 2 (in the order of 0.2 to 0.3 meter). A summary comparison of 100 year water levels is provided in Exhibit I.

19. These results indicate that the SWM criteria recommended in Class EA 2 (no post-development to pre-development peak flow controls required) are not adequate to preclude increases in the post-development 100 year flood levels.

20. Of particular concern are the Highway 417 bridge crossings that currently have substandard clearance. Ministry of Transportation design standards require 1.0m of clearance between the 100 year flood elevation and the "low chord" (or bottom) of the bridge. This reduces the chance that debris will

collect behind and threaten the bridge during flooding conditions. With only 0.4m clearance, the existing bridges do not meet this standard. Any increase in flood levels will further threaten these structures.

Additional Modeling Errors and Discrepancies

Additional errors and discrepancies in the modeling include the following items:

21. There are problems with how the five future SWM facilities to be located within the Carp river corridor were modeled. In many cases, the length of SWM facility in the model appears to be greater than that shown in the pond concept figures provided in Class EA 3. These figures are provided as Exhibit J. Also, the locations of some of the levees (which represent the proposed future fill areas in the modeling) are not properly shown beyond the upstream and downstream limits of the SWM facilities. Rather than immediately shifting to the corridor limit (i.e., moving closer to the watercourse), they gradually shift inwards. This is a result of the model interpolating where the levees should go for the interpolated sections. This also affects the actual cross-section as the model interpolates where the ground is based upon the pond bottom even beyond the footprint of the pond. These errors in coding contribute to the model accounting for more storage in the post-development condition than will actually be there (based upon the proposed restoration plan and SWM pond designs). It is estimated that these coding errors result in an additional 18,000 cubic meters of storage that would not actually exist. Calculations to this effect are provided in Exhibit K.

22. The modeling assumes that any storage above the 10 year water levels in the SWM facilities will be available as storage during less frequent events, such as the 100 year event. This might be the case if the 100 year flows were not routed through the SWM facilities but bypassed them and drained directly to the river. However, the 100 year pond outflows greatly exceed the 10 year pond outflows, indicating that any storage above the 10 year water levels in the ponds will be taken up by the 100 year flows directed to the SWM facilities. The modeling does not recognize that this storage will not be

available and so this storage is being “double-counted.” An estimate of the storage that has been double-counted is 12,000 cubic meters. Exhibit L provides calculations for this estimate.

23. The above-noted discrepancies result in a deficit of at least 30,000 cubic meters of storage – storage that has been modeled but would not actually exist upon implementation. This would indicate that the criterion that “riparian storage” be matched between the existing and post-development conditions has not actually been met. Riparian storage is defined as the resulting storage volume within a given reach when all road crossings, bridges, etc., are removed from the model. This criterion is a requirement of the Lakes and Rivers Improvement Act. It ensures that the ability of the floodplain to attenuate flood flows is maintained. As indicated in Class EA 2, the 100 year riparian storage volume for the study reach is documented as exceeding the existing riparian storage by only 10,000 cubic meters. Exhibit M provides the riparian storage summary table from Class EA 2. (Note, however, this table is of limited value as it reflects the results modeling that exluded the hydrographs from Kanata West. The double-counting and over-estimation of available storage in the vicinity of the SWM ponds compounds the error.)

24. There appears to be a discrepancy between the total runoff volume generated by the hydrologic model (XPSWMM) and the total runoff volume of the hydrographs input to the hydraulic model. These values should essentially be the same since the hydrographs input to the hydraulic model are taken from the hydrologic model. The total runoff volume in the hydraulic model is in the order of 70,000 to 90,000 cubic meters less than that generated by the hydrologic model. For comparison purposes, the excess runoff volume (the additional runoff volume generated over existing conditions) from the Kanata West site is approximately 90,000 cubic meters. This increase in runoff volume caused flood level increases (depending on the scenario) in the order of 0.10 to 0.3 meter. An additional 70,000 to 90,000 cubic meters of runoff volume input to the hydraulic model would be expected to result in additional

flood level increases in the order of 0.10 to 0.3 meter. Exhibit N provides details regarding this discrepancy in runoff volume.

Conclusions

25. The existing conditions (2005) modeling has not been calibrated and validated as required by the Guide. The comparison of simulated versus observed water levels indicates that the model is not generating enough runoff volume and/or does not reflect the poorly drained nature of the Carp River. Existing condition flood levels may be higher.

26. Without calibration and validation of the existing conditions modeling, the post-development modeling cannot be depended on to calculate the future 100 year flood line.

27. Notwithstanding the fundamental shortcoming of lack of calibration/validation, there are also a number of errors and discrepancies within the post-development modeling that, when corrected, will contribute to further increases in flood levels over what has been documented in Class EA 2.

28. Based on the various shortcomings with the current version of the modeling, it is premature to make use of the 100 year flood level it generates to delineate hazard land. The current flood levels documented in Class EA 2 are too low. Also, the current version of the modeling cannot be used to defend the proposed SWM criterion of no post-development to pre-development peak flow control.