Report on the Review of Data for the Findlay Creek Development and the Effect on the Provincially Significant Leitrim Wetland

Dr. Fred Michel and Dr. Clarke Topp

The review of data provided by Golder Associates was aimed at dealing with three outstanding issues regarding the provincially significant Leitrim Wetland. These are:

a) Whether the use of groundwater triggers in monitors 03-10A and 03-10B would provide early warning of groundwater level decline in the Leitrim PSW. This was to be determined through an analysis of groundwater elevation data for monitors 03-10 A&B by comparison with monitors 97-2A&B and 03-8 A&B.

b) Whether the taking of surface water authorized by Source 4 "Miscellaneous Ponded Areas" of the Future Stages PTTW will cause groundwater level lowering in the adjacent portion of the Leitrim PSW.

c) Whether 'seasonally safe' water levels in the PSW can be determined, based on both historical and ongoing groundwater monitoring data for periods when no groundwater pumping was occurring and, if so, what they are.

Golder provided considerable data on daily water level elevations for all of the pertinent monitoring locations and these data form the basis of any analysis and discussion. The broad periods for which ground water control measures were in effect were given, but what was really required was a more detailed listing of the actual dates of pumping, the location of pumping, the rate and duration of pumping, and where the water was discharged. Without these data only broad statements can be made regarding the effect of pumping on water levels. Each of the three issues will be addressed in turn.

a) Whether the use of groundwater triggers in monitors 03-10A and 03-10B would provide early warning of groundwater level decline in the Leitrim PSW. This was to be determined through an analysis of groundwater elevation data for monitors 03-10 A&B by comparison with monitors 97-2A&B and 03-8 A&B.

The available water level data were analysed to ascertain the relative behaviour of water levels in monitors 03-10A&B in comparison to monitors 97-2A&B and 03-08A&B. A correlation analysis was performed on a seasonal basis to determine how highly correlated the water levels in monitors 97-2A and 03-08A were with 03-10A, and similarly with the respective B monitors. The year was divided into six month seasons as: Winter – (01 Dec – 31 May), and Summer – (01 Jun – 30 Nov.) (Table 1). Additional observational analyses were done to interpret the variation in numeric correlation findings.

Table 1: Correlation Coefficients of MW 97-2 and 03-08 each with 03-10								
Year	**Winter**		**Summer**		**Winter**		**Summer**	
	97-2A	**08A**	**97-2A**	**08A**	**97-2B**	**08B**	**97-2B**	**08B**
2004	0.993	0.995	0.987	0.996	0.988	0.794	0.987	0.903
2005	0.987	0.998	0.372	0.477	0.983	0.809	0.882	0.925
2006	0.538	0.942	0.790	0.983	0.851	0.432	0.793	0.640
2007	0.953	0.966	0.975	0.983	0.892	0.857	0.830	0.728
2008	0.931	0.985	0.893	0.859	0.929	0.656	0.944	0.662
2009	0.635	0.974	0.696	0.950	0.697	0.514	0.601	0.564

In general, the correlation coefficients are high, indicating the water levels track each other closely in these monitors. There are, however, instances of lower coefficients, most of which were easily explained by observational comparison of the daily records. For example, in the summer of 2009, the amount of rise and fall was small throughout the period, resulting in generally lower correlation coefficients. Some other lower coefficients resulted from missing data and/or possible monitor malfunction not detected in Oct. 2005.

An examination of daily water level measurements throughout the October 2003 to October 2009 period also found a strong relationship between the various monitoring wells. Although there is occasionally some variance, especially in later years, many of the dates of high and low water levels (these are the points in time when the water levels change direction and either start rising or falling, regardless of the actual magnitude of the change) agree. In addition, there is a strong correlation (observational) between precipitation events and the shift to rising water levels in the monitoring wells, especially outside of the winter period. Most of the significant precipitation events resulted in rising water levels, while extended periods of no precipitation saw gradual declines in the water levels. The effect of changing atmospheric pressure on the water levels was not quantified but would have had a small influence as well.

It is clear that all of the monitors for which data were provided mimic one another in terms of water level fluctuations, although the magnitudes of the changes vary. There are periods when relatively large and rapid declines in water levels occur that cannot be attributed to the weather at that time and yet occur both during and outside of the stated periods of ground water control (GWC). Therefore, one can state that the 03-10 monitors have historically reflected water level variations within the PSW. Although such highly correlated water level behaviour is a prerequisite for MW 03-10 serving as an early warning monitor, there are additional criteria to be met. The main additional requirement is an adequate time lag between occurrences of rise and fall of water level elevations in monitors 03-10A&B and those measured in 97-02A&B and 03-08A&B.

As stated above, the rise and fall of water levels in the various monitors generally occurred simultaneously, with peak and minimum values often being attained on the same day. In some instances the water levels in the 03-10 monitors continued to decline after the water levels in the two sets of monitors in the wetland (97-2 and 03-8) stopped declining. For the shallow monitors, 03-10B often but not always, showed a change in water level that was similar to or slightly larger than 97-2B. Thus, the 03-10 monitors would not provide an 'early' warning of what would happen in the PSW, but would provide an approximate record of what has happened. Therefore, during periods of GWC, frequent downloading of the data loggers would be necessary to minimize the extent of time that excessive water level declines occur.

