Altener

Renewable Energy Scheme for Local Public Transport System

ALTENER II Project A/98-464

Final Report

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Participants wish to express their gratitude to 22 Sligo businesses of the Sligo Town Center Partnership and to Civil Engineers of Sligo County Council looking beyond Road Projects

Wilhelm Bodewigs March 2003

1. Introduction

1.1 The City

Sligo is a small city in the North West of Ireland with a population of 20,000 projected to double to 40,000 within 15 years when the city is upgraded to a regional urban growth centre. It is the focal point of the region due to its geographic location and low density structures in regional habitation. The main traffic corridor is North-South due to the restrictions of the Atlantic to the West, Lough Gill to the East and the river Garavogue. This corridor links both the North and West of Ireland and also Northern Ireland with North West Ireland.

Traffic congestion has grown rapidly in recent years and is set to continue in line with projected population and economic growth. Investment in transport infrastructure and public transport have not kept up with the pace of development. Sligo Corporation is urgently considering its approach to these problems and is anxious to do so in a sustainable way and in co-operation with local business.

With this objective it co-operated with the Sligo Town Centre Partnership to secure ALTENER funding to carry out a feasibility study into sustainable solutions to the traffic problems. The aims of the project are to:

- Examine the utilisation of renewable energy for local public transport
- Confirm that the river Garavogue is a suitable power source for such a transport system
- Create an example of excellence for new urban areas

The proposed tram passing at Hyde Bridge near the hydro station

1.2. Renewable energy for local public transport

Most European cities are experiencing ever growing traffic conditions leading to increasing problems of congestion and emission levels with a consequent loss of quality of life. One of the most effective ways of tackling this problem is to take an integrated approach of introducing more environmentally friendly vehicles and simultaneously encouraging a modal shift from private transport to public transport. Renewable energy for public transport can contribute on both fronts providing a sustainable, clean and attractive alternative to the private car. The renewable options could be considered to fall into two broad categories of biofuel vehicles or electric vehicles powered by local renewable energy sources [1].

1.2.1 Biofuels

Biodiesel produced from vegetable oil is technically feasible. In Ireland the most likely form would be rape methyl ester (RME) as rapeseed is the only oil crop commercially produced. Developments in France have been studied, in particular, as well as some pilot projects in Ireland. It is concluded that, at present, the economics are seen as not being favourable to the agriculture sector and the fuel is not available in any significant quantity.

Biogas is a ready replacement for petrol and has similar properties to compressed natural gas (CNG). At a national level there is significant potential to produce biogas from the biomethanation of domestic, industrial and agricultural wastes and considerable quantities are vented from landfill sites. The use of biogas is particularly attractive from the point of view of greenhouse gas abatement. For the purposes of this project however it is concluded that a suitable form of biogas would not be available locally in the short to medium term.

Ethanol is another petrol alternative which is being used, notably in Sweden, in various forms such as E85, E10 and E5 [2]. There is a long tradition in Ireland of growing barley for the brewing and distilling industries and sugar beet for the sugar industry and in recent years there is significant production of potable alcohol from whey residues. However, it is not foreseen that any alcohol would be available for biofuel purposes in the near future.

1.2.2 Renewable energy for electric vehicles

Solar energy for transport is a novel concept in Europe. One example is the PV (photovoltaic) charging station for electric vehicles in Palermo under the THERMIE project ZEUS. This is an unlikely option though for Sligo given its Northerly latitude [3].

Wind energy is a more likely option particularly in NW Ireland which has one of the most favourable wind regimes in Europe and there have been a number of wind farm developments in recent years in the region. London Underground interestingly has identified offshore wind power as a long term strategic energy source and the use of local wind energy is seen as a likely development in Sligo harbour in a second phase of the project [4].

Hydro-electricity is clearly the most likely and convenient renewable energy source for Sligo, being the most readily available, utilising the river Garavogue which runs through the centre of the city. This option was examined in more detail in the report.

1.3 Development of hydro-electricity resource

1.3.1 The hydro-electricity resource

The Garavogue river runs through the centre of the city from Lough Gill which is 3km upstream and 6.5m above sea level. In the past there were two mills situated in the stretch of river which runs through the city centre. The river is tidal below the second or lower weir as it opens out to the Atlantic. In a national survey carried out in 1898 the total effective hydro potential of the river in Sligo city was estimated to be 200kW continuously. Over the past 100 years all the hydro installations were let go into disuse [5].

1.3.2 Recent developments

To meet the increased demands for water in a growing city, a new water storage scheme is currently under construction. This has involved the upper weir being replaced and raised in height (adjustable) and a new fish pass being installed. At the same time a new hotel development has taken place at the site of the old mill adjacent to the upper weir. Sligo Corporation insisted in the planning permission for this development that the old mill race should be preserved so as to retain the possibility of the reinstatement of a hydro scheme. However during the construction of the new weir the tail race was demolished which eliminated the potential to use for a hydro installation. Therefore the use of a hydro scheme at the lower weir was investigated. The Fishery Authorities were also keen that this weir and fish pass were restored as it would result in a reasonable depth of retained water in the river at low water flows. This would mean that returning migratory fish would be able to pass rapidly upriver and not be stressed by having to wait in Sligo Bay.

1.3.3 Future potential

Potential available power is directly related to the flow of water and the head. The head at the lower weir is between 1m and 3.5m and the long term mean flow on the river has been measured at 10 m^3/sec (excluding fish pass). It has been calculated that a potential available power at this lower weir of a between 40 kW and 285 kW.

The lower weir is still classed as a low head site and an Axial Flow turbine from Newmills Hydro has been identified as being best suited. The advanced guide vane and runner blade control systems on this turbine will ensure the highest possible efficiency output from the turbines over a wide range of flows [6].

1.3.4 Energy distribution storage and electric vehicle charging

Initially it was envisaged that the hydro-electricity would feed directly to a storage system consisting of a battery bank which would be used for the charging of electric vehicles. However the deregulation of the electricity market in Ireland, as the investigations were started, meant that the national grid could be more easily used. The trams only need to be charged at about 2km intervals (flywheel storage) and the bus and bikes had their own storage batteries. It was very soon apparent that the additional cost, for a separate distribution system by installing cables (with the associated disruptions) and the cost for additional battery storage, was prohibitive in comparison to the cost of using the main grid at local points.

1.4 ELECTRIC VEHICLE OPTIONS

1.4.1 Electric Bus

As the main emphasis of the project is on local public transport, options such as hybrid-electric minibuses and electric minibuses were examined. The findings of the THERMIE project SAGITTAIRE and a previous study by the authors [7] lead to the conclusion that a suitable hybrid-electric minibus is not yet commercially available. A more likely option in the short term was considered to be the electric minibus Gulliver *Tecnobus* for use as a shuttle vehicle between the tram and the centre as previously demonstrated in Florence under the THERMIE project JUPITER. [8]. This would be of particular relevance to people with disabilities as the bus has wheel chair access.

1.4.2 Electrically assisted bicycles

With the input of ADFC, the German partner in the project, a bike station and a bike infrastructure was currently designed. A small fleet of electrically assisted bicycles was purchased for hire with support from the INTERREG programme (through Energy Challenge - a joint Republic of Ireland/ Northern Ireland initiative) and it was expected that these would be fully operational during the study period. Unfortunately the local Garda (Police) stopped their use because of a possible licensing infringement. A revision of the Irish law to enable their use is now in the course of being drafted by the Department of the Environment.

1.4.3 Public transport and ultra light tram options

Particular interest has been shown in the ultra light tram developed by the UK project partner Parry People Movers Ltd. The principal features of this system are its low infrastructure cost and unique flywheel energy storage. This low voltage system combined with regenerative braking results in a very low energy requirement (0.5-0.75kWh/km). If used as the only source of power, the flywheels need to be recharged at electrical supply points up to 2km apart which would be ideally suited to the system of energy storage envisaged. All-in-all it is an extremely environmentally friendly system being quiet running, emission free and requiring no overhead or underground cables on the street. This enables the tram system to be installed with minimal disruption and to run either on segregated rail or in traffic [9].

1.5. Sustainable mobility for Sligo

Sligo urgently needs a transport plan which will integrate infrastructure development with clean public transport and satisfy the mobility needs of its citizens in a sustainable manner.

The project studied the concept of an urban transit corridor based on the ultra light tram system outlined above. This would integrate with a small urban bus system using the *Rendezvous-concept* whereby arrival and departure times of buses are highly co-ordinated [10]. The public bus operator, Bus Éireann, has just initiated Sligo's first urban bus service which is a positive step and the railway station has been identified as an ideal interchange point making it the transport node for local, regional and national public transport.

Sligo is the only city in Ireland with no out-of-town shopping centre and all city centre shopping areas are within walking distance. A previous report identified city centre streets suitable for giving priority to public transport and pedestrians over the private car [11]. The transit corridor outlined above would incorporate all relevant types of mobility interchange such as: Park & Ride, bicycle to bus, train to tram, train to bicycle, tram to bicycle, etc.

1.6. Conclusions

The ALTENER study has indicated that there would be sufficient hydro-electricity to supply the intended mix of passenger electric transport vehicles in the urban environment of Sligo and there would be even a surplus, which could be sold. The Fisheries Department recognise that the ecology of the river would be improved by the rehabilitation of the lower weir and are in favour of the installation. The attractiveness of urban landscape would be increased.

2. Examination of the Renewable energy Production Potential

2.1 Research and Examination of existing data

The Garavogue River, which flows through Sligo, originates as the overflow of waters that flow into Lough Gill and it runs only 3km to terminate in Sligo Bay. Sligo Bay is on the Atlantic Ocean and is therefore tidal. The water in Lough Gill is used as the drinking water source for Sligo City and its hinterlands.
There are two places on the river in Sligo, at old mill sites, where the river falls more rapidly than its normal fall; these are located at what is known as the upper weir and the lower weir where the river enters Sligo Bay.

Investigations were carried out into the availability of data on the river. It was found that:

- a hydraulic study was carried out on the river in 1993 by the Department of Civil Engineering, University College, Cork. This study was primarily for use on the Upper Weir Rehabilitation so as to increase the water storage content of Lough Gill and facilitate the increasing demand for drinking water in Sligo. The study was mainly concerned with the effects that the raising of the weir would have on the flooding characteristics of the river; however, the findings of this study are also relevant for hydrology of the river associated with the installation of water turbines.

- the flows on the Garavogue river were recorded daily by the Department of the Environment (Station 3575) and were available for a 25 year period between 1966 and 1990. (See Annex for flows)

- the Connacht Regional Energy Planning Study states that the catchment area for the river system is 294 sq. km and the mean annual rainfall is 1394mm.

- the existing upper weir and the surrounding river bed had been surveyed by Jennings and O'Donavan & Partners for the construction of the new weir. (See the drawings in the Annex)

- as the lower weir was still the original weir since its construction in 1850. The information and drawings available in the county library was still relevant. (See the drawings in the Annex)

- The Department of marine fisheries service does not have details of levels on the river but stated that they would welcome the restoration of the lower weir at the Silver Swan Hotel. The reason for this is that it would enable the level of the river to be increased between the two weirs. This would provide water of sufficient depth to enable salmon to pass more rapidly up stream and avoid having to remain in a stressed condition in Sligo Bay until there was sufficient water in the river.

