

**ROAD GEOMETRICS EVALUATION
60 SIDE ROAD
(Between Highway #10 & Veterans Road South)
PROPOSED CLASS "A" GRAVEL PIT
584015 – SIDEROAD 60, BERKELEY
Part Lot 27, Concession 7

(FORMER TOWNSHIP OF HOLLAND)
TOWNSHIP OF CHATSWORTH
COUNTY OF GREY**

**GAMSBY AND MANNEROW LIMITED
CONSULTING PROFESSIONAL ENGINEERS
GUELPH, OWEN SOUND, LISTOWEL, KITCHENER, EXETER**

September 2014
Our File: 210099



Gamsby and Mannerow
ENGINEERS

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Township of Chatsworth Re: Sideroad 60 Assessment

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MTO Table A5-4 – Characteristics of Rural Road Classifications

MTO Table C3-2 – Minimum Radius Determined for Limiting Values of e and f

MTO Figure 2.5.1 – Embankment Warrant Guide Roadside Safety Manual





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**ROAD GEOMETRICS EVALUATION
60 SIDE ROAD
(BETWEEN HIGHWAY #10 AND VETRANS ROAD SOUTH)**

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584015 – SIDEROAD 60, BERKELEY
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1.0 INTRODUCTION

The owners of 584015 Side Road 60 (site) in the Township of Chatsworth (former Township of Holland) have retained Gamsby and Mannerow Limited (G&M) to conduct an evaluation of road geometrics for 60 Side Road, between Veterans Road South and Highway #10, where shown on Figure No. 1. The road geometrics evaluation was requested to address comments received through application under the Aggregate Resources Act (ARA) and related to the proposed haul route for the development of a Category 1, Class "A" gravel pit on the site.

The site abuts public road allowances on both Veterans Road South and 60 Side Road, as shown on Figure No. 1, however, only a single access to the site is proposed to be located at the south-easterly corner of the property onto 60 Side Road. 60 Side Road is proposed as the only designated haul route between the site and Highway #10 to the east at the Hamlet of Berkeley.

The purpose of this report is to evaluate the following existing road geometrics against typical road design standards on the designated haul route between the site and Highway #10:

- i. Horizontal curves at the "S-Bends", referenced as the south-east and north-east bends, located between West Back Line and the proposed development,
- ii. Stopping Sight Distances approaching the proposed entrance from each of the easterly and westerly directions,
- iii. Cross-section widths, including travelled Lane and Shoulder, and
- iv. Guiderail warrants along wetlands and hazard lands adjacent to 60 Side Road, located west of the Hamlet of Berkeley.

people engineering environments

Gamsby and Mannerow Limited • Guelph, Owen Sound, Listowel, Kitchener, Exeter

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2.0 EVALUATION METHODS AND STANDARDS

The intention of this evaluation is to compare existing road geometrics to usual road design standards.

Existing conditions were determined by topographical survey data collected using total station electronic survey equipment, by G&M survey staff on April 3, 2013.

Road design standards are published in the Ministry of Transportation of Ontario (MTO) “Geometric Design Standards for Ontario Highways (1994)”, which provides road design standards for Ontario jurisdictions that do not have specific design standards.

Table D.A.-2, “Geometric Design Standards for Secondary Highways”, provides a summary of the usual road design standards for rural roads for various Design Year Traffic Volumes and for various Design Speeds

The Design Year Traffic Volume is determined based on traffic data provided by the municipality (see Attachments), which indicates a 2012 - 2-way Average Annual Daily Traffic (AADT) volume of 289 vehicles on 60 Side Road. This AADT is projected to grow at 2% per year to a Design Year of 2037 (20 years from the “proposed improvement”, or 25 years from the count date) to an AADT of 474 vehicles, plus 2-way site generated traffic of 80 vehicles per day for a Design Year AADT of 554 vehicles.

3.0 EXISTING CONDITIONS - GENERAL

The length of the proposed haul route, between the proposed site access and Highway #10, is about 4.7 kilometers. This section of 60 Side Road is divided into two concessions by the West Back Line. The following provides a general description of the existing features and conditions on 60 Side Road along each of these two concessions. A general discussion of conditions on Highway #10 at 60 Side Road in the Hamlet of Berkeley is also provided. Figure No. 1 illustrates the locations of various features.

60 Side Road – Proposed Site Access to West Back Line

- A rural road cross section is provided throughout.
- No posted speed limit, 80km/hr is noted by the municipality.
- Road surface consists of surface treatment. The condition is fair to poor with areas of aggregate “pop outs” and unraveling.
- Lane widths average about 3.3 m, with 1.0m wide gravel shoulders, which are partially overgrown with vegetation.
- Ditches exist on both sides of road.

- Two significant horizontal curves are located about 423m east (south-east bend) and 1000m east (north-east bend) of the site.
- The grade of the road rises to the west of the proposed site entrance, toward the intersection of Veterans Road South.

60 Side Road – West Back Line to Highway #10

- A rural road cross section is provided throughout.
- Posted speed limit - 80 km/hr from the West Back Line easterly to the westerly limits of the Hamlet of Berkeley westerly to the (approximately 1.3 km).
- Posted speed limit - 50 km/hr from the westerly limits of the Hamlet of Berkeley easterly to Highway #10 (approximately 750 m).
- Road constructed with two lifts of Hot Mix Asphalt (HMA). The current condition of the HMA is relatively good. It appears this asphalt was placed within the past 5 years.
- Average lane width is about 3.45 m, with 1.25 m wide gravel shoulders. The gravel shoulders are partially overgrown with vegetation and are irregular in width and cross-fall in several localized areas.
- Drainage culverts exist under roadway, just west of the Hamlet of Berkeley limits (Sargents Lake). In this area, wetlands and hazard lands (Grey County Official Plan) exist adjacent to 60 Side Road. No guiderail is present.
- An asphalt gutter exists on each side of the road within the Hamlet of Berkeley.
- A ditch exists on each side of road westerly beyond westerly limits of Berkeley.
- A Rail Trail crossing exists at the westerly limits of the Hamlet of Berkeley.

