Evaluation Criteria				Segment 1 Kennedy Road – Old Brampton WWTP Site		Segment 2 Old Brampton WWTP Site – West-to-East Diversion Chamber		Segment 3 West-to-East Diversion Chamber - Eastern side of Dixie Road	
Type	**Comparative Criteria**	**Description**	**Main Consideration**	**Rock TBM**	**MTBM**	**Rock TBM**	**MTBM**	**Open-cut**	**MTBM**
Technical	**Tunneling Considerations**	- Tunnel diameter	- A tunnel size closer to the pipe size is preferred (TBM needs 2700 mm OD tunnel and MTBM needs 2150 mm OD tunnel); reduces amount of grouting required	- Significantly larger diameter (2700 mm OD) than pipe (1770 mm OD)	- Diameter (2150 mm OD) is closer to pipe diameter (1890 mm OD)	- Significantly larger diameter (2700 mm OD) than pipe (1770 mm OD)	- Diameter (2150 mm OD) is closer to pipe diameter (1890 mm OD)	Construction considerations compared to the MTBM method:	Construction considerations compared to the Open-cut method:
		- Tunnel Drive	- Single drive to tunnel each section is preferred (TBM can bore up to 3 km and MTBM can bore typically up to 800 m)	- Single drive to tunnel this segment (Shaft 1 to 2 is 1250 m)	- Two drives needed to tunnel this Segment 1 (Shaft 1 to 2 is 600 m and 3 to 2 is 650 m)	- Single drive to tunnel this segment (Shaft 2 to 3 is 1300 m)	- Two drives needed to tunnel this segment (Shaft 3 to 4 is 850 m, and 5 to 4 is 450 m)	- Hydraulically required diameter (1890mm OD) can be used i.e. a larger diameter is not required The design pipe is 1500mm ID	- Diameter (2150 mm OD) is close to pipe diameter (1890 mm OD) and there will be less volume of excavated soils compared to open-cut.
		- Number of shafts needed	- Fewer number of shafts preferred (longer drives eliminate need for intermediate shafts)	- Two shafts (Shafts 1 and 2) needed for TBM drive; one additional shaft needed for Biscayne connection using MTBM	- Three shafts (Shafts 1, 2 and 3) needed for MTBM drives; one of these can be used for Biscayne connection as well	- Two shafts (Shafts 2 and 3) needed for TBM drive	- Three shafts (Shafts 3, 4, and 5) needed for MTBM drive	- The open cut excavation will likely be undertaken as a rolling compound rather than all at once however a greater excavation extent will be required than MTBM	- Two drives needed to tunnel this segment from Shaft 5 to an Intermediate Shaft (5B); from the Intermediate Shaft (5B) to Shaft 6. An 'S' curve will not work because the radius is too tight.
		- Size of shafts	- Smaller shaft area is preferred (TBM needs minimum shaft size of 10 m for launching and 7 m for receiving while MTBM requires minimum 6.5 m for launching and 5 m for receiving)	- Shaft area will be larger at 137 m2 (Shaft 1 launching, Shaft 2 receiving, connection shaft receiving MTBM)	- Shaft area will be smaller at 86 m2 (Shafts 1 and 3 launching, Shaft 2 receiving)	- Shaft area will be slightly smaller at 77 m2 (Shafts 2 and 3 receiving)	- Shaft area will be slightly larger at 86 m2 (Shafts 3 and 5 launching, Shaft 4 receiving)	- No shafts are required. 5 No. manholes are likely to be required due to change of direction. Open cut excavation will expose more working total area than tunnelling operations, as trench/excavation footprint is larger than three shafts.	- Three shafts (Shafts 5, Intermediate Shaft (5B) and Shaft 6) are needed for the two MTBM drives. Shaft areas will impact the surface less than open-cut.
		- Presence of gases	- Gases (like methane, hydrogen sulphide and others common in the rock and found in overburden in southern Ontario) have been detected in shale in nearby projects; lower risk in the event that gas is encountered is preferred (higher risk if workers are present) as it could trigger explosions	- If encountered, higher risk with TBM as people are present	- If encountered, lower risk with MTBM as it is operated remotely	- If encountered, higher risk with TBM as people are present	- If encountered, lower risk with MTBM as it is operated remotely	- Gases may be encountered by workers inside the trench requiring more stringent H&S compliance/PPE	- If gas is encountered, lower risk with MTBM as it is operated remotely compared to open-cut where workers will be present.
