THE CORPORATION OF
THE CITY OF HAMILTON

HAMILTON AREA RAPID TRANSIT STUDY

PHYSICAL FEASIBILITY REPORT

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BOOK 1

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SECTION 5

ALIGNMENTS

The development of alternative alignments was primarily directed at providing service between the four predominant areas defined in the Terms of Reference, i.e., the Mountain, the Escarpment, the Central Business and the Bay Front Industrial areas. Although the main concern was to determine the engineering feasibility of constructing a line that would connect the four areas, consideration was given to the general location of stations and the areas they would serve.

Approximately 20 different combinations of horizontal and vertical alignments were investigated. Several of the alternatives were eliminated following discussion and agreement with the Committee and finally, the remaining six that were considered to be viable were developed for the Study.

A matter of prime importance is the urgency to protect the requisite right-of-way i.e., to ensure against development along the proposed line that would result in more costly rapid transit construction.

The alternative alignments outlined in this Report are preliminary in nature. They have been developed to define the engineering feasibility of the lines in order to furnish guidance to the decision makers for their selection of the alignment to be adopted. It is emphasized that no recommendation is made in this Study with respect to the location, spacing or number of stations. These were assumed largely to determine physical engineering feasibility. In the final analysis the location of stations would be determined from a more detailed planning study.

The development of functional plans for the purposes of: locating the stations, outlining the alignment, establishing the structural forms, defining properties required for the right-of-way and preparing more

accurate estimates of cost, would follow the selection of the preferred general alignment. During the stage in which functional plans for a selected alignment are under preparation, the design criteria would be modified to take full advantage of the operational characteristics of the rapid transit vehicles suited to Hamilton area requirements. It is reasonable to expect that such modifications will result in criteria that will be less restrictive to the further development of the alignment with consequent benefit to the planning operational, environmental impact and economic aspects of the rapid transit system.

On the whole, the development of a rapid transit alignment along a corridor to connect the four main areas in Hamilton is a task that presents many difficult problems. If ever the question was posed as to whether it would not be easier to move a city and start all over again, it is one that could surely be asked in this instance. The natural and man-made obstacles related to the topography, geology, soils conditions and development are anything but insignificant in the development of vertical and horizontal alignments for a rapid transit along a north-south corridor connecting the four areas specified.

The Mountain Area
See Exhibits 3, 21, 22, 29, 30, 37, 38

In considering the alternatives on the Mountain, extensions southerly from Fennell Avenue are relatively easy. Regardless of whether the alignment is along Upper James or East 19th or a similar parallel nearby line, the alignment may be readily curved in the horizontal plane to serve desired centres. Also, it can be underground or elevated, and possibly even at-grade, with little or no restriction on line gradients. Planning, engineering, design, construction and operations may readily be handled by existing know-how and numerous options with respect to planned development would be available.

The development of alignments northerly from Fennell to connect the Mountain to the Central Area involves problems which impose significant constraints in view of the difference in elevation of 300 feet at the Escarpment. In order to maintain acceptable gradients without resorting to a lengthy circuitous route to overcome the difference in elevation between the Mountain and the Central Area levels, the choice is limited to an underground structure south of the Escarpment.

Regardless of whether the line is underground or elevated north of the Escarpment, the underground structure south of the Mountain brow would be of such depth that tunnelling would be the recommended method of construction. Generally, excavation down from the surface becomes uneconomical when the depth of cut is over 35 to 45 feet. Furthermore, according to available information, the characteristics of the rock and the conditions at the depths under consideration should present no unusual tunnelling problems. It is expected that it can be tunnelled at reasonable cost since during construction it will require only nominal support. Similarly the permanent lining need not be particularly substantial since it is anticipated that the rock will be largely self-supporting. The depth of the structure at Fennell will be governed by the selection of the alignment to the north.

From the viewpoints of engineering design and construction, there appear to be few constraints with respect to the alignment of the southerly extension. However, in analyzing this alignment relevant to desired development and centers to be served, due consideration should be given to the requirement for property on which to locate maintenance yards and shops for the rapid transit system. This is a matter that ranks high on the priority list in any deliberations since such facilities are essential to the initial operation of the system.

The line would rise as it proceeds southerly from Fennell and consequently, the depth at Fennell will govern where construction of the southerly extension will change from tunnelling to cut and cover. This will depend on the planning decisions with respect to the southerly alignment which in turn will fix the location at which the depth of sound rock and other soil conditions will dictate the change in the method of construction from tunnelling to cut and cover.

The depth of the most northerly station on the Mountain, (Fennell, Inverness or Mohawk) will be governed by its proximity to the brow, the attitude (elevated or underground) of the line north from the Escarpment, its east-west location (Upper James or East 19th) and the governing gradient. The drawings of the alternative alignments illustrate that there would be a considerable range of depths for this station and although all are feasible insofar as engineering and construction are concerned, the final location will be governed by an assessment of costs versus journey time and convenience. Journey time includes time spent: walking, on feeders, transferring, for vertical travel (escalators and stairs) and the train trip time.