Highway #10 – In the Hamlet of Berkeley

- Posted speed limit - 50 km/hr posted speed limit within the Hamlet of Berkeley.
 - 80 km/hr posted speed limit north and south of the Hamlet of Berkeley.
- 60 Side Road is the only intersection with Highway #10 within the Hamlet of Berkeley.
- The intersection of 60 Side Road and Highway #10 is located approximately in the center of the \pm 900 meter long posted 50 km/hr zone in the Hamlet of Berkeley.
- Illumination is provided at the intersection of 60 Side Road and Highway #10.

4.0 EVALUATION OF ROAD GEOMETRICS

Sub-sections included within this section provide an evaluation of each of the following existing road geometrics against typical road design standards on the designated haul route between the proposed site access and Highway #10:

- i. Horizontal curves at the “S-Bends”, referenced as the south-east and north-east curves, located between West Back Line and the proposed development,
- ii. Stopping Sight Distances approaching the proposed entrance from each of the easterly and westerly directions,
- iii. Cross-section, including travelled Lane and Shoulder, and
- iv. Guiderail warrants along wetlands and hazard lands, located west of the Hamlet of Berkeley.

4.1 HORIZONTAL CURVE REVIEW – SOUTH-EAST AND NORTH-EAST

Two horizontal curves exist at approximately 423m east (south-east bend) of the site and approximately 1000m east (north-east bend) of the site, where shown on Figure No. 1.

South-East Bend

The south-east bend is a circular curve that changes the road direction by about 90 degrees. Based on the survey data, the centre-line radius of this curve is 89 metres. In Table D.A.-2 (see Attachments), the MTO design standard for horizontal curves for an 80 km/hr design speed is 250m, which the existing curve clearly does not meet. The south-east bend is super-elevated (as illustrated in Figure No. 2 – Section 2), which assists in cornering. MTO Table C3-2 (see Attachments) provides minimum radius standards for roads with super-elevated curves up to 6%, and also up to 8%. Based on Table C3-2, the horizontal curve standard for a 40 km/hr design speed is 55m, which the existing South-East Bend achieves.

North-East Bend

The north-east bend is a circular curve that changes the road direction by about 50 degrees. Based on the survey data, the centre-line radius of this curve is also 89 metres. In Table D.A.-2 (see Attachments), the MTO design standard for horizontal curves for an 80 km/hr design speed is 250m, which the existing curve clearly does not meet. The north-east bend is super-elevated (as illustrated in Figure 2 – Section 3), which assists in cornering. MTO Table C3-2 (see Attachments) provides minimum radius standards for roads with super-elevated curves up to 6%, and also up to 8%. Based on Table C3-2, the horizontal curve standard for a 40 km/hr design speed is 55m, which the existing North-East Bend achieves.

The Township should consider a reduced speed limit posting to 40 km/hr for these two horizontal curves. Further, each of these curves is between the proposed site entrance and the West Back Line, where the road condition is noted in Section 3.0 as being “fair to poor”. Regardless of the proposed pit operations, the Township should consider improving these horizontal curves to meet the design standard when this section of road is re-constructed at the end of its service life; which is expected to be well within the 20 year planning horizon.

4.2 SAFE STOPPING SIGHT DISTANCE – PROPOSED SITE ACCESS

The proposed site access is located at the south-easterly corner of the subject property. Based on MTO Table D.A.-2 (see Attachments), the Minimum Stopping Sight Distance for an 80 km/hr Design Speed is 135m.

Based on survey data, Figure No. 3 illustrates the vertical profile for at least 200m either side of the proposed site access.

Eastbound traffic on 60 Side Road will approach the proposed site access from the crest of a hill. The stopping sight distance for the eastbound traffic was evaluated based on a driver's eye-height of 1.05 m and a minimum object height at the site access of 0.00 m. As illustrated in Figure No. 3, the location of the proposed site access achieves the Minimum Stopping Sight Distance under existing conditions, for eastbound traffic on 60 Side Road.

Westbound traffic on 60 Side Road will approach the proposed site access from a relatively level road profile. The stopping sight distance for the westbound traffic was evaluated based on a driver's eye-height of 1.05 m and a minimum object height at the site access of 0.00 m. As illustrated in Figure No. 3, the location of the proposed site access achieves the Minimum Stopping Sight Distance under existing conditions, for westbound traffic on 60 Side Road. .

4.3 ROADWAY CROSS-SECTIONS

Based on survey data obtained by G&M, eight (8) roadway cross-sections were prepared, at locations shown on Figure No. 1. From the survey data, a detailed cross-section was prepared for each location, as shown in Figure No. 3. The following Table No. 1 summarizes a comparison of the MTO standard to each cross-section. The MTO Standard is based on an AADT of 400 to 1000 vehicles in the Design Year, and for a design speed of 80 km/hr*, as noted in Table D.A.-2.

Table 1 – Comparison of MTO Standard to Existing Cross Sections

	Lane	Shoulder	Total
MTO Standard	3.25*	1.00	4.25m
Section 1	3.20	1.0	4.20m
Section 2	3.35	1.0	4.35m
Section 3	3.55	1.0	4.55m
Section 4	3.21	1.0	4.21m
Section 5	3.43	1.25	4.68m
Section 6	3.45	1.25	4.70m
Section 7	3.47	1.25	4.72m
Section 8	3.51	1.25	4.76m

* Table D.A.-2 notes a 3.25m standard lane width for an 80 km/hr design speed, but that “a 3.0m lane width may be acceptable where the type, size and volume of trucks are not significant”. Assuming the Design Year background AADT of 474 vehicles includes 10% trucks, there would be 47 trucks in the background AADT. The proposed pit operation is expected introduce an additional 80 trucks to the background AADT for a total of 127 trucks out of a total Design Year AADT of 554 vehicles; representing about 23% trucks in the Design Year of 2037. Based on the “Functional Classification System – Table A5-4 – Characteristics of Rural Road Classifications”, for Rural Collector Roads with AADT in the range of 200 to 10,000 up to 30% trucks are not considered to be significant (see Attachments). Therefore, a 3.0m lane width may be justifiable.