	Score			◐	●	◐	◑	○	◑
	Geotechnical and Hydrogeological Conditions	- Versatility	- Versatility to tunneling in different ground conditions (overburden and bedrock) is preferred	- TBM is less versatile; works best in bedrock	- MTBM is more versatile; can excavate in bedrock and overburden	- TBM is less versatile; works best in bedrock	- MTBM is more versatile; can excavate in bedrock and overburden	-The rock is considered "rippable" by hydraulic excavator and is not expected to require blasting.	-Dewatering and/or groundwater management will be required at the shafts only as compared to open cut where groundwater would need to be managed across the entire length.
		- Groundwater	- Preference for a TBM is to excavate upward to allow groundwater infiltration to run towards the launching shaft and minimize pumping requirements; no preference for MTBM	- TBM is planned to excavate down; higher risk of flooding in the tunnel	- MTBM does not have constraints due to flooding from groundwater	- TBM is planned to excavate down; higher risk of flooding in the tunnel	- MTBM does not have constraints due to flooding from groundwater	-No groundwater information currently, but it is expected that groundwater will, at a minimum, follow the level in the nearby Creek and that dewatering and/or groundwater management will be required along the entire open cut length.	-MTBM can excavate in bedrock and overburden.
	Score			◐	●	◐	●	○	◐
	Property Requirements	- Space for work compounds	- Smaller work compounds needed for staging the launching and retrieving shafts are preferred as it will mean a smaller temporary easement (TBM 4500 m2 and 3000 m2 respectively and MTBM 2000 m2 and 800 m2 respectively)	- Work compound area is 7500 m2 (one launching and one receiving) with an additional 800 m2 for Biscayne connection shaft; larger work compound area (temporary easement)	- Work compound area is 4800 m2 (two launching and one receiving); smaller work compound area (temporary easement)	- Work compound area is 6000 m2 (two receiving); larger work compound area (temporary easement)	- Work compound area is 4800 m2 (two launching and one receiving); smaller work compound area (temporary easement)	- Ch 2550 to 3150 = 600 m section. Assuming 2 m either side of the pipe trench width is approx. 6 m. Space requirements are 3600 m2 for the trench only. For work compounds, pipe and material storage, construction vehicle parking, and stockpiling areas are required, therefore 2000 m2 of temporary compound is likely to be required	- Assume two launching compounds and one receiving and total work compound area is 4800 m2 which is expected to be less than the open-cut. Temporary easement
		- Area needed for permanent easements - Impact on private property	- Smaller permanent easement area is preferred to facilitate property negotiations - Least impact on private property is preferred to facilitate property negotiations	- Same area needed as MTBM for permanent easements - No impact on private property	- Same area needed as TBM for permanent easement - No impact on private property	- Smaller area needed for permanent easement - Impacts two private properties (permanent easement)	- Larger area needed for permanent easement - Impacts two private properties (permanent easement)	-Permanent easement is expected to be the same for MTBM and open-cut.	-Permanent easement is expected to be the same for MTBM and open-cut. Impact to one private property near Dixie but there is already a permanent easement.
		- Encroachment permit needs for Hwy 410/407 ETR/ Hydro One Lands	- Smaller area within Hwy 410/407 ETR/ Hydro One Lands	- No work compounds within IO/MTO/407 ETR Lands	- No work compounds within IO/MTO/407 ETR Lands	- Small area of Shaft 3 potentially within IO/MTO/407 ETR Lands	- Shaft 4 is within IO/MTO/407 ETR Lands; small area of Shaft 5 may also be within IO/MTO/407 ETR Lands	-TRCA permit is needed.	-TRCA permit is needed.