As for trigger elevations, during the October 2003 to October 2009 period, the water level in monitor 97-2B generally varied within the 91.5 to 92.5 m.a.s.l. (metre above sea level) range; in September 2004 it reached a low of 90.6 m.a.s.l. without any reported GWC activity. The trigger elevation established by Golder in 2008 is 91.2 m.a.s.l. for monitor 97-2B, some 0.3 m below the normal range but above the lowest values measured when no GWC activity was occurring. In February 2004 the water level in 97-2B went below the 90.0 m.a.s.l. elevation during a period of GWC; 03-10B approached a water level elevation of 90 m but did not quite reach that level, while the water level in 03-10A dropped below 90 m. It is not known whether GWC activities were halted, since no change in status was reported in the information provided by Golder. Although this February 2004 period recorded the lowest water levels in the monitors of any point in time during the six year record, water levels rose again while GWC measures were still in effect. Without more precise pumping information it is impossible to determine whether the rise was strictly due to precipitation events (natural causes) or to a reduction/cessation in pumping rates.

To examine longer term changes in the hydrogeology of the site we calculated average water levels over the period of October 15 to 31 for each year (2003 to 2009) for each monitor. This provided some comparison of water levels during a seasonal period of moderate temperatures and unfrozen ground when the water levels would be influenced by precipitation events and during which GWC measures were in effect at the time for some years (2005, 2006, 2009) but not others (2003, 2004, 2007, 2008); it does not necessarily reflect the seasonal interval of lowest water levels. For the 03-10 monitors, the October seasonal water levels declined yearly between 2003 and 2006 by nearly two metres, stabilized at the 2006 level through to 2008, and then rose slightly in 2009 so that as of October 2009 levels were 1 to 1.5 metres below the 2003 levels. The 97-2 and 03-8 monitors also showed a steady decline from 2003 to 2007, but have since risen, so that in 3 of the 4 monitors water levels are now above the 2003 October levels. Thus there is some degree of correlation between GWC activity and the water levels in the PSW monitors.

In conclusion, the 03-10 monitors generally reflect changes (rises and falls) in water levels seen simultaneously in monitors from the wetland, but there has been some divergence in the last few years. This may be due to the effect of the berm, with water levels in the wetland rising more than that seen in the 03-10 monitors. The changes in water levels in the various monitors tend to be coincident and the 03-10 monitors would not provide an 'early' warning of what will happen within the wetland. Therefore frequent monitoring and downloading of the data loggers would be required during periods of GWC in order to minimize periods of excessive drawdown within the wetland.

b) Whether the taking of surface water authorized by Source 4 "Miscellaneous Ponded Areas" of the Future Stages PTTW will cause groundwater level lowering in the adjacent portion of the Leitrim PSW.

This question was investigated by looking at section BH90-6 and BH03-03, and the section 03-01, 03-01R and 03-02. Both of these sections are approximately perpendicular to the normal groundwater flow direction in the area and thus one would expect to see virtually no hydraulic gradient along the sections examined. However, for the section 03-01, 03-01R and 03-02, as shown in a figure provided by Golder, there is actually a small gradient induced by the Findlay Creek Extension (FCE) acting as a drain. Flow is toward the FCE from both the wetland and the proposed area of future development. After examining ground surface levels and expected water level elevations caused by the temporary pumping, there is expected to be no effect on the wetland groundwater levels.

For section BH90-6 and BH03-03, the surface elevation in the area of BH90-6 will be raised 0.5 to 1.0 m above 94.0 m (data provided by Golder). An examination of amended ground surface levels and expected water level elevations requiring the temporary pumping showed that a slight but negligible gradient would likely occur toward FCE but not have an effect on water level elevations in the PSW.

In conclusion, the FCE will continue to be the low point as far as water levels are concerned and the pumping of the "Miscellaneous Ponded Areas" will not negatively impact the groundwater elevations in the PSW.

c) *Whether 'seasonally safe' water levels in the PSW can be determined, based on both historical and ongoing groundwater monitoring data for periods when no groundwater pumping was occurring and, if so, what they are.*

To determine any such levels based on the monitoring data of water levels would require at the very least the provision of detailed pumping data that include actual times of pump operation, rates of pumping, location of pumping, and location of discharge. These data were not made available. One can only look, therefore, at when the lowest water levels occurred and whether this was during a period of 'ground water control'. The lowest levels do occur during a period of GWC in February of 2004.

The bigger question for this item is how does one define a "seasonally safe water level"? It cannot be based strictly on water levels alone, but must really be focused on determining at what water level in the PSW the ecosystem will be damaged, either temporarily or permanently. At present, we do not believe that we have the information to answer those questions, and even the provision of more detailed pumping data probably will not provide fully adequate answers.