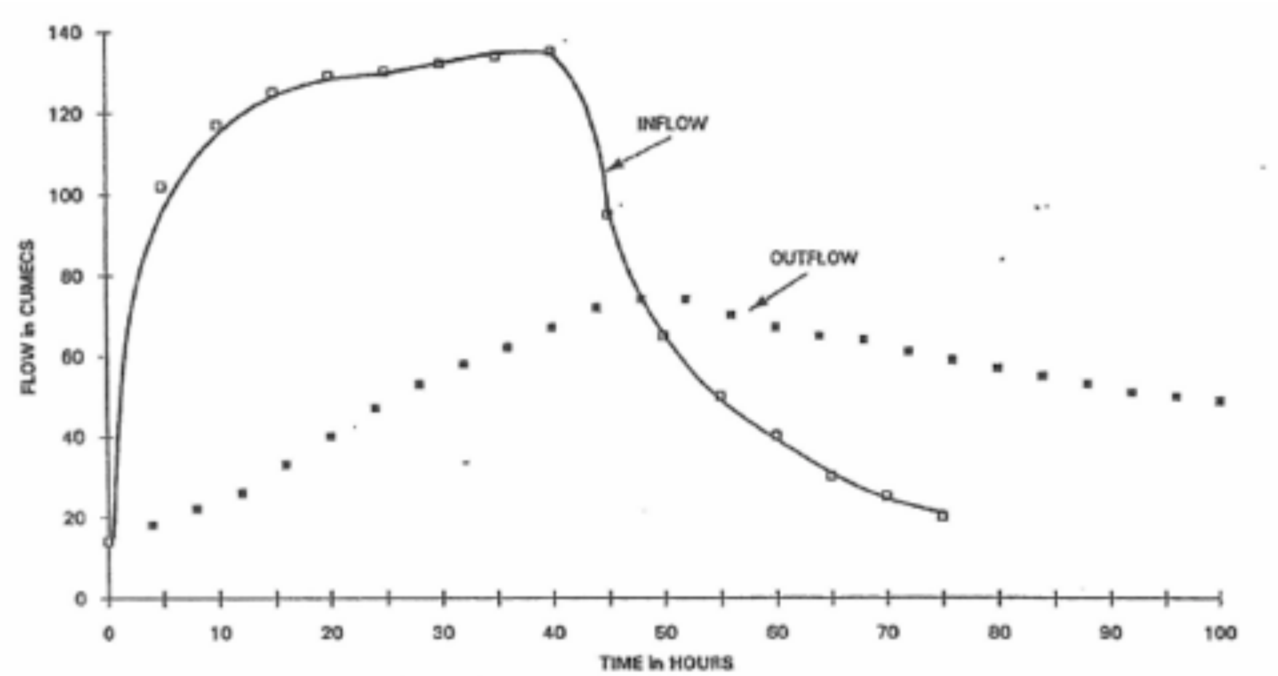
- The Sligo Harbour Commissioners publish the depth of high tides and have established a relationship between high water and low water, (see table in Annex). The lower weir is the boundary between the where the river becomes tidal.

- The survey of the upper weir undertaken by G.G. Bracken in 1981

The data collected from the above enabled the essential hydrology data on the river to be established:

Flow m^3/sec	Comment
4.0	Low flow
15.15	Annual Average Daily Flow AADF
55	2 year return period flood flow
66	5 year return period flood flow
82	20 year return period flood flow
108	100 year return period flood flow

Lough Gill acts as an accumulator by reducing the amplitude of the fluctuations between the periods when it rains and when it does not rain. This can be dramatically be seen in Figure which shows the inflow and out flow hydrographs during a flood in 1978.



Here there is a flow of over 120 m^3/sec into Lough Gill from its catchment area but the outflow into the Garavogue river is reduced to 60 m^3/sec but discharging this higher level for a much longer period. The Lough then acts to give a more even flow on the river, which is beneficial for the possible hydro installation.

The actual flow in the river is related to the level of Lough Gill and the level of the upper weir. A computer model was made of the relationship and tested by University College Cork. It showed that at flows up to 55 m^3/sec the control on the by way of the level of the upper weir.

As the river is a prime river for Atlantic salmon there is a requirement for adequate fish passes on the river. It has been determined by the fisheries department that the flow required on these passes is 3m m^3/sec. As already stated the fisheries have no objection to a hydro installation and would welcome the rehabilitation of the lower weir.

2.2 Potential turbine locations

There are two obvious potential locations for hydro installations which are associated with falls in the river and both are located at previous mill sites. These are known as the upper weir and the lower weir.

2.2.1 Upper weir

When the proposal to Altener was made in early 1998 the upper weir had not been renovated and Sligo Corporation had made it a condition of planning permission for the development of a new hotel that the intake culverts on the old mill must be retained. This was to ensure that the reinstatement of the site for water power would be possible at a later date. It was initially considered that this would be the most suitable site for a hydro installation.

In late 1998 work started on the rehabilitation of the upper weir as part of the scheme by Sligo County Council to increase the storage capacity of Lough Gill. In 1999 work started on the building of the hotel adjacent to the upper weir. This meant that when the site was inspected in early 1999 it was covered with builders' rubble and the intake culverts were not visible so further investigations of this site were suspended. However, after an inspection of the work on the renovation of the adjacent weir, it was obvious that Sligo County Council had carried out more work than was depicted on the drawings of the scheme. The tail races from the old mill had been demolished and flood gates had been installed in mass concrete at the exit to the culvert.

In early 2000, when all the building work had been completed and the site had been cleared, the site was revisited. It confirmed that the head available on this particular weir was much too low for economic exploitation. The potential to raise this weir by the use of an inflatable weir would be possible but it was considered that flood control conditions would restrict the potential increase in head in times of high flow. The costs of an inflatable weir on this rehabilitated weir structure greatly exceed any cost benefit from the hydro power derived from this site. It was therefore recommended that no development be carried out at this point in time.

2.2.2 Lower weir

The Lower weir originally diverted flow from the Garavogue River through the first two arches of Victoria Bridge to where the water entered a forebay before running into the intake channel and water wheel located within the meal and flour mill. The tail race discharged at Martins Quay to the sea. (See drawing in Annex). The original installation would have been subject to tidal level variations and variable outlets.

The site of the original meal and flour mill is now the Silver Swan Hotel and opportunities to develop the existing water course would not be feasible. However, it would be possible to restore the broken down weir at Victoria Bridge and still continue to use the first two eyes of Victoria Bridge as a water channel. A new channel would be created around the side to Martins Quay, breaking through the existing quay wall into the now disused mill tail race which exits into Sligo Bay and is tidal.

2.3 Site Head and Flow Conditions

Using the figures are taken from the Sligo Tide Tables and the information from the Harbour Board Commissioners, the maximum head available on the site on an average low tide would be 3.55m below the weir. However, the average high tide level is 1.05m below the weir giving a tidal variation of 2.5m.

The flow information for the hydrology of the river is already known. Based on this information and the restrictions of passing water under Victoria Bridge and through any potential channel or pipe to a new turbine location, it is estimated that the maximum flow for the sign point QT max should be 10 m^3. Given the tidal variation of 2.55m, the turbine output at 1.00m head would be 40kw - rising to 285kw @ 3.55m head

The existing Lower weir has been breeched over 50% of its length. Because of the close proximity of the river walk and shopping development adjacent to the weir structure, consideration must be given to the potential for flooding in this area if the weir were to be re-built. It is likely that a tilting flood gate would be required to be fitted into the upstream section of the weir above Victoria Bridge, to take care of the high flows experienced in the Garvoge River. Consideration also needs to be given to the water rights which are still vested with the owners of the site of the meal and flour mill, now the Silver Swan Hotel.

The simplest development of the new hydro scheme would, therefore, be to construct an open channel around the side of the Silver Swan Hotel, breaking through Martins Quay wall and constructing a new turbine building within the quay basin. Channel modeling and evaluation may have to be done to the down-stream tidal side of Victoria Bridge to assess if the reduction in cross-section would cause flooding to the Victoria Bridge area in times of high river flows and concurrent high tides.

To obtain the best kilowatt output from the site it would be necessary to install a double regulated axial flow turbine due to the variation in head and subsequent flow as a function of head. (See details in the Annex). It is expected that the total annual kilowatt output would be 900,000 kWh.

An estimate of the costs involved for the installation was obtained from Newmills Hydro, Antrim NI. Their estimated cost of the mechanical and electrical package for this project would be 445,000 EURO with civil costs in the region of 355,000 EURO making a total project cost of 800,000 EURO. This does not include the costs for professional fees in respect of the mechanical, electrical and civil design concepts an additional 8% should be added to these costs so the overall cost will be 864,000 EURO.

2.4 Control Strategy for turbine

The output of the hydro installation will vary and is dependent on the following:

- The hourly variation between high and low tide
- The lunar monthly variation in the absolute values of the high and low tides
- The flow of water of the river

As these are all natural phenomena there is very little that can be done to control them. The only possibility is that the new upper weir installation could be used to control the flow on the river in the lower flow situations. This could be achieved by the opening on the motorised gates being reduced at night to reduce the flow on the river and the opening of the gates being increased in the daytime. This would enable a greater daytime production output from the turbine and as the transport system would be mainly operated during the day, it would provide more power when it is required.

The electricity market in Ireland was deregulated in 1999. Energy provided from renewable generators could be supplied to all of the electricity market and not just large users. This was unexpected as it had not been carried out in any other area of the EU. This change in regulations has been such that the optimum method of distributing and supplying the generated electricity to the vehicles is now through the electrical grid network. This is because it enables existing electrical infrastructure to be used and obviates the need for considerable expenditure on a separate distribution system between the generator and the points of use. A licence is obtained from the Electricity Commission to generate electricity and the electricity produced is sold to a green supplier. A contract is then made with the green supplier for the consumption at the usage points. This means that the hydro generator is connected and supplies into the grid system. The grid is then used as a large buffer between the generation periods of the turbine and the periods of usage by the vehicles. The electricity requirement of the transport system is estimated at 428,842 kWh/year, there remains a surplus of 471,158 kWh which, because of being connected to the grid, means that this power can now be traded and provide additional income.
The need for an elaborate control and storage system to match the output from the generator to that of the use by the transport system, as was envisaged in the initial proposal, is obviated. However the cost is reflected in the price paid to the green supplier (because of the economies of scale, these will be much smaller than the provision of own storage).

2.5 Back up supply

As indicated above, the hydro site is envisaged to operate as a green generator in the new deregulated electricity market and will be connected to the grid. The charging points for the tram will also be connected to the grid at various locations along the track. There is no independent cabling between the generator and the charging points so it is impracticable to install a separate electricity supply at the generator. Also because, under the licence from the Electricity Regulator, it is not permitted to use a thermal source of electricity in place of electricity generated from a green source. The back electricity supply, will, therefore, be provided by other green electricity producers. Back up electricity could be provided at each charging point for the tram by the use of batteries but the cost of providing and maintaining these units could not be justified by the relatively infrequent outages in the grid system. The electric bikes and the electric bus use batteries, which are mainly recharged overnight. Therefore a back up for these is not warranted.