	Score			◐	●	◐	◑	◑	◑
	Accessibility	- Construction access	- Ease of accessing shaft locations is important	- Both shafts are in close proximity to roads (Shafts 1 to Kennedy Rd and Shaft 2 to Westcreek Blvd); Biscayne connection shaft is not easily accessible and will need a temporary paved road (Biscayne connection shaft to Kennedy Rd)	- Two shafts are in close proximity to roads (Shaft 1 to Kennedy Rd and Shaft 3 to Westcreek Blvd); the other is not easily accessible and will need a temporary paved road (Shaft 2 to Kennedy Rd)	- One shaft is in close proximity to a road (Shaft 2 to Westcreek Blvd); the other is much further away and requires temporary paved road (Shaft 3 to Tomken Rd)	- One shaft is in close proximity to a road (Shaft 3 to Westcreek Blvd); one is moderately accessible and will need a temporary paved road (Shaft 4 to Tomken Rd); one shaft is much further away and will need a temporary paved road (Shaft 5 to Tomken Rd)	- Access for excavators and loading trucks likely to be difficult in ravine land. Temporary access will need to be constructed. - However open-cut through Dixie Road is deemed to be a significant access constraint as it is a busy 6 lane road	- Shaft access will be most difficult for Shaft 5 (west end) and the Intermediate Shaft (5B) and Shaft 6 are relatively easy access.
	Score			◐	◐	◐	○	○	◐
	Maintainability	- Ease of maintenance - Operation access	- More opportunities to use shaft locations for maintenance holes is preferred - Ease of accessing the maintenance holes and diversion chambers is important	- Same number of opportunities; shafts spaced somewhat far apart (600 m and 650 m) - Two maintenance holes (at Shafts 1 and 2) will be easily accessible; one will not be easy to access (at Biscayne connection)	- Same number of opportunities; shafts spaced somewhat far apart (600 m and 650 m) - Two maintenance holes (at Shafts 1 and 3) will be easily accessible; one will not be easy to access (at Shaft 2)	- Less opportunity; shafts spaced very far apart (1300 m) - One maintenance (at Shafts 2) will be easily accessible; one will not be easy to access (at Shaft 3)	- More opportunity; shafts spaced somewhat far apart (750 m and 450 m) - One maintenance (at Shaft 3) will be easily accessible; two will not be easy to access (at Shafts 4 and 5)	- Likely require 5 No. maintenance holes (at bends and one on each side of Dixie) - Access Routes to maintenance holes likely to be the same for Open-Cut/MTBM operations.	- 3 No. maintenance holes - Ease of access to maintenance holes likely to be the same for Open-Cut/MTBM operations.
		- Maintenance needs	- Longer distances between maintenance holes may require specialized and costly inspection and repair equipment; lower need for specialized equipment is preferred	- Maintenance holes are spaced to support typical maintenance and equipment	- Maintenance holes are spaced to support typical maintenance and equipment	- Further separation may require specialized maintenance and equipment	- The longer section may require specialized maintenance and equipment	- Maintenance requirements slightly easier for open cut option as there is an extra intermediary maintenance hole	
	Score			◐	◑	○	◑	○	◑
	Schedule	- Duration of project	- Shorter time duration for completion of work is preferred	- Overall longer duration; although speed of tunneling will be faster, pipe installation will be separate after tunneling	- Overall shorter duration; although speed of tunneling is slower, pipe installation is combined with tunneling	- Overall longer duration; although speed of tunneling will be faster, pipe installation will be separate after tunneling	- Overall shorter duration; although speed of tunneling is slower, pipe installation is combined with tunneling	- Open cut excavation is likely to be quicker than MTBM operation in terms of the speed of installation. - However closing Dixie Road and open-cut across it will be significant and will take longer than MTBM - The significant utilities that will need to be protected/relocated with open cut across Dixie will take longer than MTBM	-The method of installation is generally expected to take longer due to MTBM rig mobilization, compound set up and shaft excavation - however it could be similar in this case as the operation could be run 24/7. And also the MTBM will be set up for Segments 1 and 2. - Also time will be saved as MTBM operation does not need to deal with existing utilities and traffic on Dixie Road as it will avoid it altogether going underneath
