APPENDIX H:

Devil's Creek Crossing Alternatives

APPENDIX B

Evaluation Criteria Matrix
Devil's Creek Crossing Alternatives

EVALUATION CRITERIA - CAMBRIDGE WEST DEVIL'S CREEK CROSSING ALTERNATIVES

Factor Category / Factor Group / Factor		L=31m S=6.1m R=2.2m Sewer - Above	L=31m S=6.1m R=3.0m Sewer - Below	L=40m S=6.1m R=3.0m Sewer - Below	L=40m S=6.1m R=2.2m Sewer - Above	L=31m S=9.4m R=3.0m Sewer - Below	L=40m S=9.4m R=3.0m Sewer - Below	L=48m S=9.4m R=3.0m Sewer - Below	Comments
		1	2	3	4	5	6	7	
1. NATURAL ENVIRONMENT									
1.A Terrestrial Ecosystems									
Vegetation Communities and Flora	*Impact on feature and function of vegetation communities and flora, including wetlands, (amount of removal / disturbance, impact to ecologically sensitive / significant communities, indirect impacts).	10	9	7	7	9	8	1	As there are no impacts to rare or sensitive habitats or flora, the primary consideration is the total area of vegetation removal. The total area of vegetation removal ranges from 3120 ñto 4000 m^2 among the 7 options. Options 1, 2, and 5 have the smallest total area of vegetation removal. Option 7 had the greatest area of vegetation required for removal, as such was the least preffered. In terms of total area of vegetation being removed, options 1,2, and 5 are very compareable as are 3, 4, and 6.
Wildlife Habitat	*Impact on wildlife habitat feature and function (amount of removal / disturbance, impact to ecologically sensitive / significant communities, indirect impacts). *Effects on wildlife movement opportunities.	6	7	4	1	10	8	5	As there are no impacts to specialized / significant wildlife habitat and a relatively small amount of habitat removal for all options, the main consideration is the ability to provide wildlife passage within the new culvert structure. The 'Openness Ratio' (OR) and culvert height (i.e., the clearance between the terrestrial bench and the culvert roof) are useful design considerations for improving wildlife passage. For large mammals, literature suggests appropriate design objectives of OR=1.0 and 2.5 m to 3.0 height clearance, though there is recent evidence of large mammals using culverts with a much smaller OR and less than ideal height. Considering this, a minimum cross section of 6.1 m (wide) by 2.2 m (high) culvert should provide adequate passage for large mammals (i.e., deer), however greater clearance would likley function better. In addition, the length of the culvert can influence the effectiveness of the culvert for passage; the longer the culvert, the lower the OR / greater 'tunnel' effect and reduced potential for successful use for wildlife passage. Hence, the shortest culvert length is generally preferred. It should be noted that the existing culvert provides almost no opportunity for wildlife passage (it is a small circular concrete culvert with no native substrates and barred ends). Hence, all of the proposed op would represent an improvement in terms of wildlife passage, allowing wildlife to move between natural areas north and south of Blenheim Road and reducing potential road mortality in the vicinity of the crossing.
	Normalized Factor Group Score	8.0	8.0	5.5	4.0	9.5	8.0	3.0	
1.B Aquatic Ecosystems									
Aquatic Habitat	• Impact to existing natural channel (length of removal / disturbance; removal / impact to higher quality habitat such as trout spawning areas) • Impact to riparian vegetation / habitat • Requirement for creation of new channel	8	9	4	3	10	4	1	The primary consideration is the total area of aquatic habitat that will be affected with construction of the new culvert. An additonal consideration includes the culvert dimensions and the ability to allow ambient light into the culvert; the greater the opening/shorter the culvert length, the greater opporuntity to allow ambient light in. The downstream reach represents the majority of area proposed for alteration (new channel construction, riparian vegetation removal, and areas newly enclosed by culvert). The new culvert has potential to extend downstream from approx.8 to 17 m, depending on the option. Habitat in the existing downstream reach (up to approx. 30m) has evidence of channelization and is considered of relatively lower quality compared to other reaches in the general area. All options result in newly created habitat upstream with the removal of the existing culvert. Reaches of newly created habitat range from 2 to 11m. Options 1, 2, and 5 will all result in a net gain of aquatic habitat when the existing culvert structure is removed. The preferred Option 5 incorporates the following: • minimizes total area that will be altered (enclosed, new channel constructed, and loss of riparian habitat) and will actually result in a net gain of aquatic habitat (approx. 3 m) • maximizes the opportunity to offset the new stream enclosure via newly established habitat upstream, where the existing culvert will be replaced • avoids confirmed Brook Trout spawning habitat • greater opening to allow for ambient light in It should be noted that the replacement of the existing closed bottom concrete culvert with an open bottom culvert set outside of the annual high water mark will result in an overall net improvement to aquatic
	Normalized Factor Group Score	8.0	9.0	4.0	3.0	10.0	4.0	1.0	
1.C Surface Water									
Water Quality and Thermal Regime	*Impact on water quality of surface water features. *Impact in the thermal regime of surface water features.	10	10	10	10	10	10	10	
Quantity (flows)	*Effects on surface drainage contributions to surface water features.	10	10	10	10	10	10	10	
	Normalized Factor Group Score	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
1.D Geomorphology									
Channel Morphology and Fluvial Processes	*Potential impacts to the morphology of the existing channel, including potential for erosion/scouring, alteration of stream morphology	9	8	6	7	10	8	1	Key considerations in the evaluation of potential impacts to existing channel morphology and fluvial processes are: • The location at which the new channel will tie into the existing channel - considering existing channel morphology, angle of tie-in and vertical gradient • Culvert structure dimensions - total culvert length (footprint) and cross sectional area (capacity) • Projected stream flow velocities of each proposed option **Tie-in Location** The more preferred tie-in locations are at stable and straight sections of the existing channel, with minimal angle of approach and minimal requirements for existing channel alteration; these attributes minimize risk of erosion and potential changes to stream morphology. Based on available information, all seven options appear to tie-in at locations where the channel is straight, with a small angle of approach and matched elevation (i.e., no vertical [channel] gradient changes are required). The primary difference is the the potential disturbance to the existing channel. Because all options require a scour pool to dissipate flows outletting the culvert, any options which have an existing scour pool in the channel will require less disturbance. Options 1 through 6 tie in at locations that have existing scour pools at the proposed outlet locations, which reduces the disturbance and potential for channel morphology alterations; hence, these are preferred. **Culvert Dimensions** Key considerations are the total length and cross-sectional area. Options that are shortest in length (i.e., Options 1, 2, and 5 at 31 m) have the smallest footprint, with the least alteration to the channel/floodplain, greater potential for creation of new channel upstream of the structure and greater ability to convey flows in an unaltered floodplain. Options with a greater cross-sectional area (in addition to a shorter length) have greater capacity to convey flows. In high flow conditions, options with shorter length and greater cross-sectional area (opening) have the greatest capacity to convey stream flows, for the shortest duration, limiting the volume and time in which flows are constricted. Hence, Option 5 is preferred. Longer culverts with smaller cross-sectional area are less preffered as they will constrict flows which has the potential to result in increased velocities, erosion/scouring, and changes to stream morphology.
	Normalized Factor Group Score	9.0	8.0	6.0	7.0	10.0	8.0	1.0	
1.E Groundwater Resources									
Groundwater Recharge Areas	*Encroachment on significant groundwater recharge areas (Regional Recharge Area) (removal/disruption of function – area; depth).	10	10	10	10	10	10	10	
Groundwater Quality	*Potential for impacts to vulnerable areas (Area).	10	10	10	10	10	10	10	
Shallow Groundwater Movement/Contributions	*Potential for interference with existing flow patterns (baseflow) relative to proximity to surface water and significant groundwater discharge areas.	10	5	4	9	5	3	1	Impacts to groundwater by dewatering.
	Normalized Factor Group Score	10.0	8.3	8.0	9.7	8.3	7.7	7.0	
1.F Surface Drainage									
Flood Plain Function	*Impacts to Regulatory Floodplain of Devil's Creek. *Changes (+/-) to Devil's Creek floodplain hydrologic function.	6	7	7	1	10	9	8	(Reduce flood risk over existing conditions) Largest opening are the best. Option 4 - smallest opening
Stormwater Management	*Opportunities to enhance roadway stormwater management measures, including coordination with/use of adjacent development facilities.	10	10	10	10	10	10	10	
	Normalized Factor Group Score	8.0	8.5	8.5	5.5	10.0	9.5	9.0	
	TOTAL CATEGORY SCORE	53.0	51.8	42.0	39.2	57.8	47.2	31.0	
	NORMALIZED GROUP SCORE	8.8	8.6	7.0	6.5	9.6	7.9	5.2	
	CATAGORY RANKING	2	3	5	6	1	4	7	