All other things being equal, the further south of the brow that the most northerly station on the Mountain is located, the shallower the station may be. This would result in significant savings in construction and escalator costs. It would also decrease the time it takes to travel between surface and train level. On the other hand it is bound to have a detrimental effect on patronage that could be generated in the area north from the station to the brow. There is a natural tendency against back tracking on trips of relatively short length but quite probably the effect of this may not be significant. In fact, back tracking has been an accepted fact in the everyday life of Hamilton's motorists who negotiate the Escarpment through a series of switchbacks in the roads.

Finally, deep stations on the Mountain, in addition to being feasible from the engineering and construction standpoint, would be by no means unique. Several stations in the London Underground and in other cities around the world are considerably deeper than anything contemplated here.

The Escarpment Area
See Exhibits 4, 5, 22, 23, 30, 31, 38, 39

In discussing the rapid transit alignment in the Escarpment Area it is of little significance in the Study to define precisely the line of delineation between it and the Central Area. The transition is gradual and the Escarpment Area is treated as an integral part in consideration of the alignment for both the Mountain and Central Areas.

Regardless of whether the line is elevated or underground, it must traverse a zone of unstable soil after it passes the northerly face of sound rock. Following selection of an alignment in the Mountain formation, further investigation will be required to determine the extent and additional characteristics of the unstable soil zone which the line will traverse. The forthcoming data will be required for final design and will assist in the selection of a method of construction that will be both safe and economical.

Basically three alternatives are proposed for the area south of the T.H.& B. railway tracks. Alignments 1 and 2 are the same in this area and would be entirely in underground structure constructed by the cut and cover method. There could be a station in the vicinity of St. Joseph's Hospital at James and Herkimer.

Alignments 3 or 4 would emerge from the face of the Escarpment in the vicinity of St. Joseph's Drive and Ferguson and would be on elevated structure along Ferguson Avenue. An elevated station could be located in the vicinity of Forest and Ferguson.

Alignments 5 or 6 would be entirely in underground structure, cutting diagonally across to John and Young, and would then follow a line westerly, parallel to Augusta, to pass under James before curving to the North. An underground station could be located in the block bounded by John, Forest, Catharine and Young.

Soil conditions in the area south of the T.H.& B. tracks will present some difficulties during the construction stage for an underground line, but no special measures will be required with respect to the design of the permanent underground structure. Special techniques will be required during construction due to the high water table and the granular soils that will be encountered at the depths under consideration.

It is anticipated that the methods of construction will involve the use of conventional soldier piles and lagging combined with the slurry wall technique in carrying out the excavation. For excavation to expose and maintain underground utilities above the water table, soldier piles and lagging would be used. Below the water table, the slurry wall method would be used to retain the sides of the excavation to prevent loss of ground.

The problems posed by the soils conditions would be considerably reduced by resorting to an elevated instead of an underground line, and would much be preferred from a purely technical engineering point of view. However, from the standpoint of environmental impact it is an entirely different matter. It was concluded an elevated structure would be least disruptive with respect to visual intrusion and as a physical barrier if confined to a line in the vicinity of Ferguson. Therefore an elevated structure is proposed for the alternative alignments in the easterly area in order to take advantage of the economies that would be realized in construction costs.

Consideration of the other lines, 1, 2, 5 and 6, south of the T.H.& B. tracks led to the conclusion that elevated structures would be significantly disruptive and it was agreed that elevation for these alternatives should be eliminated for the present. However, if redevelopment will take place in the future, it may be planned so that an elevated structure would be acceptable in this area. In this event, the higher costs of underground construction in the difficult soils could be avoided.

The Central Area
See Exhibits 5,6,7,14,15,16,23,24,39,40,41

Two alternatives are proposed in the area north from the railway tracks to Cannon Street; one elevated and one underground. The continuation of Alternatives 3 and 4 would be elevated structure crossing over the T.H.& B. tracks and following the C.N.R. right-of-way northerly along Ferguson to Cannon and beyond. An elevated station would be located on these lines in the vicinity of King and Ferguson.

It is considered that an elevated structure along this line would be acceptable since it would not conflict with the present development. Furthermore, if redevelopment of the area is to be undertaken in the future it would be reasonable to expect that it would be planned and designed so that the elevated structure would be compatible with the new constructions.

Alignments 1, 2, 5 and 6 would be in underground structure tunnelled under the T.H.& B. tracks and would generally follow the line of MacNab Street. An underground station would be located between Main and King and possibly could be integrated into the Civic Square complex. At this writing the design of Civic Square is under development and definite information on it is not at hand for the purpose

of investigating detailed location of the rapid transit facility. If an alignment is selected along this line, a station in the Civic Square undoubtedly would be of significant benefit to that complex and it is anticipated that the Owner would willingly cooperate by making provision in his design for the accommodation of a facility that would furnish rapid transit service.