	Score			○	●	○	●	○	●
	Average Score			◐	●	◐	●	○	◐
	Terrestrial Environment	- Area within natural environment	- Smaller area of work area within the natural environment is preferred; presents less disturbance to the natural environment, habitats and ultimately species that use the area	- Shafts 1 and 2 are within the natural environment; larger work areas	- Shafts 1 and 3 are within the natural environment; smaller work areas	- Shafts 2 and 3 are within the natural environment; larger work areas	- Shafts 3, 4 and 5 are within the natural environment; smaller work areas	- Substantive surface disturbance due to open-cut area along the entire segment is within the natural environment	- Minimal surface disturbance from smaller area (Shafts 5B, and 6) within the natural environment
		- Crossing of the natural system	- Perpendicular crossing of the Natural System at its most narrow point	- Similar alignment	- Similar alignment	- Similar alignment	- Similar alignment	- Longer alignment crossing the natural environment	- Shorter alignment crossing the natural environment
	Score			◐	●	◐	●	○	◐

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Type	**Comparative Criteria**	**Description**	**Main Consideration**	**Rock TBM**	**MTBM**	**Rock TBM**	**MTBM**	**Open-cut**	**MTBM**
Natural Environment	**Aquatic Environment**	- Impact to aquifers and surface water receptors (e.g., watercourses, wetlands, and woodlands)	- Fewer number of shafts/work area close to the Etobicoke Creek is preferred to minimize impact on aquifers and surface water receptors	- Shaft 1 is in close proximity to the creek (<50 m)	- Shaft 1 is in close proximity to the creek (<50 m)	- Shaft 3 is in close proximity to the creek (<50 m)	- Shaft 5 is in close proximity to the creek (<50m); Shaft 4 is in relative close proximity (~50m)	- Open-cut alignment will require open-cut works within proximity to /through wetland	- Tunneling alignment will tunnel under wetland; however there may be risk of Frac-out
	Score			◐	◐	◐	○	○	◐
	Groundwater Impacts	- Groundwater levels	- Less impact to groundwater levels is preferred; can be impacted by tunnelling in rock	- Permeability of rock and open-face of TBM can lead to lowering the groundwater table during tunnelling	- Tunneling with MTBM does not impact the groundwater levels	- Permeability of rock and open-face of TBM can lead to lowering the groundwater table during tunnelling	- Tunneling with MTBM does not impact the groundwater levels	- Trenches will require dewatering to allow work to proceed	- Tunneling with MTBM does not impact the groundwater levels
	Score			○	●	○	●	○	●
	Contaminated Lands	- Proximity of contaminated lands	- Fewer number of work compounds and shafts within Areas of Potential Environmental Concern (APEC) is preferred to reduce the potential for groundwater contamination during construction	- Three shafts within APEC	- Three shafts within APEC	- Two shafts within APEC	- Three shafts within APEC	- Trench segment within APEC	- One shaft within APEC
	Score			◐	◐	●	◐	○	●
	Soil Management	- Quantity of excavated soils	- Less soil needing to be hauled after excavation is preferred	- More excavated material	- Less excavated material	- More excavated material	- Less excavated material	- More excavated material	- Less excavated material
	Score			○	●	○	●	○	●
	Average Score			◐	●	◐	◐	○	●
Socio-Cultural Environment	**Impact to Cultural Heritage**	- Proximity to cultural heritage sites	- Fewer number of Cultural Heritage Resources (CHR) in close proximity of work compounds, shafts and alignment is preferred	- No CHRs	- No CHRs	- One CHR that may be impacted by alignment	- One CHR that may be impacted by alignment and shaft location	- One CHR that may be impacted by larger footprint of the open-cut section	- One CHR that may be impacted by smaller footprint of one shaft location
	Score			●	●	◐	○	○	◐
	Archaeological Potential	- Impact to archaeological potential	- Preference is for work compounds and shafts to be outside of areas requiring archaeological assessment	- One shaft (Shaft 1) close to area needing Stage 2 archaeological assessment; one shaft (Shaft 2) close to previously unassessed area	- One shaft (Shaft 1) close to area needing Stage 2 archaeological assessment; one shaft (Shaft 3) close to previously unassessed area	- One shaft (Shaft 3) close to area needing Stage 2 archaeological assessment; one shaft (Shaft 2) close to previously unassessed area	- One shaft (Shaft 5) close to area needing Stage 2 archaeological assessment; two shafts (Shafts 3 and 4) close to previously unassessed area	- Sections of open-cut alignment close to area needing Stage 2 archaeological assessment	- Two shafts (Shaft 5 and 6) close to area needing Stage 2 archaeological assessment