2.6 Costs of energy and economics

Based on average displaced energy cost of 0.1 Euro/kWh, an annual revenue from the site of 90,000 Euro per year. It is obvious from these figures that without further financial assistance the project would not be economically viable. However, other benefits will be derived as a result of the construction of the hydro-electric scheme:

- Additional works to the weir and improvement of the fish pass and regulation of the flow will improve the fishery.

- An improved tourist attraction would be created by the retention of a pool between the two weirs in Summer when the river level usually falls (not to mention the visual aspects of a newly installed weir and flood control gate)
- The combination with a clean transport system will reinforce the PR image of sustainability for Sligo

It is expected that these additional benefits will be more than the direct benefit of the annual revenue therefore increasing substantially the prospects of the project being carried out.

3 Sligo: Urban Development and Transport

3.1 The situation 2001

3.1.1 Introduction: Urban generated Population

Sligo City is the ninth largest regional urban centre in the Republic of Ireland with a current population of approximately 17,786 (1996). The city is serving a large rural space with the next large regional centres - Galway and Derry - approx. 150 km or 2 hours' car drive away. The density of population in the three electoral districts of the Borough of Sligo is assessed at over 3,000 residents per sqkm. Due to the geographic boundaries - ocean, lakes and mountains - the main residential development areas are mainly situated north and south of the borough, with two seaside resorts west of the town. They show a population density of between 30 -300 res./per sqkm while large areas of Sligo's hinterland are showing a population down to 8 res./sqkm and less. The average population density of County Sligo in 1996 has been 28 res. / sqkm while the average population density in the Republic has been 49 res. / sqkm.

1. Motive: Co. Sligo: Residential Density; Source: Baseline Data Report 1996

Due to the attractiveness of Sligo's environs and hinterland - coastline and mountain areas - Sligo has experienced severe urban diffusion over the last decades. Figures until 1986 are showing higher increases of population in Sligo's surrounding districts than in the borough area. Today much of the urban-generated population of Sligo is residing in the surrounding countryside. People are commuting to Sligo for work and services over a distance of 5 to over 15 km. Figures compiled by Sligo County Council are showing that today 60,000 people are living within a 30 min. driving distance to Sligo City, and 170,000 people in a distance of up to 60 minutes' drive.

The daytime population (residents within the Borough of Sligo and commuting population in employment, shoppers and service customers) has been assessed at 36,769 people in 1986. It is expected that the daytime population in 2001 is larger than 40,000 people.
The Fitzgerald Report, June 1999, demonstrates the very high average commuting distances to Sligo as the longest distances of all urban centres in the Republic. Compared with the national average figure, Sligo's employees are travelling higher distances daily.

These circumstances of low density in population combined with long daily travelling distances must be seen as enormous obstacles to a sustainable regional transport solution which requires an integrated transport model favouring public transport and low energy solutions.

3.1.2 Regional Development and Transport Planning

The Irish National Development Plan 2000-2006 is addressing Sligo as one focal place of the "Border, Midlands and Western Region" and as an urban growth centre with an estimated increase in residential population to between 40,000 and 50,000 people until 2020. The exact positioning of Sligo in the framework of Ireland's central places and strategic transport investments will be made more feasible by the implementation of the "National Spatial Strategy" under the National Development Plan 2000-2006, to be expected until the end of 2001.

The elements of sustainable transport concepts are addressed also in the “National Climate Change Strategy”, October 2000, outlining among other measurements investment and better integration in regional public transport, as well as the integration between land use and public transport. Specific programmes and targets for the reduction of CO_2 are not outlined yet.

The current Development Plan for the County of Sligo (1998) is outlining in its chapter “Settlement Strategy Policy” the need for strengthening of existing towns and villages. It is encouraging to urban development in villages within a short commuting distance to Sligo to ”...enable them to retain an identity separate from Sligo Town”.

The “Roads and Transportation Policy” of this Development Plan is addressing in detail the National Road enhancements under the “Operational Programme on Pheripherality 1994-1998” as well as improvements of regional roads. Public transport is mentioned in five lines under “Rail Links”. Local and regional public transport as well as cycling is not addressed in the development plan.

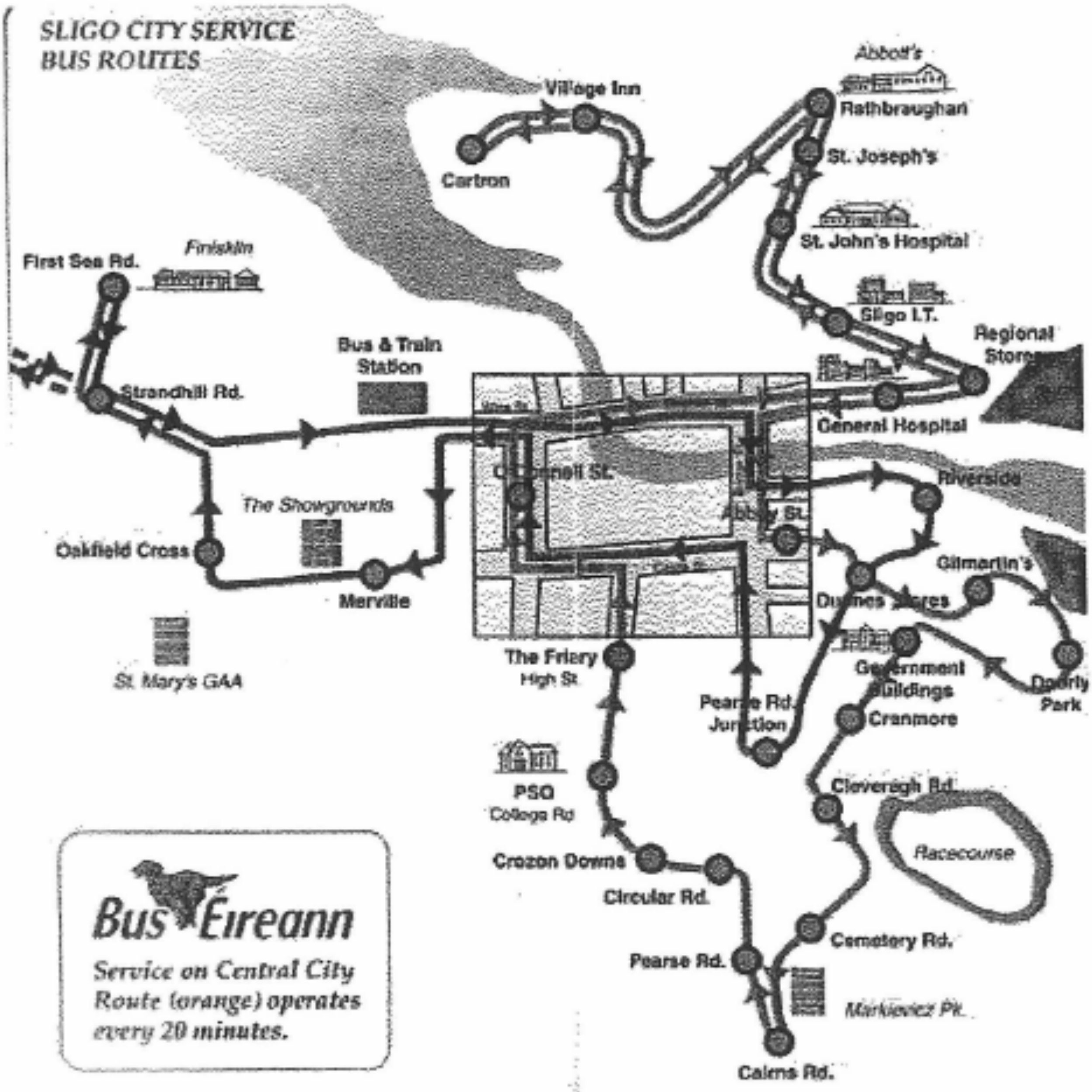
The “Sligo City Development Plan 1992-1997” has to date not been renewed and is still valid. Careful attention had been given in this plan to the construction of new roads and the reorganisation of car traffic access and circulation within the Borough. No concept has been put forward to the county’s and town’s public transport and its requirements for infrastructure. The most important point of interchange of public transport of the Northwest, the Sligo Railway and Bus Station, is not mentioned in this plan.

3.1.3 The existing urban means of transport

Walking: No priority is given to pedestrians in the town centre and conditions in the surrounding districts are not satisfying. It is hoped that the construction of the “Sligo Inner Relief Road” and future’s concentration of car traffic at the relief road will allow for a pedestrianisation of parts of the shopping streets.

Cycling: Sligo’s only cycling lane has been built north of the river Garavogue close to the Institute for Technology at Ash Lane. The lane is not accepted by cyclists due to extremely dangerous discharging at both ends into a traffic junction and urban roundabout. There are no public bike stands in Sligo.
The town centre is quite flat and feasible east - west cycling links and routes can be identified. North and south of the centre the surrounding hills are showing gradients of more than 10 % which are limiting the daily use of the ordinary bike.

Buses: The inter-urban bus services have their terminus at the Railway/Bus Station, they are well used and acceptably priced. Local bus services of Bus Eireann received a boost with the arrival of a small fleet of Impact-Buses, which allowed for the opening of two new urban bus routes. However, the limited financial resources did not allow for a full utilisation of the Railway and Bus Station by upgrading them to be core place for the point of interchange between all bus routes and railway services.