Based on the results provided in Table No. 1, the existing road cross sections do not meet the design standard for an 80 km/hr design speed in all cases, as highlighted in bold italic for Section 1 and Section 4. However, each of these sections is between the proposed site entrance and the West Back Line, where the road condition is noted in Section 3.0 as being “fair to poor”. Regardless of the proposed pit operations, the Township should consider improving these cross sections to meet the design standard when this section of road is re-constructed at the end of its service life; which is expected to be within the 20 year planning horizon.

The cross sections demonstrate “general conformance” with MTO design standards at those sections. For further verification a visual inspection was conducted on April 4, 2014, at which time snow had mostly receded from the shoulders. Certain locations were observed where shoulder cross-fall and/or width are not consistent, and where grass cover makes the shoulder width appear narrower. The Township should consider general shoulder maintenance throughout the area.

4.4 GUIDE RAIL WARRANTS

West of the Hamlet of Berkeley, sections of wetlands and watercourses related to Sargents Lake lie adjacent to 60 Side Road, approximately 800 meters west of Highway #10 (Section 6) and 1600m west of Highway #10 (Section 5). Currently, there are no traffic barriers (guide rails) along either side of 60 Side Road in these areas.

Guide rail warrants are provided in the MTO “Roadside Safety Manual (1993)”. The Manual provides the following “Guide Rail Philosophy”:

“Where economically feasible the designer should make every effort to design without the use of guide rail. This can be done by clearing the roadside of obstacles, flattening embankment slopes, or introducing greater median separation where practical.”

Generally, the theory is that although a guide rail can shield a hazard, it can also introduce a hazard and so the risks must be assessed. The Manual further identifies a “Need for Guide Rail”, as follows:

“The installations of guide rail on embankments is warranted only where the combination of height and slope of the embankment is a more severe hazard than the barrier system itself.” MTO Figure 2.5.1 provides a tool for assessing guide rail warrants. Figure 2.5.1 (see Attachments) notes that guide rail is not required for undivided highways on fill heights less than 3 metres and for slopes 3:1 or flatter.

Based on survey data, Figure No. 2 illustrates Section 5 and Section 6 through the area where wetlands are adjacent to 60 Side Road. Since fill heights do not exceed 3 metres a guide rail is not warranted. Fill slopes are steeper than 3:1 in some localized areas and the Township should consider general shoulder maintenance throughout the area.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on this evaluation of specific road geometrics, the following conclusions and recommendations are provided:

- i) The South-East Bend and North-East Bend do not achieve an 80 km/hr design speed standard. Regardless of the proposed pit operation, the Township should consider posting a reduced speed limit of 40 km/hr through these bends and, further, consider achieving a current design standard upon reconstruction at the end of the service life of this section of 60 Side Road.
- ii) Safe Stopping Sight Distance exists for both east bound and west bound traffic, from the proposed site access location.
- iii) Existing road cross sections do not meet the MTO design standard for an 80 km/hr design speed in all cases. However, in each case (Section 1 and Section 4) the maximum variance is 0.05m. These sections are between the proposed site entrance and the West Back Line, where the road condition is noted as being "fair to poor". Regardless of the proposed pit operation, the Township should consider improving these cross sections to meet the design standard when this section of road is reconstructed at the end of its service life. Further, the Township should consider general shoulder maintenance along 60 Side Road.
- iv) The fill height across the sections where the wetland is adjacent to 60 Side Road is less than 3.0m and, therefore, the warrant for guide rail is not met.

Prepared and respectfully submitted by,

GAMSBY AND MANNEROW LIMITED

Per:

Derek Brewster, C.Tech.

Reviewed by:

John B. Slocombe, P. Eng
db/af



Encl.

cc: Brian and Pearl Bumstead
Don Scott – Cuesta Planning
Mike Davis – Cuesta Planning
File - 210099

**ROAD GEOMETRICS EVALUATION
PROPOSED CLASS "A" GRAVEL PIT
584015 – SIDEROAD 60, BERKELEY
Part Lot 27, Concession 7
(FORMER TOWNSHIP OF HOLLAND)
TOWNSHIP OF CHATSWORTH
COUNTY OF GREY**

FIGURES

- **Figure 1** – Site Location, Proposed Haul Route & Cross Section Locations
- **Figure 2** – Proposed Haul Route – Road Cross Sections
- **Figure 3** – Proposed Site Access – Stopping Sight Distances