	Score			◐	◐	◐	○	○	○
	Impact to Recreation	- Impact to recreational trails/ facilities	- Minimal temporary disruption to access recreational trails and facilities preferred	- Connection Shaft will impact availability of recreational fields (i.e., cricket field) on CAA Land	- Shaft 2 will impact recreational availability of fields (i.e., cricket field) on CAA Land	- Shaft 3 is in close proximity to the trails and may impact its accessibility	- Shafts 4 and 5 are in close proximity to the trails and may impact its accessibility	- Open-cut section west and east of Dixie Road in close proximity to trails and baseball diamond	- Shafts 5 and 6 in close proximity to trails and baseball diamond
	Score			◐	◐	◐	○	○	◐
	Average Score			◐	◐	◐	○	○	◐
Economic Factors	**Cost of Tunneling and Infrastructure**	- Equipment cost - Cost of shaft excavation and work compound preparation - Cost of material - Cost of hauling material - Cost of pipe	- Lower equipment cost is preferred (including cost of tunnel) - Lower cost for shafts and work compounds is preferred - Lower cost for material (i.e., backfill grout to fill in annular space) is preferred - Lower cost for material to be hauled from site is preferred - Lower cost of pipe is preferred	- Typically TBM has a higher unit rate; however, cost is highly variable depending on market conditions and equipment availability - Larger shafts and compounds will result in higher cost - More grout will be needed to fill in the gap (1770 mm OD diameter pipe and 2400 mm ID tunnel; similar length tunnel) - Larger diameter and similar length tunnel will result in more material needing to be hauled; higher cost - Smaller pipe; cost is lower	- Cost of tunnelling with MTBM is anticipated to be lower - Smaller shafts and compounds will result in lower cost - Less grout will be needed to fill in the gap (1890 mm OD diameter pipe and 2150 mm ID tunnel; similar length tunnel) - Smaller diameter and similar length tunnel will result in less material needing to be hauled; lower cost - Larger pipe; cost is higher	- Typically TBM has a higher unit rate; however, cost is highly variable depending on market conditions and equipment - Slightly smaller shafts with larger compounds will result in higher cost - More grout will be needed to fill in the gap (1770 mm OD diameter pipe and 2400 mm ID tunnel; similar length tunnel) - Larger diameter and similar length tunnel will result in more material needing to be hauled; higher cost - Smaller pipe; cost is lower	- Cost of tunnelling with MTBM is anticipated to be lower - Slightly larger shafts with smaller compounds will result in slightly lower cost - Less grout will be needed to fill in the gap (1890 mm OD diameter pipe and 2150 mm ID tunnel; similar length tunnel) - Smaller diameter and similar length tunnel will result in less material needing to be hauled; lower cost - Larger pipe; cost is higher	-Open cut costs likely to be lower than MTBM operations in terms of installation/ equipment method for depths up to 8 m - Cost of preparing the work plan for crossing Dixie Road and the utility relocation/ protection will be significant - Cost of material is the only aspect likely to be more cost than tunnelling. - Hauling/backfilling material from open cut excavation across Dixie Road. - Cost of the pipe is likely to be slightly more than the MTBM alignment as the MTBM alignment is shorter in linear length with the curves	- Cost of tunnelling equipment and shaft excavation/work compound setup with MTBM is anticipated to be higher than open-cut if the depth is less than 7 m. - There is a cost associated with excavation within TRCA flood plain to provide access, but this is the same for open cut. - Cost managing excess soil is less costly than for open cut as there is no backfill requirements for tunnelling - The temporary easement required for tunnelling is narrower than for open cut works and this will require less restoration works hence MTBM will cheaper with hauling material. - The cost of pipe is likely to be slightly less than the open cut option
	Average Score			○	●	○	◐	○	●
Total Score				◐	●	◐	◐	○	●