Map of Bus Eireann on Sligo local services

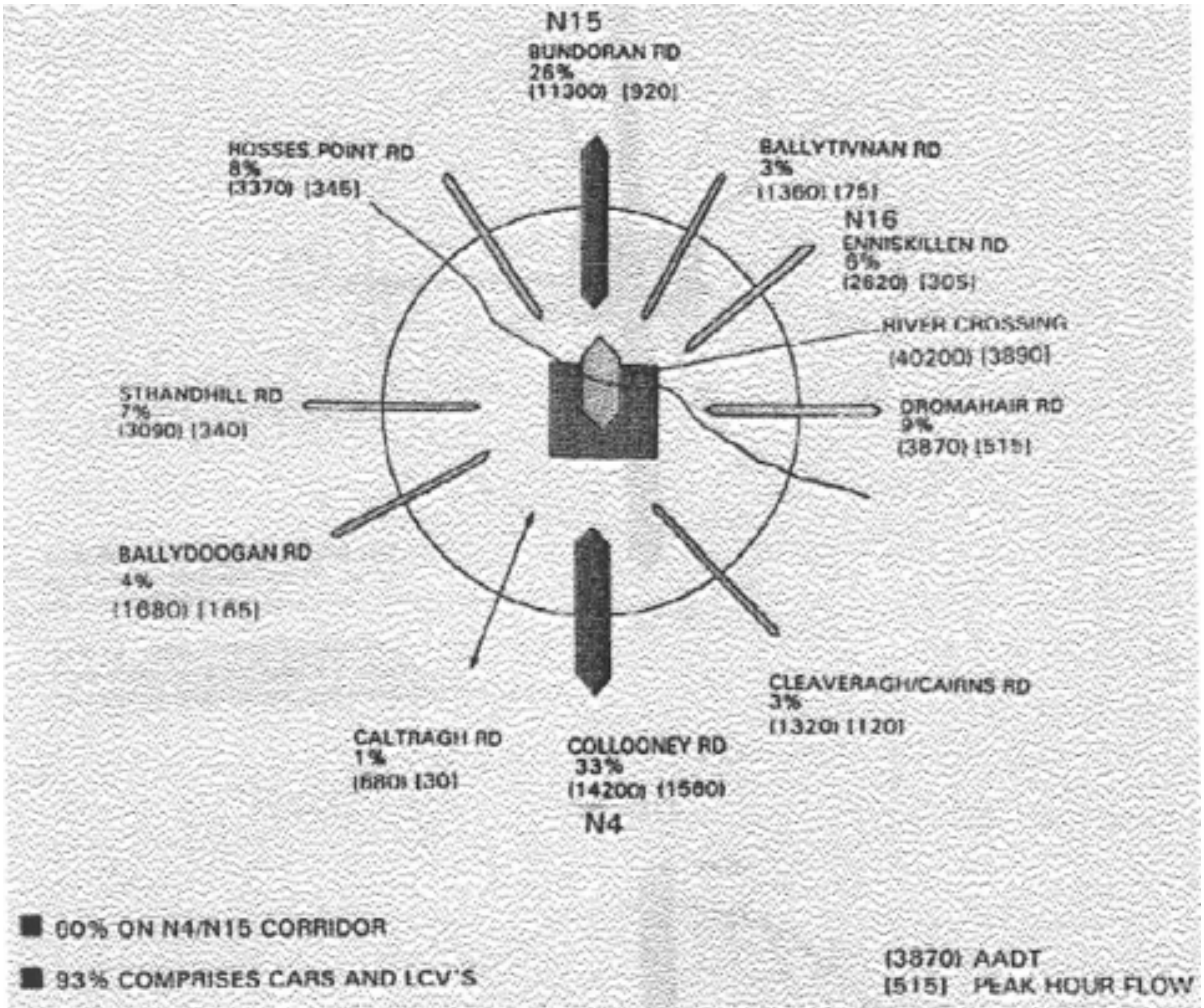
Rail / Sligo Railway Station: The commitment to the survival and more economic viability of the railway line as the backbone of public transport has given encouragement to local promoters and operators of public transport. Iarnod Eireann, the Irish public provider of train services, is currently concentrating its resources on track renewals on the Intercity train service between Sligo and Dublin. Three train connections are offered daily.

There is a disused regional rail network between Sligo and Galway. One essential to bring this network back into service the increased attractiveness of all points of interchange, i.e. railway stations and -stops.

Modes of local transport beside bus transport, pedestrians access, cycling and taxi services are not organised yet in an attractive manner at the station.

Taxis: Sligo Corporation has licensed 68 taxis and 18 hackneys. Because of low coverage areas of the urban bus services for many people the taxis are a useful alternative to the car, more than buses. The main taxi stand is at Quay Street in opposite of the Sligo City Hall, where a change to other modes of motorised transport is not possible.

Roads: The road system is of mixed quality. Due to its key geographic location between Northern Ireland and the West of Ireland all traffic corridors and routes are affecting Sligo, its environs and its lands for urban growth. The lack of a National Road Bypass is guiding all national and regional passenger and goods traffic through Sligo's built-up areas dating back to the 19th century and through the town centre, conflicting with local needs.
Car traffic congestion has grown already over the last years to such an extend that at off-peak time it can take up to 30 minutes to traverse the 3km city area, while at peak time this can take up to one hour. A traffic survey was carried out 1993, which showed that 85% of the destinations for the people were in the city including its peripheral residential and employment areas, while approx. 45% of the people had destinations in the city centre. The report shows strongest figures on AADT and peak hour traffic flow (60%) at the main entries into the Corporation area north (N15) and south (N4) of Sligo.



1993 TWO-WAY AADT FLOWS CROSSING THE BOROUGH BOUNDARY

Freight: Regional freight is largely organised by roads. A rail container terminal has been installed at the Sligo harbour area, in close vicinity to the Finisklin Industial Estate but also in short distance to the existing town centre. Sligo has the infrastructure for rail based freight transport, as well as sea transport, available if competitive pricing can be achieved.

3.1.4 The N4 Sligo Inner Relief Route

The central road project under the current development plans must be seen in connection with the intention to construct a main national strategic road corridor through Sligo. Due to its key geographic location between Northern Ireland and the West of Ireland, all traffic corridors and routes are affecting Sligo, its environs and its lands for urban growth.
Both local authorities decided the realignment of this road corridor (N4 to N15 and N16) but to retain local, regional and national car traffic in Sligo's built-up environment of the 19th century. The proposed alignment is separating the historic and commercial core from the Sligo Railway and Bus Station.

Objections to this road project by Sligo's residents resulted in an order of the Minister for the Environment in 1993 to establish a new "Sligo Traffic and Transportation Study". An interim report, including an "Environmental Impact Statement of the preferred Relief Road Option" (12), was published in August 1995. The examination of all routes in the strategic road corridor and their implications for Sligo did not include their consequences or limitations on public transport. A cycling network was not addressed in this transport study.

Renewed objections by Sligo's residents, the disapproval of newly elected Borough Councillors (1998) of the road concept stated publicly as well as rising concerns of Sligo's business community were guiding the Minister for the Environment to order a Public Enquiry into the N4 realignment in the Sligo County and Town Borough area. This Public Enquiry took place in June 1999. Environmental Impact Statements on the chosen route for the N4 for both the County and Borough area were prepared for the Public Enquiry with reference to the EU Regulations on Environmental Impact Assessments. Both statements were focusing on car- born traffic; the transport node of Sligo Railway and Bus Station, local public transport and cycling infrastructure were not examined.

The representative of the planning group, Mr. Tom Lyons of McCarthy Partners, had been questioned during the Public Enquiry on the needs of the strengthening of public transport as an essential for a sustainable regional and local development. The essence of his answer demonstrated the priorities of road engineering: "Access by car to the Railway and Bus Station of Sligo from the Inner Relief Road will be easy."

In his report to the Minister for the Environment the Road Inspector chairing the Public Enquiry enlarged on this view (13). He outlines that "One cannot favour a particular mode of transport for a town without a detailed examination, including costing" (14) but he does not report on the lack of concepts on alternative means of transport. Elements of an integrated transport model incl. P&R facilities are mentioned in his report, but not seen as feasible by him or relevant for the decision on the N4 Inner Relief Road.
Based on the report on the Public Enquiry the Minister for the Environment, Mr. Noel Dempsey, approved both EIS and the construction of the N4 Inner Relief Road in August 2000 with minor design changes.

.5 The Sligo Town Centre Partnership

The partnership, established in 1998, consists of 22 local shops, enterprises and investors in Sligo town who raised concerns about the quality of urban life in Sligo and the commercial success of Sligo's town centre caused by further urban diffusion and out-of-town shopping proposals. It is a member of the "Association of Town Centre Management (ATCM)", London. The group is committed to helping develop Sligo into the regional growth centre in partnership with towns in Northern Ireland, where eleven groups have already been established (in the year 2000).

The Sligo Town Centre Partnership found it essential to take part in developing the quality of Sligo City by promoting the many various design possibilities of integrated transport solutions at Railway stations. These designs have contributed to an urban revival in European towns and the European Commission supports them. The group is guided by the transport policy of the ATCM, which has been one key element for the revitalisation of several towns and cities in the UK (15). A report by the group's spokesperson, who is also co-author of this report, had been sanctioned by the group and published in March 1999 (16).

Based on this report this "Altener" project team has carried out a design study on the enhancement of the transport node in Sligo at the Railway station. Strongly increased capacities for public transport, new taxi facilities, a Bike Station proposal and careful attention to the design of all places of interchange are key elements of the study.

Motive 4:Proposed Reorganisation of Sligo Transport Node

3.1.6 Consideration for a feasibility study under the "ALTENER" programme

Sligo Corporation is considering its approach to the contradictions described above and is anxious to create awareness of the aspects of sustainable mobility in Sligo. The exceptionally high need for daily travel of Sligo's population, the very high needs for fossil fuel imports per capita into the region, have stimulated an examination of the traffic situation combined with the energy aspects and provisions.

With this objective in mind it co-operated with the Sligo Town Centre Partnership to secure ALTENER funding to carry out a feasibility study into sustainable traffic solutions in the rapidly growing City of Sligo. The study intends to demonstrate significantly reduced energy needs of an enhanced urban transport model. Better efficiency of urban transport and more integration of public transport should encourage Sligo's citizens to utilise public transport and non-motorised means of transport.

3.2 Urban Structures

3.2.1 Sligo Town: Urban Footprint / Town Centre

Sligo Borough has a circular shape with a diameter of 4.03 km (2.5 miles) and its centre at the historic core of Market Street. It covers an area of 1272 ha (including river, harbour and tidal areas), with a population of 17786 in 1996. The town and its centre are divided by the Garavogue river, which runs through the built-up area in east - west direction. Due to geographic and topographic limitations - the ocean, Lough Gill, mountains - the main areas of urban growth are situated north and south outside the town boundaries. The extension of the boundaries is to include the urban generated population and areas served by the town's infrastructure.
Until today the historic town centre has retained its outstanding centrality in regional trade. Intensive public consultation has taken place since 1998 to achieve a balanced development between commercial and community interests (17). Sligo's main parties share the view that new regional shopping centres should be established exclusively in the town centre. Two larger shopping developments are under construction or drafted and a "Centre Block Masterplan for Sligo is currently finalised by the National Building Agency. Both developments are located in less than 5 minutes walking distance from the Railway– and Bus Station.
An almost square frame of four streets defines the core of the town centre with the River Garavogue running diagonally through this area. Beside O'Connell Street, which is the commercial centre of Sligo, this square consists of Stephen Street, Thomas Street and Castle Street. A solution for local public transport in Sligo will utilise one or some of these streets because Stephen Street and Thomas Street are crossing Garavogue River.

3.2.2 Structures of Density

The analysis of Sligo's central position in the region depends on findings on the spatial distribution, the density and mixture of residential and employment areas and their comparison with competing central urban places. The Central Statistic Office only can provide statistical data on the electoral districts, i.e. the main three districts of the Borough. Statistics and comparisons of the townlands of the Borough are not available.