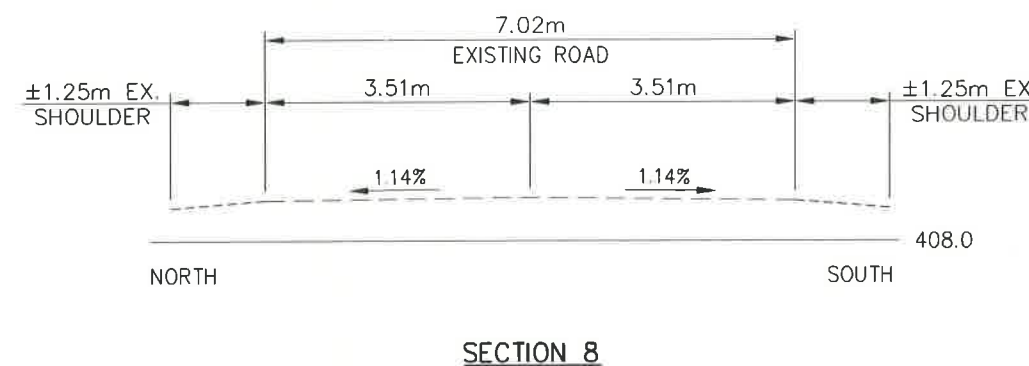
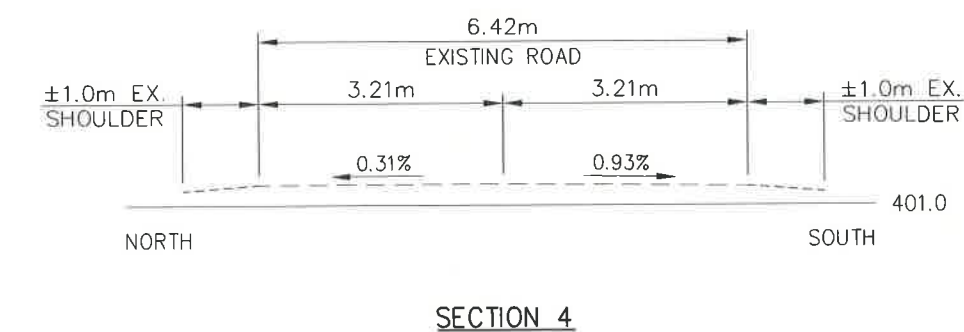
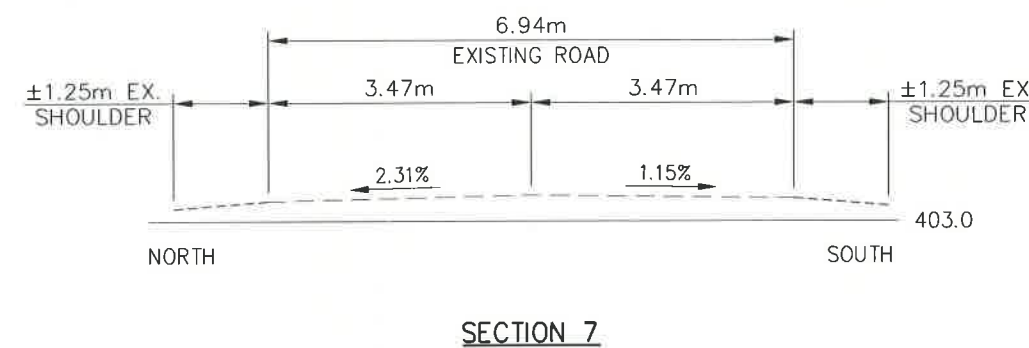
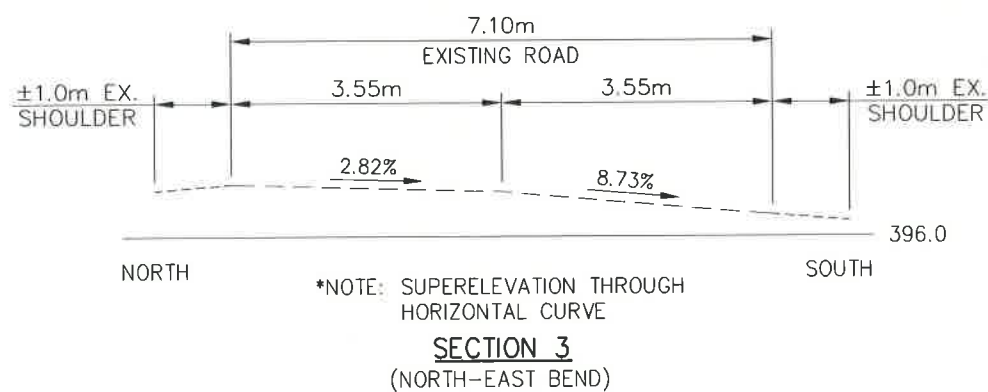
