June 17, 2021

Robert A. Centa
Paliare Roland Rosenberg Rothsten LLP

Re: Red Hill Valley Parkway Inquiry: Tradewind Scientific Inc.
(May 31, 2021 Letter from Robert Centa)

Dear Mr. Centa,

At your request, we have reviewed following two (2) documents that you provided to us enclosed with your letter from May 31, 2021:

1. CIMA Memorandum dated February 4, 2019, Red Hill Valley Parkway – Pavement Friction Testing Results Review [the "February 2019 Report"]
2. CIMA Final Report dated May 2020, Review of Red Hill Valley Parkway Friction Test Results [the "May 2020 Report"]

You have asked us to respond or comment on six (6) specific passages of the CIMA Reports, which in turn provide comments on our original report prepared in January 2014 for Golder Associates titled Friction Testing Survey Summary Report: Lincoln Alexander & Red Hill Valley Parkways (Hamilton) [the "Tradewind Report"].

Please find following the CIMA Report passages copied from your letter for reference/context, in addition to our comments.

1. **February 2019 Report, p.4-5:**
   The Tradewind Report included a reference table showing investigatory threshold levels. However, the table they used is different from the reference table typically applied. The reference more broadly used for determination of investigatory levels is the table from the United Kingdom Pavement Management (UKPMS) publication for interpretation of Grip Tester data, shown in Figure 1. We note that it is this table which is also referenced in the United States in the Guide to Pavement Friction. We have assessed reported friction values using the UKPMS table.

   Tradewinds reported that the friction testing results were 'below or well below' the investigatory levels. When assessed against the UKPMS table we found that the results were closer to the threshold levels than indicated by Tradewind.

As detailed in our original report, the measured Grip Number (GN) friction results from both the Lincoln Alexander and Red Hill Valley Parkways were compared against the Risk Rating Table for UK Roads reference levels in Appendix I of the report, specifically, the 0.48 GN value for "Dual Carriageway" (Investigatory Level 2).

As noted in our report, the measured results showed that nearly all areas of the RHVP were below or well below the 0.48 GN level.

Figure 1 of the February 2019 report from CIMA shows GN reference values of 0.41 or 0.47 for "Dual Carriageway". If assessed against these lower GN thresholds, the measured results are indeed closer to (or put another way, "less below") the thresholds, particularly in the 0.41 case.

In consulting with the GripTester OEM, Findlay Irvine Ltd. of Scotland, it appears the levels in the table in Appendix I of our report originate from an earlier version of the UK Design Manual For Roads and Bridges from 1994 (HD 28/94), whereas the levels in the table from CIMA reports appear to be from the newer 2004 version (HD 28/04). The GN reference levels in HD 28/94 are, broadly speaking, slightly more conservative (higher) than those in HD 28/04.

2. **May 2020 Report, p.8-9 (this passage is similar to #1, but not identical):**
   The Tradewind report included a reference table showing investigatory levels. However, the table used in their report is different from the reference table that is typically applied. The reference more broadly used for determination of investigatory levels is the table from the United Kingdom Pavement Management (UKPMS) publication for interpretation of Grip Tester data, shown in Figure 6. Therefore, the reported friction values in Figure 5 were assessed using the UKPMS table.

   Tradewind reported that the friction testing results were 'below or well below' the investigatory levels for dual carriageways, with similar roadway characteristics to the RHVP. When assessed against the UKPMS table, it was found that the average friction numbers were closer to the threshold levels of 41 to 47, than indicated by Tradewind. It is important to note that the UKPMS categories were intended to indicate the need for further investigation.

Similar to #1, and as detailed in our original report, the measured Grip Number (GN) friction results from both the Lincoln Alexander and Red Hill Valley Parkways were compared against the Risk Rating Table for UK Roads reference levels in Appendix I of the report, specifically, the 0.48 GN value for "Dual Carriageway" (Investigatory Level 2).

As noted in our report, the measured results showed that nearly all areas of the RHVP were below or well below the 0.48 GN level.

Figure 5 of the May 2020 report from CIMA shows GN reference values of 0.41 or 0.47 for "Dual Carriageway".

If assessed against these lower GN thresholds, the measured results are indeed closer to (or put another way, "less below") the thresholds, particularly in the 0.41 case.

In consulting with the GripTester OEM, Findlay Irvine Ltd. of Scotland, it appears the levels in the table in Appendix I of our report originate from an earlier version of the UK Design Manual For Roads and Bridges from 1994 (HD 28/94), whereas the levels in the table from CIMA reports appear to be from the newer 2004 version (HD 28/04). The GN reference levels in HD 28/94 are, broadly speaking, slightly more conservative (higher) than those in HD 28/04.

3. **May 2020 Report p.3-4**

There are currently no applicable reference standards or guidelines in North America with which to directly compare data collected by fixed slip friction measurement equipment, such as GripTester, with locked wheel methods.

There have been numerous efforts by different countries and agencies to better understand the relationship and behavior of different friction testing devices and the influence of texture, speed, and other external conditions on these measurements.

The Permanent International Association of Road Congresses (PIARC) conducted a series of experiments to compare texture and friction measurements. In 1992, PIARC undertook an experiment across 54 sites in Belgium and Spain with the intention of comparing and harmonizing texture and skid resistance between a range of measurement methods including locked wheel, fixed-slip and other methods. Based on the modeling exercise, the International Friction Index (IFI) was then developed to allow for the harmonizing of friction measurements taken with different equipment and/or at different slip speeds to a common calibrated index.