The following residential densities are assumed:

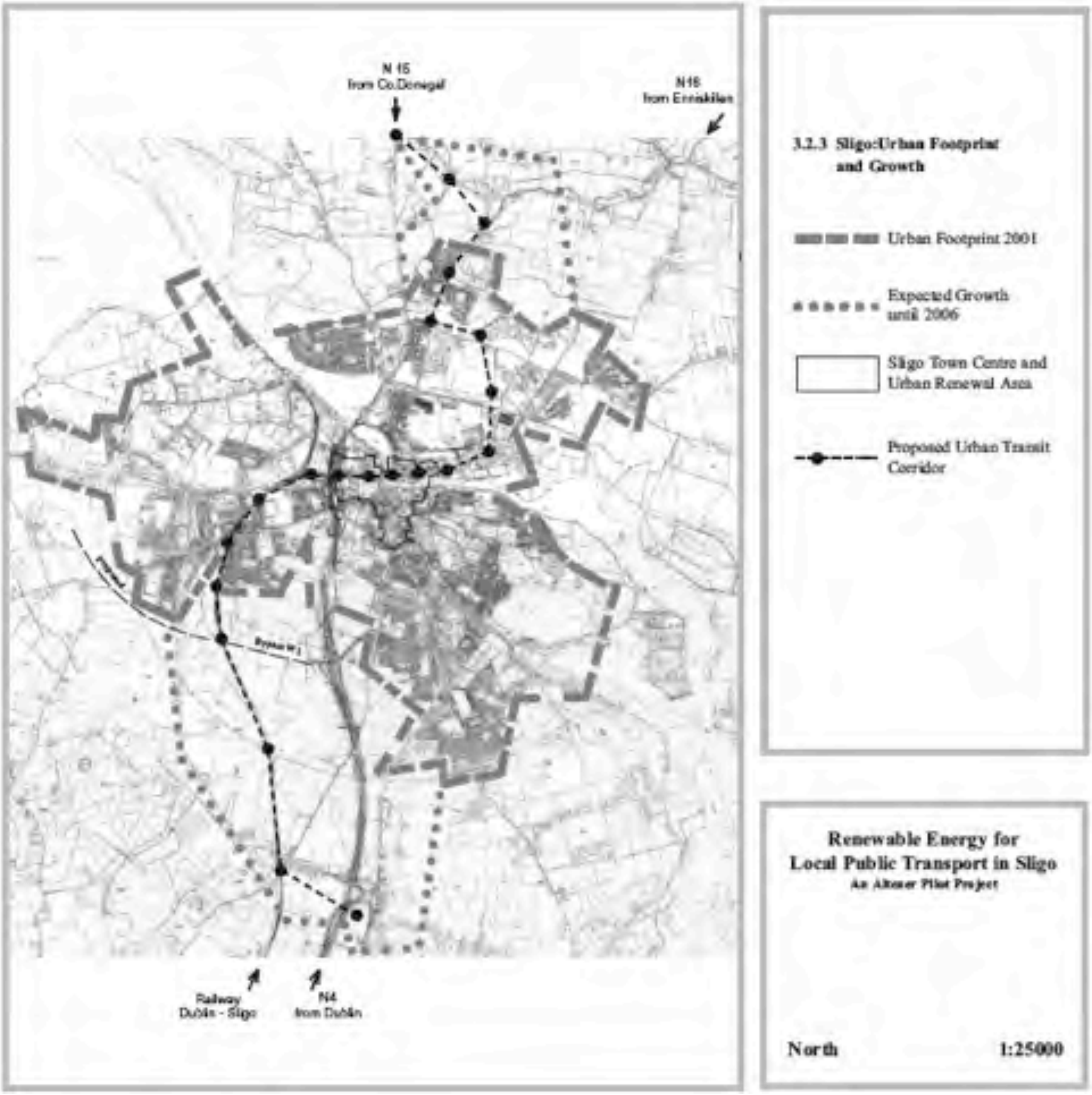
Sligo's historic town centre has been built with a housing density of approx. 40 to 50 dwellings per hectare,
-- Residential areas built over the last thirty years mainly have a density of approx. 15 dwellings per hectare,
-- The urban spread of residential buildings outside areas specified by the city development plan shows densities down to less than 1/2 dwelling per hectare.
-- New residential areas are planned with approx. 30 dwellings per hectare, while the current national guidelines on housing density are recommending 40 dwellings per hectare.

The success of local public transport depends on a high attractiveness to users like residents and employees. In the interest of short walking distances to the stops of public transport vehicles the housing density within the route corridors must be significantly increased.
It is recommended that public transport is serving urban areas with a population density of more than 200 residents / ha. With Sligo's average household size of 3.2 residents it is advisable that planning for new residential areas will specify over 60 households / ha.

3.2.3 Projected Growth

Today Sligo Corporation can only confirm intentions or figures for residential urban growth for a period of five years. The following main expansion areas are planned:

-- The increase in the population of the village / place of Rosses Point and Ballincar of between 5000 and 8000 residents,
-- New residential areas at Lisnalurg north of the borough boundary with 2000 to 3000 residents,
-- New residential areas at Caltragh inside the boundaries south of the town centre with 3000 inhabitants (already planned in 1992-97 City Development Plan),
-- New residential areas at Carraroe south of the boundaries with up to 8000 residents,
-- A new industrial area at Caltragh, inside the boundaries south west of the town centre.



Map: Urban Footprint and Growth

3.2.4 The need for a Transport Node

Sligo Corporation is aware that the transportation requirements of the rapidly growing city need a multi-modal approach. The priorities of the new transport system can be described as follows:

-- To secure the environmental qualities of the town and region,
-- To achieve a flexible transport system with high capacity,
-- To contribute to sustainable regional development by reducing the import of fossil burn material into the region,
-- To offer an attractive, seamless local and regional system of public transport,
-- To encourage non-motorised modes of transport: walking and cycling.

With the development of Sligo to the regional distribution centre of the Northwest the elements of local transport infrastructure are also basic assets for a regional transport infrastructure. The Sligo Railway and Bus station must be seen as the most important and crucial place between Derry and Galway, for the creation of an integrated transport solution considering lower energy input.

Studies of the University College Dublin, Dept. of Planning (18) and the Sligo Town Centre Partnership (19) already have addressed the integration and design options for efficient interchange between all modes of transport at the Sligo Railway Station.

3.3 Proposal of Urban Transit Corridor / Light Tram

3.3.1 Concept of North South main Transport Corridor

Sligo Railway and Bus Station is located west of the town centre. The town's core of trading and service activities, O'Connell Street, is located within 5 minutes' walk; the entire town centre can be accessed in less than 12 minutes on foot.
With the main expansion areas of Sligo situated north and south of the city, and a local consensus for the retention of a strong, compact town centre, it is tempting to examine the feasibility of a north south urban transit corridor as the backbone of regional transport facilities.

Key elements of an urban transit corridor for public transport would be:

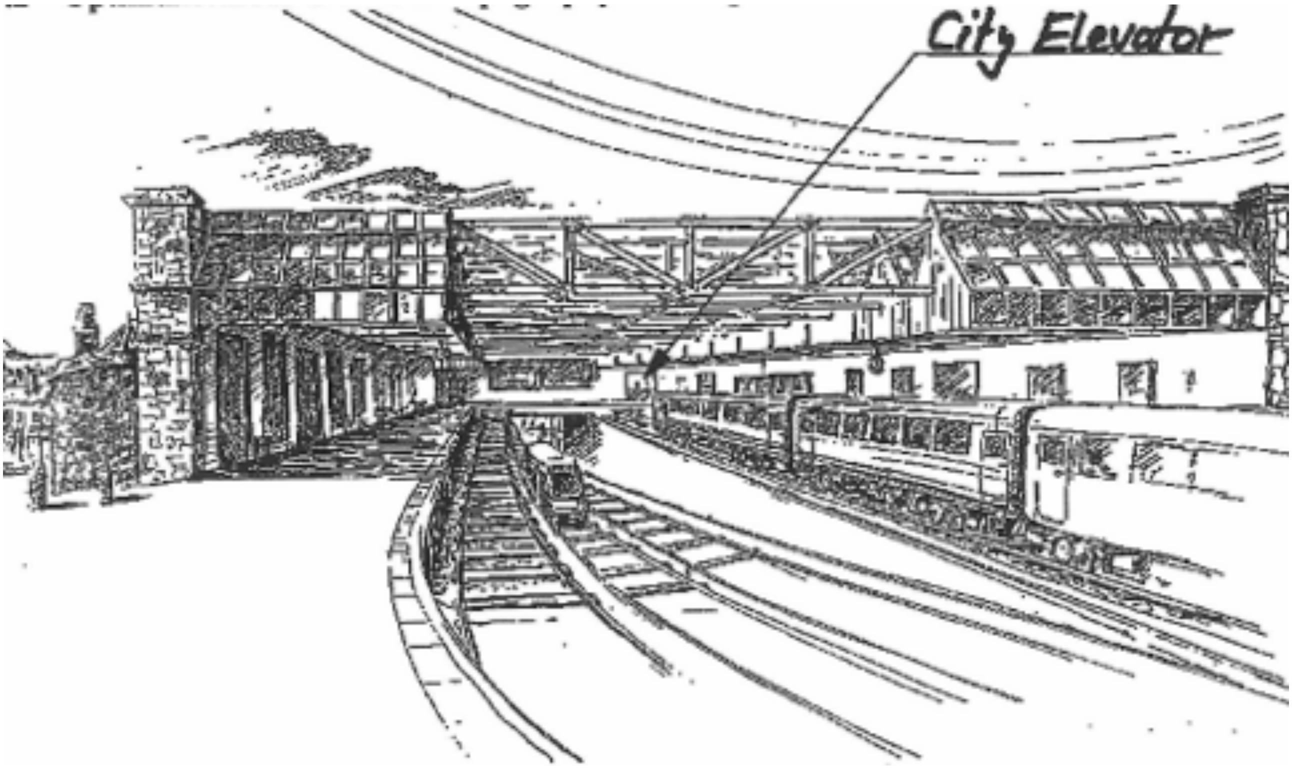
-- The Sligo Railway and Bus station to be strengthened as the central point of interchange between national and regional / local transport.
-- The corridor to be integrated with the regional road network by means of two large P&R facilities at both ends, north and south, with several other transfer points between car and public transport,
-- The corridor should provide points of interchange for urban bus routes crossing the corridor,
-- The corridor should facilitate the needs of cyclists with a suitable design for the points of interchange and by integrating a local system of cycling routes.
-- The rolling stock of the transit corridor - buses or trams - should provide a quality, high frequency service.

The inspections of Sligo's urban areas carried out by the Sligo Town Centre Parnership and Sligo Borough engineers have shown that optimum benefits and capacities of such a corridor would be achieved with a routing between Carraroe south and Bundoran Road north of the city.

Any bus route for this urban transit corridor would mainly utilise the existing and new radial streets of Sligo, conflicting with the needs of cars at many crossroads. The design speed of this urban bus system would only be at a maximum of 15 km/h.

First inspections have shown that Sligo's existing rail infrastructure and street arrangements would be ideal for a rail based transport axis with a small tram system providing urban services. The low space requirements by a two-track, narrow gauge tram system allow for the utilisation of CIE's existing dual railway tracks, as well as for the utilisation of lands owned by Sligo's public bodies and services. The design speed of an urban tram system is seen as feasible at over 20 km/h. This average speed can only be achieved if larger segments of the tram route can be segregated from car traffic. Priority must be given to the tram and public transport in general in streets of the city centre.

3.3.2 Optimum Route of Tram: Topography and Regional Intermodality



Motive 5: Tram ramp inside Railway Station

The route, which looks most central for a tram based urban transit corridor in Sligo, consists of three route sections:

From the southern end at Carraroe one of the two existing railway tracks into Sligo railway station could be utilized exclusively for the urban needs of Sligo. A single-track tram route without loops would reduce the capacity of the system. A frequency of 12 minutes can be achieved if the tram system is extended to Caltragh with one track only.