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		1	2	3	4	5	6	7	
2. SOCIO-CULTURAL ENVIRONMENT									
2.A Land Use Policy									
Land use designations and policies	*Efficiency of land use and consideration of development on adjacent lands.	10	8	7	8	7	7	1	consider size of the structure, with smaller being preferred; locating sewer above creek for efficiency; and, the least impact on adjacent lands. Option 1 has the smallest structure and has the least impact on adjacent lands.
	Normalized Factor Group Score	10.0	8.0	7.0	8.0	7.0	7.0	1.0	
2.B Noise									
Noise Sensitive Areas	*Noise sensitive receptors experiencingincreases (5 dB ranges) in sound levels over pre-existing conditions. *Noise sensitive receptors experiencing resultant absolute noise levels over 60 dBA.	10	10	10	10	10	10	10	No difference in impact among alternatives
	Normalized Factor Group Score	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
2.C Archaeological Resources									
Known and/or Potential Archaeological Sites	*Number/type/significance of direct/indirect impacts to known archaeological resources and/or areas of high archaeological potential.	10	10	10	10	10	10	10	No difference in impact among alternatives
	Normalized Factor Group Score	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
2.D Built Heritage									
Built Heritage Features	*Number/type/significance of direct/indirect impacts to built heritage resources (based on presence of built heritage resources identified by the City of Cambridge).	10	10	10	10	10	10	10	No difference in impact among alternatives
	Normalized Factor Group Score	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
2.E Pedestrian Trail Connection									
	*Safety regarding pedestrian/vehicle conflicts *CPTED Principals *Functionality/Constructability	10	9	8	8	5	3	1	Consideration given to length of structure, with shorter being preferred; level of personal safety; and, length of structure. Alternatives 1 to 4 relatively equal; however, Alternative 1 has a narrower right of way making it more desirable
	Normalized Factor Group Score	10.0	9.0	8.0	8.0	5.0	3.0	1.0	
	TOTAL CATEGORY SCORE	50.0	47.0	45.0	46.0	42.0	40.0	32.0	
	NORMALIZED GROUP SCORE	10.0	9.4	9.0	9.2	8.4	8.0	6.4	
	CATAGORY RANKING	1	2	4	3	5	6	7	