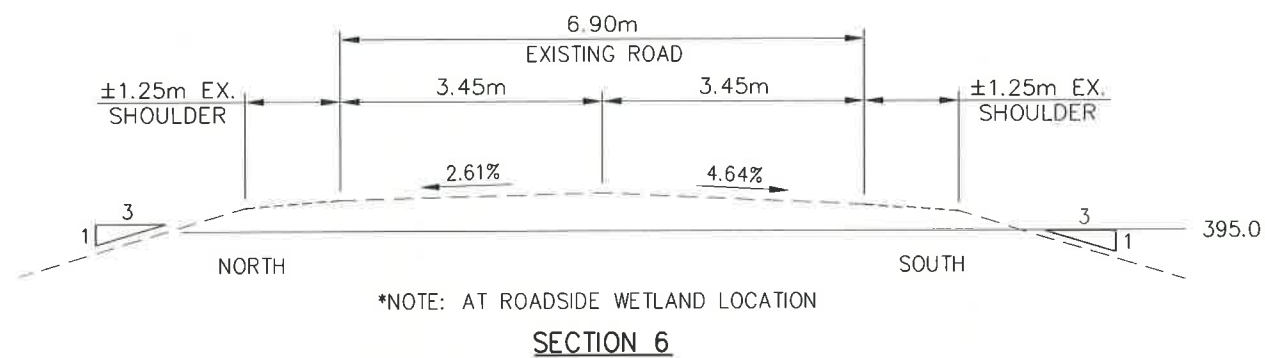
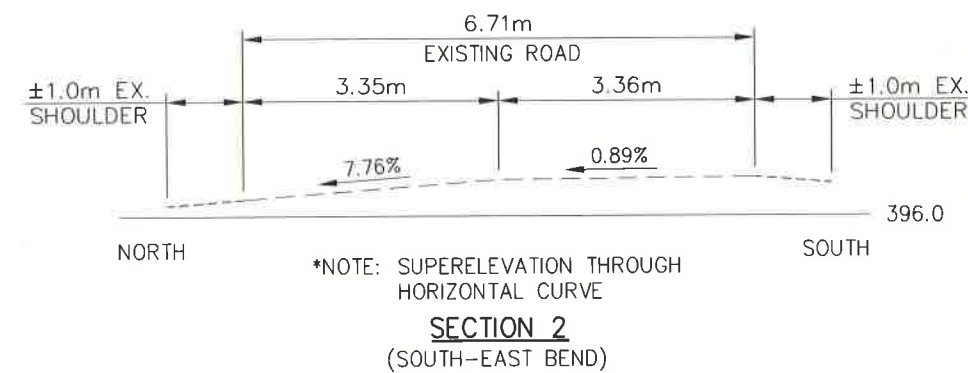
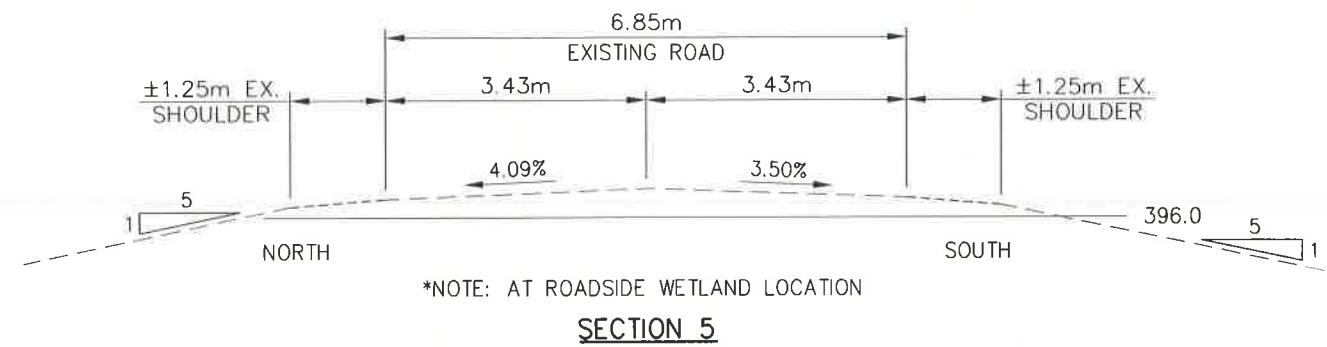
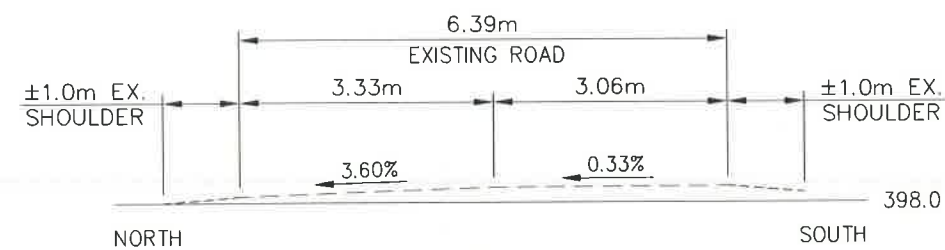
APRIL 2014