- The low gradient of the track at 1% would be ideal for a light tram system. A dual track ramp in the center of the railway station would allow for a tram connection between the traditional railway track and the urban streetscape at Wine Street. The discussed Light Tram rolling stock will allow for gradients up to 7 –8% over short distances.

- The inner urban section of the tram route consists of Wine Street, Stephen Street and the Mall, with the crossing of Garavogue River in the center of the city. The findings and recommendations of the "Sligo Traffic and Transportation Study", indicate that these streets can be taken out of the traffic circulation. Street gradients in this section are below 5%.

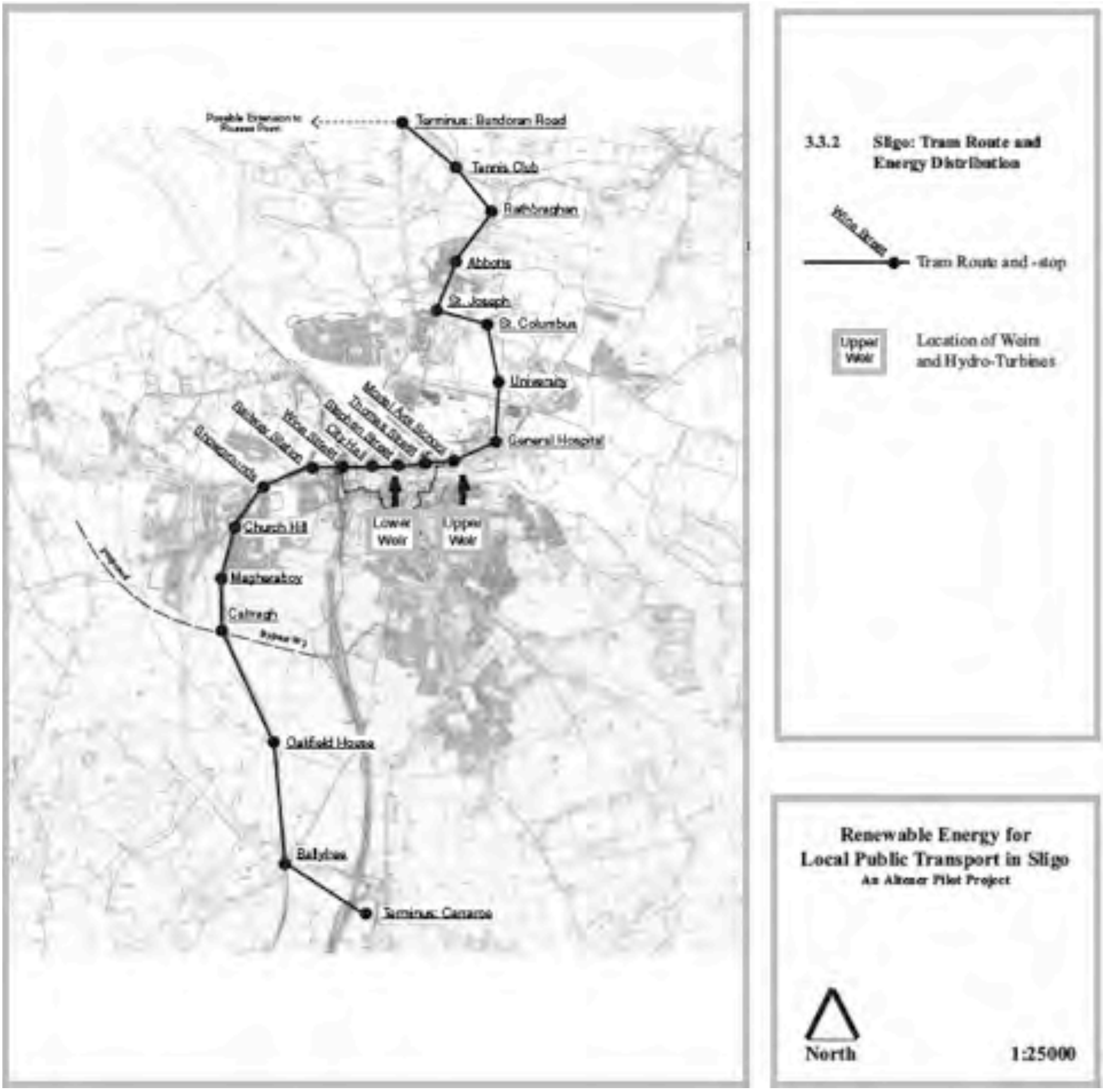
- The northern section starts at the Sligo General Hospital where the parking facilities along the Mall can be used for the tram track. The low noise created by the tram (below 65 dezibel) (20) and its restriction to daytime operation will allow for a route close to the buildings of the General Hospital.

- A small road bridge over the tramline will be needed to secure easy access for cars and pedestrians to the main entrance of the hospital. The green areas and parking areas north of the main entrance are suitable for the track alignment towards Ash Lane.
- A light rail bridge will cross Ash Lane, with an embankment needed at the grounds of the Institute of Technology. The route continues to the grounds of Sligo's old mental hospital where the route turns west until it reaches Ballytivnan and the old Bundoran road. This road shows only light internal traffic. Access solutions to one large company (Abbotts) would have to be co-ordinated with the needs of tram transport.
  The northern section ends at the N 15 to Bundoran where a P&R facility would be installed.

Light Tram Sligo: Route Alignment

Tram Stop		Distance (total appr. 7700 m)	Max. Gradient	P&R	B&R	B&R Charging	Bus Link
1.	Carraroe	600m	1%	x		x	x
2.	Ballyfree	600m	1%		x		
3.	Caltragh	400m	1%	x			
4.	Magheraboy	550m	1%		x		
5. x	Church Hill	550m	1%	x	x		
6.	Railway Station	450m	7%			x	x
7.	Wine Street	200m	3%				
8.	City Hall	250m	3%				x
9.	Stephen Street	200m	3%				
10.	Thomas Street	250m	5%			x	x
11.	Model Arts School	350m	5%				
12.	General Hospital	550m	5%				
13.	University	450m	5%	x		x	x
14.	St. Columbus	450m	3%		x		
15.	St. Joseph	450m	3%		x		
16.	Abbotts	500m	3%			x	

17.	Rathbraghan	500m	5%			x
18.	Tennis Club	450m	3%			
19.	Bundoran Road			x	x	x



Map of Tram Corridor: Topography and Construction

3.3.4 **Proposed location of new residential/ employment areas along the corridor**

The new residential and employment areas planned by Sligo Corporation mentioned in this report under "2.2.3 Projected Growth" are situated within 10 minutes’ walking distance from the urban transit corridor. The new residential areas at Rosses Point and Ballincar could be served by an extension of the tramline from the N15 to the Roses Point road.

3.3.4 Optimum points of interchange along the corridor: Park and Ride

At both ends of the corridor Park & Ride facilities should be provided, each with a minimum capacity of 200 spaces. The points of interchange at the Old Bundoran Road, Ash Lane, the Railway Station and Church Hill, all within the built-up area, are suitable for smaller car parking facilities. A larger P&R facility will be suitable at Caltragh close to the planned Caltragh road interchange between the N4 and the W2 Sligo Western Bypass.

3.3.5 Covered Areas of Tram Corridor: Time Zones by Walking, Cycling, Bus and Car

Walking: Urban bus systems are seen as attractive if the walking distance from place of residence to the bus stop does not exceed 250m or 5 min. walk. Successful tram systems demonstrate that this can be increased by implementing a high- frequency timetable. It is assumed that citizen living up to 400m or 8 min. walk away would accept this distance to the Sligo tram stops.

Tram Stops: Walking access of less than 400 m can generally be secured if the distance between single tram stops is no more than 300m . With the high density of destinations in Sligo's town centre and shoppers' needs it is recommended to reduce distances between stops to around 200m.

The proposed tram stops have been located with a view to giving priority to local employment, services, shopping as well as to the highest residential density.

Bus, Car & Taxi, Cycling: The tram corridor can be reached by these transport modes from all built-up areas of Sligo City and its closer environs within ten minutes. This concept is especially important for the daily transport of secondary school attendants. Feasible access to the tram stops, combined with safe walking conditions from the tram stops to the Sligo schools, will encourage parents to accept the tram system for their daily needs.

3.3.6 Access from Tram by Eight Minutes Walk

3.3.6.1 Coverage of Town Centre

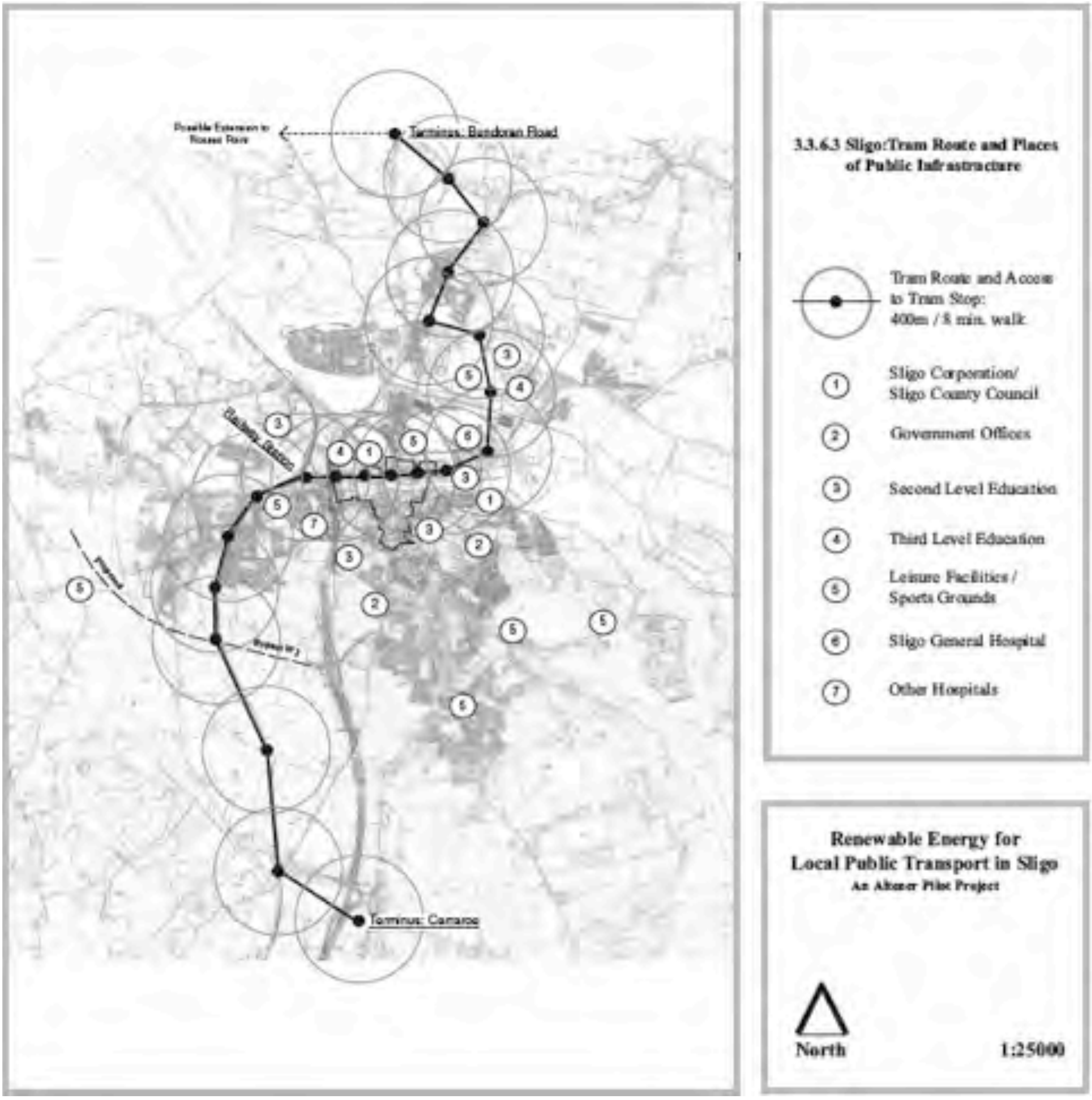
The boundaries of Sligo's town centre are outlined in the City Development Plan 1992. Approx. 95% of its area is situated within 8 minutes' walking distance from the tram stops.