Theoretically, the IFI values should be the same for tests conducted at the same location, speed, and weather conditions. However, several studies in North America found discrepancies in the IFI values. In 2009, a study focused to compare measurements obtained with different types of equipment on 24 pavement sections with a wide range of textures. Data were collected with two locked-wheel skid trailers, a GripTester, and a dynamic friction tester, and the relationship between friction and speed for the different pavement sections and devices was studied. Even though all steps included in the specifications derived from the experiments by the PIARC were followed, the results obtained were not satisfactory.

A more recent study aimed to compare the friction data measured by the ASTM Brake force trailer and the Findlay Irvine brand of GripTester on a 100 km section of a highway in Ontario.

During the field testing, approximately 600 Friction Number (FN) and over 200,000 Grip Number (GN) values were measured. While the difference between the two measurements were found to be around 14.4%, the general correlation between the two values was poor, with the model R_2 of 16% for the asphalt surface conditions.

The findings are not overly surprising. Different test methods measure different aspects of pavement friction. Even when the same tire or slider is used, other details may vary, such as speed, mode of operation, and water film control. The research shows that there is no simple 'conversion' available to obtain a one-to-one correlation between friction measurement results from different types of testers.

The reasons for this lie mainly in the complexities of the friction behavior of rubber and tires during the testing process, which has been extensively discussed in the literature.

Based on the discussions above, a direct comparison between the friction values obtained from the two different testing methodologies that have been used at different times on the RHVP would not be recommended

The May 2020 CIMA report provides a good overview of the complexities and realities of friction measurement, as well as the difficulty in attempts to compare or correlate results from various testing methodologies and equipment types.

Friction is not an absolute property (unlike, for instance, mass), but rather a complex result of the two interacting/sliding surfaces, as well as any contaminant or lubricant between them. Its measurement is therefore quite dependant on the exact technique (i.e., fixed slip or locked wheel) and equipment being used, in addition to universal factors such as speed, applied water film depth, temperature, test tire type, etc.

As a result, we agree that a direct comparison between the measured results from two different testing methodologies is not recommended.

4. **May 2020 Report, p.9-10:**
   It is important to know that, while research does confirm a correlation between lower pavement friction levels and collisions, this correlation is not automatically confirmation of collision causation. Interpretation of the fixed slip GripTester pavement friction data, or the locked wheel testing method, as they relate to safety requires greater consideration.

   Road sections that have lower friction measurements may indicate a need to undertake review of the location because of the potential that collision risk may be elevated.

However, friction measurements that are at investigatory levels are in no way a definitive indication that a location is 'unsafe'.

The research for the development of the investigatory level thresholds states that for some sites, where friction numbers are below 35, collision risk may increase, but it also notes that for many sites with the same readings, collision risk will not exist. Thus, further investigation of conditions is needed.

In short, the friction values measured by the Tradewind are in the range that the UKPMS would identify as 'investigatory' and would suggest a need for additional review of the roadway as a whole. The Golder / Tradewind report made a similar overall conclusion from the data, albeit using a different reference table. These findings were also reported in our February 04, 2019 memo.

Tradewind is not in a position to comment on the absolute "safety" (or lack thereof) based on the measured friction results of a pavement or road surface.

In a general sense and with all things being equal, a pavement surface with lower friction affords decreased limits for friction-dependant maneuvers such as decelerating, accelerating, and cornering, as compared to a higher friction pavement.

As noted in our report and based on the low measured friction results as compared to the UK Investigatory Levels, further examination and investigation was recommended for the RHVP, as well as possible remedial action to enhance the surface texture and friction characteristics of the roadway.

5. **February 2019 Report, p.8:**
   Friction measurements may also be useful in the comparison of the service being provided on different roads. The Golder / Tradewinds study completed comprehensive assessment of friction levels on both the LINC and the RHVP. The results show a significant difference in friction values between the two facilities. While RHVP friction values are within the design domain expected for the road, they are significantly below those measured for the LINC. This difference can present a concern from a safety perspective. Road design principles allow for a wide range of operations by motorists. When pavement conditions are such that frictions [sic] values are significantly higher that [sic] those used in design, drivers are able to comfortably travel the road at higher speeds.

   The difference in friction values for the LINC and the RHVP means that there is a different margin of safety available to drivers between the two roads. That variance between the facilities is something that drivers may not be readily aware of and can result in varying safety outcomes.

The February 2019 report from CIMA highlights an important consideration in the usefulness of comparing measured friction results from the same equipment and test conditions on different pavement surfaces.

As noted in our report, the measured friction results from the Lincoln Alexander Parkway were significantly and consistently higher than those measured on the RHVP using the same equipment and test conditions.

Again, Tradewind is not in a position to comment on the absolute "safety" (or lack thereof) based on the measured friction results of a pavement or road surface.

In a general sense and with all things being equal, a pavement surface with lower friction affords decreased limits for friction-dependant maneuvers such as decelerating, accelerating, and cornering, as compared to a higher friction pavement.

6. **May 2020 Report, p.12:**
   In addition to the MTO and ARA report, the friction values measured by the Tradewind using a different methodology in 2013 were lower than the investigatory levels set by UKPMS and would suggest a further investigation.

As noted in our report and based on the low measured friction results as compared to the UK Investigatory Levels, further examination and investigation was recommended for the RHVP, as well as possible remedial action to enhance the surface texture and friction characteristics of the roadway.

We trust that this information is helpful for your inquiry.

Sincerely,

Rowan L. Taylor, M.Eng., B.Eng.
Engineering Manager & CTO
Tradewind Scientific Ltd.