**PART LOT 27, CONCESSION 7
TOWNSHIP OF CHATSWORTH
COUNTY OF GREY**

Figure No. 1



210099
ROAD GEOMETRIC EVALUATION
TOWNSHIP OF CHATSWORTH



SECTIONS BETWEEN WEST BACK LINE
AND VETERAN'S SIDEROAD
(SURFACE TREATMENT)

SECTIONS BETWEEN WEST BACK LINE
AND HIGHWAY No. 10
(HOT MIX ASPHALT)

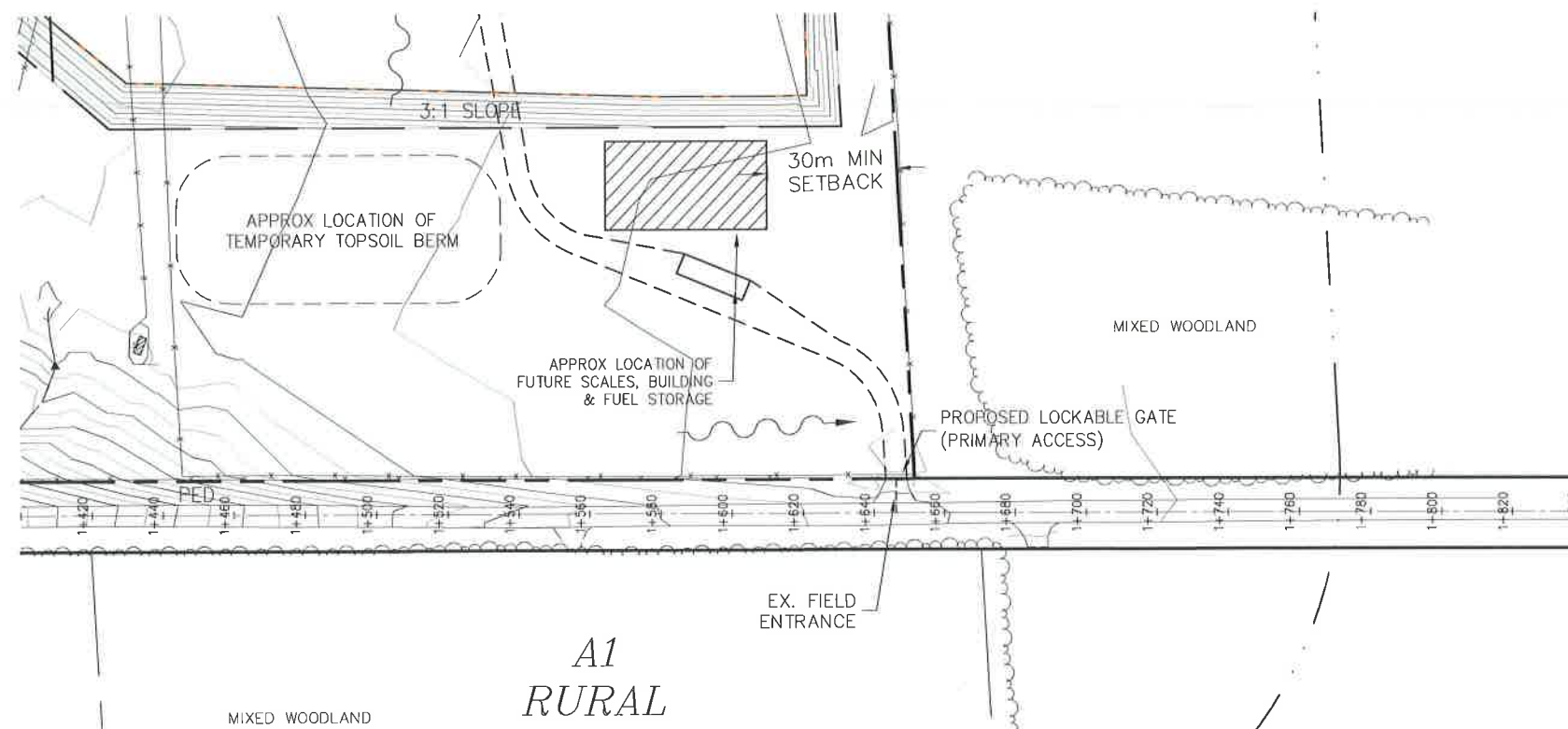
SCALE 1:100
APRIL 2014

PROPOSED HAUL ROUTE
ROAD CROSS SECTIONS
PART LOT 27, CONCESSION 7
TOWNSHIP OF CHATSWORTH
COUNTY OF GREY

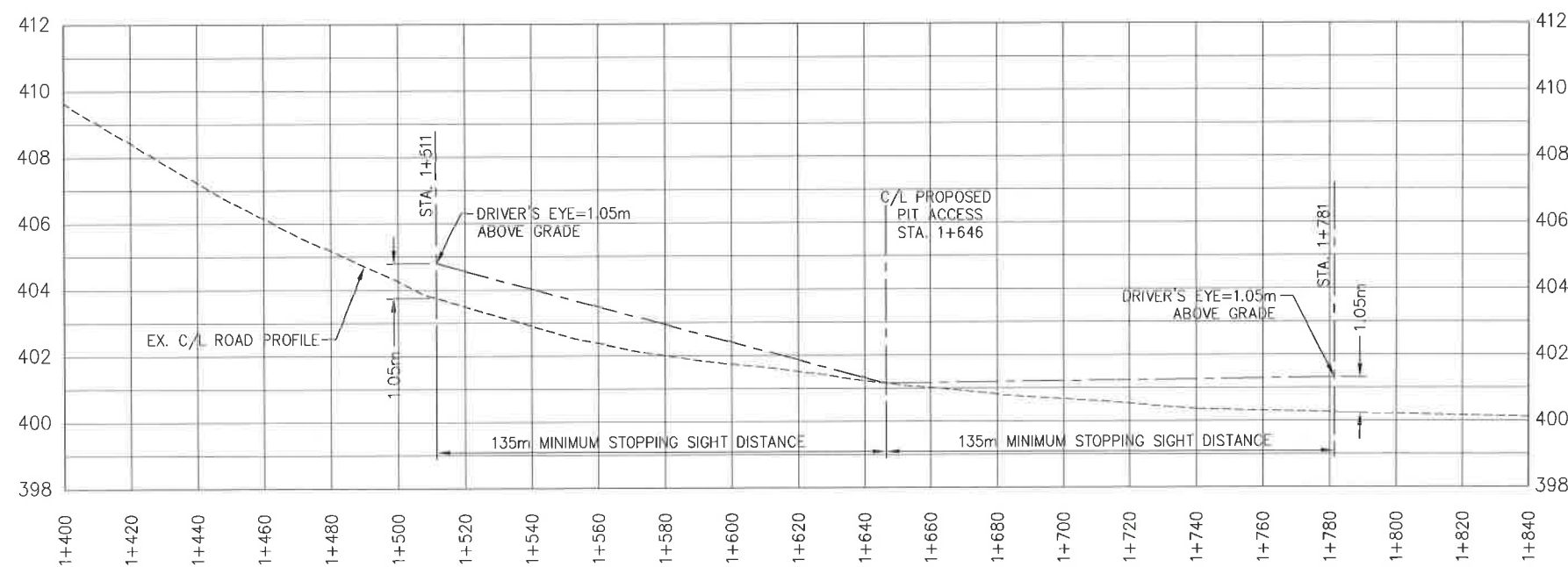
Figure No. 2



210099
ROAD GEOMETRIC EVALUATION
TOWNSHIP OF CHATSWORTH



PLAN VIEW
SCALE 1:2,000



PROFILE VIEW
SCALE 1:2,000 HORIZ.
1:200 VERT.

SCALE: AS NOTED
APRIL 2014

**PROPOSED SITE ACCESS
STOPPING SIGHT DISTANCES**

**PART LOT 27, CONCESSION 7
TOWNSHIP OF CHATSWORTH
COUNTY OF GREY**

Figure No. 3



**ROAD GEOMETRICS EVALUATION
PROPOSED CLASS "A" GRAVEL PIT
584015 – SIDEROAD 60, BERKELEY
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(FORMER TOWNSHIP OF HOLLAND)
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ATTACHMENTS

- Township of Chatsworth Re: Sideroad 60 Assessment
- MTO Table D.A.-2 – Geometric Design Standards for Secondary Highways
- MTO Table A5-4 – Characteristics of Rural Road Classifications
- MTO Table C3-2 – Minimum Radius Determined for Limiting Values of e and f.
- MTO Figure 2.5.1 – Embankment Warrant Guide Roadside Safety Manual



Chatsworth

Township of Chatsworth

RR 1

Chatsworth, Ontario N0H 1G0

Telephone no. 519-794-3232
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Fax No. 519-794-4499
Grace Nayler, Treasurer, Deputy CAO-Clerk

January 21, 2013

Gamsby and Mannerow
1260 2nd Ave East, Unit 1
Owen Sound, Ontario
N4K 2J3

Attention: Derek Brewster

Re: Sideroad 60 Assessment

Dear Mr. Brewster:

The following comments are provided based on the information available and the information provided by Gamsby and Mannerow. It should be noted that the proposed Pit licence volume or a traffic study has not been provided.