3.3.6.2 Walking Distances to Places of Public Infrastructure

The City Hall at Quay Street is located one minute's walk from the tram, as are the engineering offices of Sligo Corporation. The County Council offices can be reached in 5 minutes using the pedestrian bridge at Riverside. The main government buildings - the Dept. for Social Services, the Tax Office etc. - are situated outside the tram corridor.

Sligo has five secondary schools, of which two are within 2 minutes' walk and the remaining three schools in around 10 minutes. All departments of the Third Level Colleges of Sligo, the VEC at Quay Street and the Institute of Technology (IT), are situated under 3 minutes walk from the tram. The central training premises of FAS at Ballytivnan can be reached by 10 minutes walk. Two of Sligo's seven large Sport Facilities, the Sligo Showgrounds and the Community Grounds at Ballytivnan, can be reached by a 3 minute walk.

The tram stops at the main entrance of Sligo's General Hospital. The second, St. Josephs Hospital, can be reached by an 8 minute walk. Places of Cultural Interest: The tram runs opposite the Model Arts School and the W.B. Yeats Building. The Abbey Theater is 8 minutes walk away from the tram.

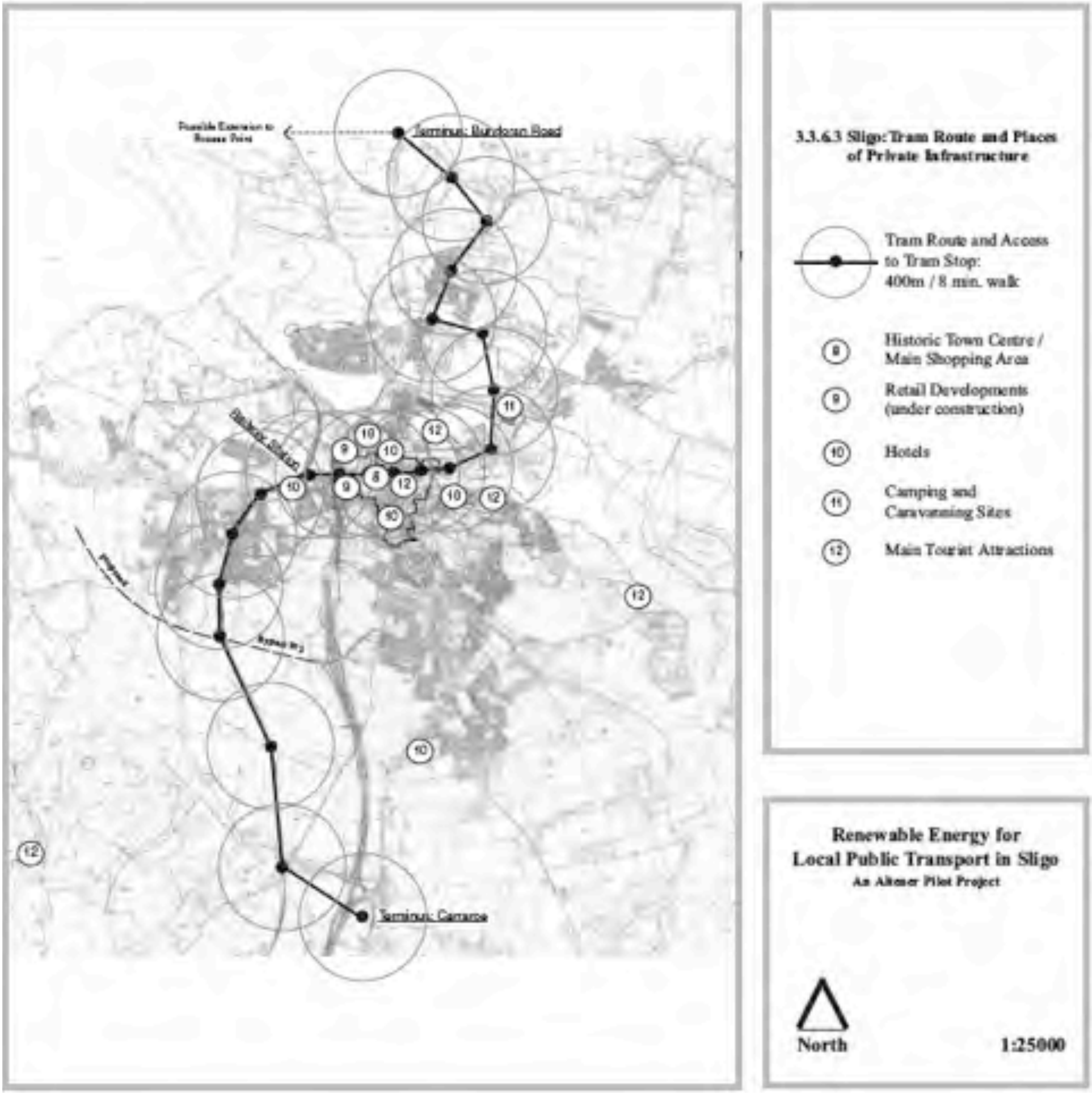


Map: Tram and Location of Public Infrastructur

3.3.6.3 Walking Distances to Private Infrastructure

The traditional shopping streets of Castle Street, Market Street and High Street are 5 minutes walk away. Both new regional shopping complexes, the Buttermarket and Wine Street development, can be reached in less than two minutes from the tram.

Three of five hotels in Sligo are situated within the 8- minute corridor. Sligo' only Camping and Caravanning Site at Ballytivnan is situated beside the tramline at the Institute of Technology.



Map: Tram and Location of Private Infrastructure

3.3.6.4 Walking Distances to Main Areas of Employment

Distribution of Manufacturing: Sligo's two main Industrial Estates, The Finisklin and Cleveragh Industrial Estate, are situated outside the tram corridor, more than 10 minutes walk away. Four of the large employers in the county are situated in these industrial estates and one company is outside the borough boundary. Sligo's largest employer, "Abbott IRL" with 750 employees, is situated in Ballytivnan where the proposed tramline will stop at the main entrance. Sligo's fifteen medium sized companies are situated mainly in the two industrial estates.
Private Services: Employment in Sligo's urban area has been at 4875 in 1996. Financial and specialised services are situated mainly in the town centre and are well served by the tramline.

3.4 SLIGO URBAN TRANSIT CORRIDOR: LIGHT TRAM

3.4.1 The General Concept

To assume that growing prosperity in traditional towns will automatically be accompanied by at least equivalent growth in the use of the private motor car is to ignore the physical constraints of space needed for roads and car parks. The North American model of sprawling towns and cities in, for instance, California and Nevada has taken planning for the car to its logical conclusions. The huge parking lots and wide, 10 lane, boulevards connected by numerous space-consuming interchanges make it possible (generally) for journeys to be completed smoothly, stress-free but with other costs to society and to the environment.

European towns and cities can rarely be adapted to this model without wholesale demolition of valued clusters of public and private sector premises. The creation of new localities such as Milton Keynes in England follows the American model but even there traffic growth is causing problems.

Two European countries, Ireland and Great Britain, have seen the use of the motor car grow very rapidly and the associated pressure on road and parking space in traditional towns has begun to create stresses which other countries such as France, Switzerland, Holland and Germany have acted more quickly to avoid.

A once quiet shopping street in an Irish town, now overwhelmed by stationary and moving vehicles.

Where the problem of traffic has been 'solved' by wholesale demolition of traditional centres, the results have generally been adverse.

In the congested Irish street scene, apart from two vans delivering goods for the shops, all of the other vehicles' passengers could have been accommodated in a single public transport unit such as a bus or a tram. And, because it moves on after discharging its passengers, this vehicle would not have been in the street at all for 80 percent of the time.

The contrasting scene below, photographed on a rainy day in Freiburg, Germany, is one where one can expect the air to be cleaner, the task of crossing the road to be safer, and the journey into the town centre much quicker and less stressful than is the case in a typical Irish and British town.

A street in Freiburg, Germany where most workers and shoppers arrive and depart by tram or by bicycle.

Public transport when carefully planned can actually speed up journeys and reduce costly dependence on private motoring, even though (a seeming paradox) car ownership continues rising. The nationals of Switzerland and Germany own more cars per head of population than do the Irish and British but where it comes to routine, repeated journeys they use their cars less, out of choice, because they have an alternative which is acceptable.

The executive in charge of public relations of Freiburg's tram fleet, Herr Hildebrand, says that his company is toying with the idea that their publicity message could be based on the justifiable claim that journey by tram in Freiburg is 'quicker than by Porsche'.

3.4.2 Sligo: Changing Traffic Priorities

Local traffic in Sligo is building inexorably as prosperity puts car keys into the hands of more and more people and demographic trends lead to the adolescents reaching adulthood generally being car drivers while the majority of people reaching the end of their lifespan are not drivers. Like Freiburg, Sligo has a river passing through its centre crossed by several bridges, a railway station just outside the centre, and has an attractive commercial heart comprising historic buildings and modern pedestrianised alleyways linking narrow streets. But in Sligo the streets are crowded with vehicle traffic.

Like Freiburg, Sligo would be well served by discouraging car traffic for local journeys while introducing the use of trams. The feature which would make trams far more effective than existing bus services is the facility to run much of their alignments separate from the roads which are used by local and through traffic.

3.4.3 Main Characteristics of System

SLIGO LIGHT TRAMWAY

PROVISIONAL DATA

- **Length**: 8km including rail alignment
- **17 stops**:
  - 5 transfer bus-tram
  - 1 transfer train-tram
  - 2 park-and-ride areas (parking spaces)
- **Civil works**: 1 bridge and embankment and 1 elevated section/ramp
- **Rolling-stock**: 8 low floor vehicles + 2 spare
  Length: 8.0m width: 2.30m
  Capacity: 50 passengers (22 seats)
- **Commercial speed**: 22km/h
- **Frequency**: 6 min. Peak; 71/2 min. off-peak
- **Integrated tariff** with buses, trains, coaches, park-and-ride
- **Estimated ridership**: approx. 12,000 pass./day
- **Investment cost**: IR. £10 million or IR. £1.2/km

3.4.4 Prospect of Mixed Running on Main Railway Line

To approach Sligo from the south by means other than by road, it is natural to look at the wide clear corridors reserved for the inter city railway trains, only used for a tiny proportion of the working day.