However, at this time, the Civic Square designers have no authoritative information that would warrant making special provision in their design to accommodate future rapid transit. Similarly, until this Study is reviewed and decisions are handed down by the City it would not be reasonable to expect that the Developer should be approached to modify the design. On this account the Study Consultants have not contacted the Developers to furnish them with information relevant to future rapid transit.

As discussed previously, the boundary line between the Escarpment and Central areas cannot be firmly defined. The same holds true with respect to the line separating the Central Area from the Bay Front Industrial Area. Therefore, for the purposes of the Study it has been decided that the dividing line would be in the vicinity of the intersection of Victoria Avenue and Burlington Street.

Three alternatives are proposed for the continuation of the routes northerly from Cannon Street to the Bay Front Industrial Area. Alternatives 2 or 5 would be east of and parallel to MacNab. They would slope up to ground level in the block north of Barton and would continue to rise to elevated structure to cross over the C.N.R. tracks. At Macaulay the elevated structure would curve easterly to follow a line along the north side of Burlington Street to Victoria Avenue.

An underground station would be located in the vicinity of Cannon and elevated stations would be located on MacNab near Macaulay and on Burlington near Ferguson.

North from Cannon, Alternatives 3 or 4 would continue on elevated structure generally following the C.N.R. right-of-way along Ferguson, curving easterly to Wellington, northerly to Burlington and westerly along the north side of Burlington Street to Victoria Avenue. There would be two elevated stations; one at Ferguson and Barton and the other in the vicinity of Wellington and Macaulay.

North from Cannon, Alternative 1 or 6 would be a combination of the MacNab and the Ferguson lines. Continuing underground from the Civic Square station, northerly along MacNab the line would curve easterly along Cannon. It would then curve northerly, climbing to an elevated alignment in the C.N.R. right-of-way along Ferguson. There would be an underground station at Cannon and Hughson and two elevated stations on the Ferguson-Wellington line as previously described.

The appended soils report describes the varying geological formations and soils and groundwater conditions likely to be encountered along the alternative alignments proposed through this area. It may be concluded from the soils report that insofar as soils engineering factors are concerned, it is feasible to construct the types of structures in the attitudes and along the alignments proposed.

The Bay Front Industrial Area
See Exhibits 8, 9, 10

Along Burlington Street, easterly from Victoria Avenue, one alignment is proposed. It would be an elevated structure along a line that would be common to and a continuation of the six alternative alignments previously described. This alignment was developed to suit existing land occupancy conditions and roadways in addition to the presently planned Burlington Street improvement. For the most part, it will occupy privately owned property but will require the

demolition of a minimal number of buildings and the buildings to be demolished are considered to be neither substantial nor costly.

Much of the route could traverse those parts of the properties which have not been built upon and could also share land occupied by railway sidings. Existing structures along the line include H.E.P.C. transmission towers, overhead pedestrian and materials handling bridges and substantial buildings which would be costly to acquire or relocate. The elevated structure could be located to horizontally clear some of these and the others could be cleared vertically. Apart from the small land areas occupied by the piers and stations, most of the space above and below the elevated structure would be available for use of the land owners. East of Wellington there are five potential locations for the elevated stations in the following vicinities: Wentworth, Sherman, Gage, Ottawa and Kenilworth.

Soils conditions favour an elevated rather than an underground structure. It is possible to construct an underground line through this area but in view of the high costs associated with the soils condition problems, it would not be a feasible solution. Furthermore, in this industrial environment an elevated structure would cause little disturbance and would be acceptable.

3. Tracked Air Cushion Vehicles - support and guidance supplied by an air cushion between the vehicle and guideway. Propulsion supplied by turbo prop-fan jet or linear electric motors. One system being actively promoted for urban use is known as URBA. This uses a suction air truck in an inverted U shape track. The vehicle is suspended below the track and propelled by a linear electric motor. URBA is in prototype form and a more advanced model will be built at Lyons, France.

4. Monorails - two basic types have been developed in which the vehicle runs above the support track or is suspended below it. Both types use rubber tired wheels for support and guidance and conventional electric motors for traction.

   (a) Alweg: a bottom supported vehicle straddles a narrow concrete beam; support wheels bear on the top of the beam and guidance wheels on the side of the beam. In commercial use in Disneyland, Seattle World's Fair and in Tokyo.

   (b) Safege: a vehicle is suspended below an inverted U shape beam and uses metro type trucks. A vehicle and test track were built at Chateaneuf sur Loire, France.

5. Bus Rapid Transit - conventional or guided buses operated on an exclusive roadway. These would combine trunk route service with capability to use local streets for collector/distributor function, thus avoiding change of mode for passengers on the routes served. Demonstration projects, studies and experiments are underway in a number of countries to develop a guidance device and also to test operation with conventional bus vehicles. Propulsion is by diesel or turbine engines driving rear wheels, although electric traction is feasible.