Township of Chatsworth will enter into an access agreement with Gamsby and Mannerow in order to conduct the subsurface investigation along 60 Sideroad. The Township will require proof of liability insurance with the township named as insured and proof of WSIB coverage for Gamsby and Mannerow as well as any sub-contractors performing any works on township property. Please contact the Township prior to starting any investigative works.

With respect to the use of 60 sideroad as a haul route the condition of the road is a concern. Current township practice is to require any haul routes for new gravel pits to be constructed (if required) and to be hard surfaced. Your sub surface investigation noted above and a site inspection with our Road Forman should determine any areas that require reconstruction.

In response to your specific questions be advised:

1. The road classification is Class 4
2. The traffic count on 60 sideroad from West Back Line to Veterans Road is 289 vehicles per day and Veterans Road South 188 (counted in 2012) . Contact MTO for counts from Highway 10 to West Back line (if available).

3. Load restrictions have not been posted on 60 Sideroad for Highway 10 to Veterans Road.
4. A Roads Needs Study is not available.
5. There are no road design drawings available.
6. No improvements are planned on the proposed haul route.
7. There are no reports of flooding on the proposed haul route.
8. The speed limit is 50 km/hr within the hamlet of Berkely and 80 km/hr outside.
9. There are no township restrictions or agreements on the rail trail crossing.
10. As noted above the Township requires the road to be of a standard suitable for the proposed traffic. Further concerns may be raised during the public consultation process.

A traffic study should be completed to determine if the proposed haul route is appropriate.

Please note that these are preliminary comments on the proposed haul route and should not be taken as Township approval for the project. Council will take into consideration public input prior to making any final decisions with respect to project approval.

If you have any comments or questions, please call.

Yours truly,

Will Moore, CAO/Clerk

Table D.A-2

GEOMETRIC DESIGN STANDARDS FOR SECONDARY HIGHWAYS

DESIGN ELEMENTS DESIGN YEAR TRAFFIC VOLUME		DESIGN SPEED	MINIMUM CURVES (m)			MINIMUM STOPPING SIGHT DIST.	MAX. GRADE	WIDTH (m)	
			HORIZ.	VERTICAL					
AADT	DHV	km/h	Radius	K - Crest	K - Sag	m	%	Lane	Shoulder
Greater than 1000	Greater than 150	100	420	70	45	185	6 - 8	3.50	2.00
		90	340	50	40	160	6 - 8	3.25	2.00
		80	250	35	30	135	6 - 8	3.25	2.00
		70	190	25	25	110	6 -12	3.00	1.00
		60	130	15	18	85	6 -12	3.00	1.00
1000 to 400	150 to 60	80	250	35	30	135	6 - 8	3.25 *	1.00
		70	190	25	25	110	6 - 12	3.00	1.00
		60	130	15	18	85	6 -12	3.00	1.00
Less than 400	Less than 60	80	250	35	30	135	8	3.25 *	1.00 **
		70	190	25	25	110	12	3.00	1.00 **
		60	130	15	18	85	12	3.00	1.00 **
		50	90	8	12	65	12	2.75	1.00 **

Lane width may be increased by 0.25 m to a maximum of 3.5 m if warranted by type, size and volume of truck traffic.

* A 3.0 m lane width may be acceptable where the type, size and volume of trucks are not significant.

** 0.5 m shoulders will be permitted where there is no foreseeable possibility of the road being paved within a 20-year period. A minimum of 1.0 m shoulder must be used where guide rail is installed.

Notes:

- Design Year should reflect the anticipated life span of the proposed improvement. Design Year is normally 10 years beyond the Program Year for resurfacing and reconstruction projects, and 20 years beyond for new construction projects.
- Use DHV if available for selection of design standards.
- Desirable Maximum Design Speed is 80 km/h.
- Minimum Horizontal Curve Radius based on maximum superelevation of 0.06 m/m.
- Minimum Vertical Curve Standards based on stopping sight distance.
- Lower value in maximum grade range is desirable maximum. Higher value is acceptable maximum.
- Minimum desirable shoulder width for:
 - pavement support - 1.0 m gravel shoulder
 - 0.5 m paved shoulder
 - disabled vehicle - 2.0 m shoulder
- Desirable Shoulder Rounding - 0.5 m.

Table A5-4
CHARACTERISTICS OF RURAL ROAD CLASSIFICATIONS

FUNCTIONAL CLASSIFICATION	RURAL FREEWAYS	RURAL ARTERIALS	RURAL COLLECTORS	RURAL LOCALS
Traffic Service	optimum mobility	traffic movement primary consideration	traffic movement & land access equal importance	traffic movement secondary consideration
Land Service	no access	land access secondary consideration	traffic movement and land access equal importance	land access primary consideration
Range of Traffic Volume A.A.D.T	more than 10,000	1,000 - 20,000	200 - 10,000	not applicable
Traffic Flow	free flow	uninterrupted flow except at signals	interrupted flow	interrupted flow
Design Speed	100 - 120 km/h	80 - 110 km/h	60 - 100 km/h	60 - 80 km/h
Average Running Speed Off-peak Conditions	80 - 120 km/h	60 - 100 km/h	60 - 90 km/h	50 - 80 km/h
Vehicle Type	all types heavy trucks average 20 - 30%	all types up to 20% trucks	all types up to 30% trucks mostly single unit type	predominantly passenger cars and light to medium trucks and occasional heavy trucks
Percentage of Total Length	up to 5	5 - 10	10 - 20	75 approx.
Connects to	freeways arterials collectors	all classifications	all classifications	arterials collectors locals