3. TRANSPORTATION/MUNICIPAL SERVICES AND UTILITIES									
3.A Transportation Operations									
Traffic Operations	*Road safety *Guardrail situation *Pedestrian separation from vehicles	3	1	7	9	3	7	10	-Guardrail safety -Horizontal distance to sidewalk
Transportation policy initiatives Capacity/capability to accommodate forecast traffic demand Provides for appropriate access to existing properties	*Capability to support municipal policy initiatives (transit, active transportation, roundabouts). *Impact on access to existing properties.	10	10	10	10	10	10	10	
	Normalized Factor Group Score	6.5	5.5	8.5	9.5	6.5	8.5	10.0	
3.B Municipal Services and Utilities									
Municipal Services	*Operation/maintenance costs *Sanitary sewer location	10	5	5	9	4	4	1	
Utilities	*Degree of exposure of utilities and/or utility conflicts with road design.	10	10	10	10	10	10	10	
	Normalized Factor Group Score	10.0	7.5	7.5	9.5	7.0	7.0	5.5	
	TOTAL CATEGORY SCORE	16.5	13.0	16.0	19.0	13.5	15.5	15.5	
	NORMALIZED GROUP SCORE	8.3	6.5	8.0	9.5	6.8	7.8	7.8	
	CATAGORY RANKING	2	7	3	1	6	4	4	

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		1	2	3	4	5	6	7	
4. FINANCIAL									
Cost	*Estimated capital cost - Culvert length. - Property requirements (number, area) and ease of acquisition. - Extraordinary operations and maintenance requirements/costs. - Species at Risk mitigation/overall benefit. - Cultural heritage mitigation measures. - Dewatering costs.	10	9	7	8	6	5	1	
	Normalized Factor Group Score	10.0	9.0	7.0	8.0	6.0	5.0	1.0	
	TOTAL CATEGORY SCORE	10.0	9.0	7.0	8.0	6.0	5.0	1.0	
	NORMALIZED GROUP SCORE	10.0	9.0	7.0	8.0	6.0	5.0	1.0	
	CATEGORY RANKING	1	2	4	3	5	6	7	
5. TECHNICAL									
Functional geometric design requirements	*Conformance to City of Cambridge standards.	3	1	8	8	3	8	10	- sidewalk location - length
Foundation/culvert design requirements	*Requirements for foundation footprint, based on soil conditions. *Structural requirements relative to capital cost and long term maintenance requirements.	10	6	5	9	3	2	1	
Topographic; extent of cut/fill	*Potential for excessive borrow quantity or excessive off-site disposal of earth material (volume). *Requirements for excessive (steep) grades (length).	10	9	5	5	9	5	1	
Constructability	*Physical constructability. *Potential conflicts with existing infrastructure (other than utilities). *Provision of standard horizontal and vertical clearance requirements.	10	6	5	9	3	2	1	
Railway – vertical alignment of crossing	*Disruption to rail service. *Ability to meet design standards. *Flexibility to retrofit in the future. *Ability of the City to implement. *Cost.	10	10	10	10	10	10	10	
	Normalized Factor Group Score	43.0	32.0	33.0	41.0	28.0	27.0	23.0	
	TOTAL CATEGORY SCORE	43.0	32.0	33.0	41.0	28.0	27.0	23.0	
	NORMALIZED GROUP SCORE	8.6	6.4	6.6	8.2	5.6	5.4	4.6	
	CATEGORY RANKING								
	GRAND TOTAL	**45.7**	**39.9**	**37.6**	**41.4**	**36.4**	**34.0**	**24.9**	
	OVERALL RANKING	**1**	**3**	**4**	**2**	**5**	**6**	**7**	
Assumptions		9.1	8.0	7.5	8.3	7.3	6.8	5.0	
		10	8	7	8	7	7	1	