In recognition of the critical importance of water levels for wetland biology and for wetland protection from degradation, it is imperative that safe water levels be defined and used for assuring the shorter and longer terms of protection for the PSW. Having safe water levels encompassing both hydrological and biological constraints will require additional work for the integration of the biological and hydrological aspects to a specific application for the Leitrim wetland accounting for the conditions there in 2010. This additional investigative work would involve biological expertise, which may come from among Golder staff who would make this work part of a determination of criteria for limiting the adverse effects from lowered groundwater elevations. We would hope to be involved on a consultative basis to facilitate the completion of this aspect.

Adopting the assumption that safe water level development as envisaged above will be aided by safe water levels derived from recorded water elevation for each borehole we assembled in Table 2 those data that would assist in making initial choices for "seasonally safe water elevations" (SSWE). The historical data collected prior to 2003 was used to make a first estimate of SSWE for those boreholes (BH) near where historical data were available, e.g. BH03-1, -2, -3, -4, -5, -6, -8A, -8B, 97-2A and 97-2B. Initial bounding limits for each BH were identified as the maximum and minimum recorded elevations for the groundwater in each BH. The following step was to make use of Golder's 'Groundwater Elevations and Monthly Precipitation' charts (April 2008) to identify periods where it appeared the groundwater elevations were not likely affected by GWC or some other land activity not recorded, e.g. a lowering of the groundwater elevation when precipitation was near or above normal as occurred in August 2005, but not in August 2004 for similar precipitation regimes. Once acceptable periods were established for each season for each BH, the minimum level was selected and a numerical value assigned to each by using the digital data recordings and by choosing representative numbers for the date or period chosen to represent a best estimate for the SSWEs. In general, for the seasons showing the acceptable BH minimum elevations, the precipitation was not extremely below normal for any of these periods indicating that the chosen SSWE may arise from natural causes.

The results from this estimation process are given in Table 2. The columns in Table 2 represent the following:

BH Monitor # is the number of each borehole assigned by Golder at the time of drilling the BH in either 1997 or 2003.

Ground Surface Elev. is the elevation recorded by Golder at the time of drilling the BH.

Trigger Elev. is the elevation Golder has chosen and reported in Groundwater Monitoring report (April 2008) and accepted by MOE in regard to conditions on PsTTW at which GWC was to cease.

Max. Elev. Record is the maximum elevation recorded for each BH monitor as given from the Golder data.

Min. Elev. Record is the minimum elevation recorded for each BH monitor as given from the Golder data.

Seasonal Safe Water Elev. is the elevation chosen for each season in each BH Monitor.

Date (Period) is the approximate time period (date) in the BH records at which the final choice was made for the SSWE.

Table 2: Showing much of those data used to determine the Seasonally Safe Water Elevations

BH Monitor #	Ground Surface Elev. (m)	Trigger Elev. (m)	Max. Elev. Record (m)	Min. Elev. Record (m)	Seasonal Safe Water Elev. (m)	Date (Period)
97-2A	92.84	91.3	93.9	90.3	91.9 S 92.5 W	May-Jun 07 Dec 04
97-2B	92.85	91.2	93.8	89.9	91.7 S 92.3 W	May-Jun 07 Dec 04
03-1	94.87	94.5	95.53	94.0	94.6 S 94.6 W	Jun 05 Nov 04
03-2	94.88	94.5	94.00	94.6	94.8 S 94.8 W	Jun 05 Nov 04
03-3	94.07	93.2	94.44	93.3	93.7 S 93.7 W	Jun 05 Oct 04
03-4	94.08	93.5	94.68	93.6	94.0 S 94.1 W	Jun 05 Dec 04
03-5	93.44	91.9 S 92.5 W	94.02	91.0	93.4 S 93.4 W	Jul 05 Dec 04
03-6	93.43	91.9 S 92.5 W	93.78	90.6	93.2 S 93.2 W	Jun 05 Jan 05
03-7A	93.47	93.4	94.10	93.0	93.5 S 93.5 W	Jul 05 Dec 04
03-7B	93.40	92.6	94.0	91.6	93.2 S 93.2 W	Jul 05 Dec 04
03-8A	93.02	91.0	92.8	91.0	92.0 S 92.0 W	Jun 07 Dec 04
03-8B	93.01	91.1 S 91.8 W	94.0	91.5	93.0 S 92.8 W	Jun 07 Mar 07, Dec 07
03-9A	93.75	92.4	94.0	91.5	93.0 S 93.0 W	Jun 07 Nov 04
03-9B	93.78	93.0	93.9	92.6	93.4 S 93.4 W	May-Jun 07 Dec 04, Dec 07

We have made initial estimates of 'seasonally safe water elevations', although we recognize the somewhat limited applicability of 'safe water levels' unless hydrological conditions are tied to appropriate biological conditions. These estimates are intended to provide a basis to which one can add selectively chosen biological criteria for adequate protection of the PSW.

February, 2010