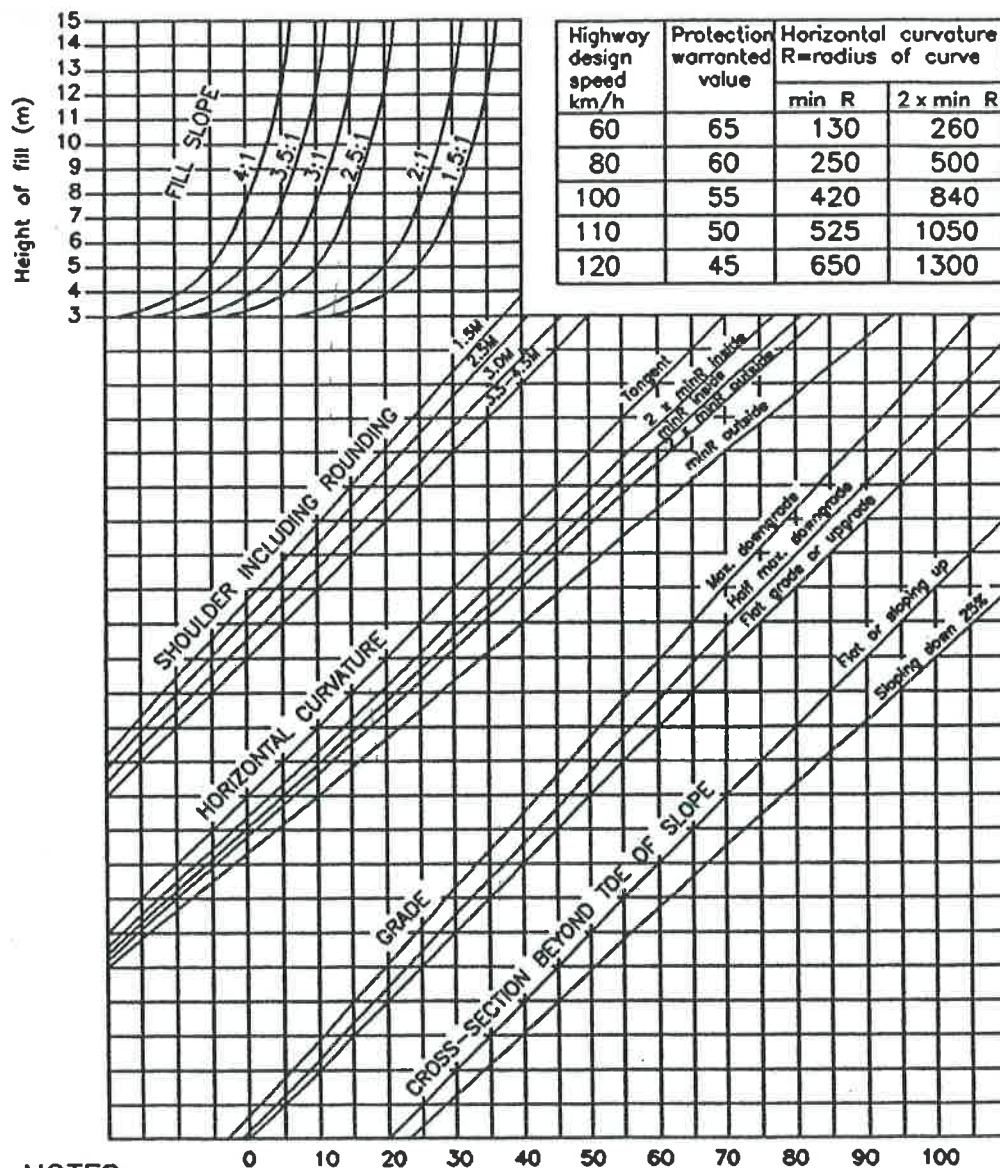
Table C3-1
STANDARD CIRCULAR CURVES
 (radii stated in metres)

45	100	180	340	600	1150	2500
50	105	190	350	650	1200	3000
55	110	200	380	700	1250	3500
60	115	210	400	750	1300	4000
65	120	220	420	800	1400	4500
70	125	230	450	850	1500	5000
75	130	240	475	900	1600	6000
80	140	250	500	950	1700	7000
85	150	280	525	1000	1800	8000
90	160	300	550	1050	2000	9000
95	170	320	575	1100	2200	10 000

Table C3-2
MINIMUM RADIUS DETERMINED FOR LIMITING VALUES OF e AND f

Design speed	e_{\max}	Max. f	Total $e + f$	Minimum radius	Min. Radius MTC Standards
km/h	m/m			m	m
40	0.06	0.165	0.225	55.99	55
50	0.06	0.159	0.219	89.89	90
60	0.06	0.153	0.213	133.08	130
70	0.06	0.147	0.207	186.39	190
80	0.06	0.140	0.200	251.97	250
90	0.06	0.134	0.194	328.76	340
100	0.06	0.128	0.188	418.83	420
110	0.06	0.122	0.182	523.49	525
120	0.06	0.115	0.175	647.92	650
130*	0.06	0.109	0.169	787.40	800
140*	0.06	0.103	0.163	946.81	1000
150*	0.06	0.098	0.158	1121.30	1150
160*	0.06	0.091	0.151	1334.93	1350
40	0.08	0.165	0.245	51.42	50
50	0.08	0.159	0.239	82.36	80
60	0.08	0.153	0.233	121.66	120
70	0.08	0.147	0.227	169.97	170
80	0.08	0.140	0.220	229.06	230
90	0.08	0.134	0.214	298.04	300
100	0.08	0.128	0.208	378.56	380
110*	0.08	0.122	0.202	471.66	475
120*	0.08	0.115	0.195	581.47	600
130*	0.08	0.109	0.189	704.08	700
140*	0.08	0.103	0.183	843.34	850
150*	0.08	0.098	0.178	995.31	1000
160*	0.08	0.091	0.171	1178.80	1200

**These values are beyond the normal range of application and are for information only.*



NOTES:

1 Guide rail is not required for:
Undivided Hwys

- On fill heights less than 3 metres.
- Slopes 3:1 or flatter.

Divided Hwys

- On fill heights less than 2 metres.
- Slopes 4:1 or flatter.

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2 When the embankment protection index is greater than the protection warranted value guide rail or slope flattening is required.

FIGURE 2.5.1 Embankment Warrant Guide