Railway culture has traditionally fought against intrusions by any type of vehicle which is different from that of a railway train. A locomotive with carriages typically weighing several hundred tonnes, sometimes moving at over 60 miles per hour, this constituting a massive accumulation of energy. Collisions between road and rail vehicles on railway crossings usually result in the total demolition of the former. As a result railway authorities normally exercise a total ban on lighter vehicles using the railway in times of operating heavy rail services, fearing human error by those controlling use of the railway which might result in a train colliding with a lighter vehicle on the same line. This ban is only lifted when another organisation, such as a track maintenance organisation, is formally allowed to 'take possession' of the section of railway and normal operations are suspended.

German railways, however, have recently led the way towards a more accommodating system which makes it possible to run light vehicles on railway tracks which are only intermittently used by heavy rail services and are at other times lying idle. The pioneers of this approach are the operators of the trains and trams in the city of Karlsruhe. Here for the last five years it has been permitted to operate suburban services carefully separated by time from the heavy rail services which intermittently use the same line. Modern train protection systems make it safe to operate shared use railways.

After provision of additional boarding points along the railway, the authorities experienced a very large increase in passenger loads, comprising significant numbers of people who previously used their cars for the same journey.

In Britain, Railtrack, the company which controls the national rail network, has begun preparing for circumstances where they may permit light rail vehicles to operate on ‘Railtrack Infrastructure’ and this is already established on the Tyne and Wear Metro system.

Arising out of the international precedents, CIE may now be approached to ascertain whether they, in turn, may be prepared to consider shared use of the inter city railway line over the southern approaches to Sligo.

In the past there were double tracks leading as far south as Ballymote. If intensive light rail services were to be contemplated it would be desirable to reinstate the second ‘road’ so that services can run in both directions simultaneously.

3.4.5 Prospect of Using Road for Tramway Paths

While to the south of Sligo it may be possible to institute shared use of CIE rail infrastructure, in the urban centre it is inevitable that the trams would run along existing roads, after suitable traffic management measures have been applied.

Trams in Ireland originally ran in the centre of the Road creating hazards for alighting passengers when car traffic increased. Nowadays central running is more practical than before because stopping places can be protected by pedestrian crossings, traffic - light controlled at busy places. Where road side premises have no need to be served by delivery vehicles, the tracks can run alongside the kerbs making boarding at stops more convenient.

3.4.6 Revenue Expectations and Operating Costs

As a result of road improvements it will be some time before the build up of traffic slows journey times down to the 'Freiburg' situation where it becomes much quicker to go to town by tram than by car. It would therefore be wise to anticipate relatively low levels of average occupancy in the early life of the system. However, as Sligo's population grows as expected from the present 20,000 to 40,000 the wisdom of building a public transport system which can avoid road traffic over much of its length.

Passengers will perceive the benefits of fares which higher than those charged on buses (£0.15/km) because of the quicker journey times and superior ride characteristics. Car drivers avoiding rising centre town parking charges, will contribute additionally to revenue by paying to park at edge of town sites, as well as to ride on the trams.

Advertising inside and out is a further source of revenue. The following table indicates the revenue from the close combined of fares, parking and advertising as just exceeding the total of main operating costs. Because of the need to service the capital employed and depreciate the assets, it will be necessary to apply a subsidy to the tramway in its earlier years. However, increased occupancy to 15-20% from the initial modest 10% could turn the tramway into a good business in years to come.

2.4.7 Capital Investment

Estimates of the cost of constructing a tramway are usually put together after preliminary system design. In the case of Sligo a contingency figure of IR. £10 million is suggested based on estimating exercises for other localities, mainly in Britain which are not dissimilar. The IR. £10 million comprises roughly 25% vehicles, 75% civil engineering, permanent way and depot costs, and the considerable amount of design, professional and legal costs entailed in bringing a system into being.

SLIGO LIGHT TRAMWAY
SYSTEM RUNNING COSTS & REVENUE

MAIN COST ITEMS	IR £/Year	No	IR £/Year Total
Driver costs	20,000	24	480,000
Energy cost per vehicle	5,000	8	40,000
Cleaning costs per vehicle	1,500	10	15,000
Consumables per vehicle	500	10	5000
Maintenance per vehicle per year	4,000	10	40,000
Infrastructure maintenance (route, stops, track)	20,000		20,000
Insurance + other overheads	50,000		50,000
Main Cost Items			**670,000**

ANNUAL REVENUE INCOME - EARLY YEARS

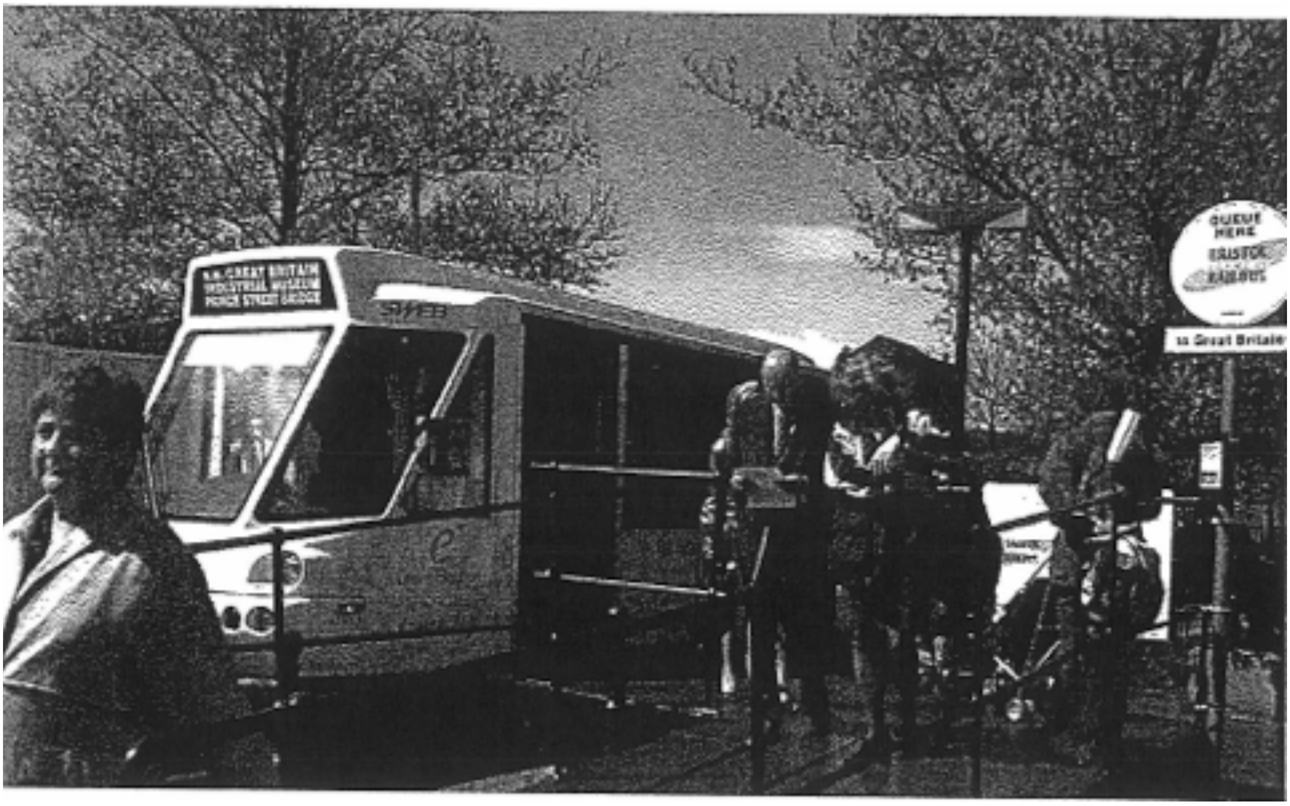
Expected annual passenger fares at 10% occupancy			365,000
Parking income			200,000
Advertising - external			100,000
Advertising - internal			75,000
Annual revenue			**740,000**
Estimated Annual Operating Surplus			**70,000**

Operating Cost information

Running hours per day:	12
Operating days per year:	360
Number of vehicles running (typical):	8

Revenue Information

Service frequency (minutes)(averge)	6
Terminus return time (minutes)	30
Gross passenger capacity per hour/2 directions	1000
Running hours per day	12
Operating days per year	360
Gross annual system capacity	4,320,000
One way fare	IR £1.00
One way fare (school & OAP)	IR £0.50
Average fare	IR £0.80



Motive 6: Parry Tram in Bristol

Main urban installation elements and cost estimates (as of 2000):

1. “Park & Ride” Facilities at southern and northern end of transit corridor: Lisnanurg and Carraroe (200 places @ 1800.00 each) £ 720,000.00

2. 100m and 400m access roads £ 60,000.00
3. Two small sized “Park and Ride” facilities at Ash Lane and Church Hill, each 50 Parking places (1000.00 per place) £ 100,000.00
4. Construction of Archway at Sligo Railway Station:
   - Earth movements 2000 cub.m £ 12,000.00
   - Side Concrete Walls £ 58,000.00
   - Archway (6 m width, 4 m high) £120,000.00

   £ 190,000.00

5. Street Furniture, Railings and various improvements at Wine Street / Stephen Street and Mall £ 60,000.00
6. Construction of tramway at Sligo General Hospital:
   - Earth movements 2000 cub.m £ 12,000.00

Crossover at Front of Hospital	£ 24,000.00	
Concrete Walls to Parking / 100 m	£ 24,000.00	
Modifications of Parking and Lanes	£ 24,000.00	£ 84,000.00

7. Light Rail Bridge at Ash Lane / Length approx 40 m
(5000.- per m span) (without cycling and pedestrian facilities) £
200,000.00
8. Tram embankment at RTC /Length approx. 150 m £ 100,000.00

9. Drainage and Underground Services Diversion - none -

Grand total approx. £ 1530,000.00

3.5 Sligo Urban Transit Corridor and Cycling Infrastructure

3.5.1 Topography and Cycling Routes

It is assumed that today cycling counts for less than 0.1 % of all traffic movements in and around Sligo. Very few cycling facilities - lanes, sign posting, stands - are in place. To achieve a significant increase to more than 5% of traffic movements of up to 3 miles (which is already achieved at some other Irish regional urban centres) a wide range of measures and activities is required.

A proposed cycle network plan will consist of a strategic network of cycle tracks, lanes and routes. An inner town network for Sligo Town should be supplemented by commuter routes into the centre, it should be linked to a wider regional network and linked to recreational and tourist facilities and routes. Special attention must be given to the points of interchange to other modes of transport, i.e. Railway Stations, Bus Stops and P&R facilities.

Motive 7: Railway access at Tegelen / Netherlands

As a first step towards a cycling network for Sligo this project has identified the most feasible radial routes into the centre of Sligo and their connection / crossing points with the proposed tram corridor.
At these points of interchange bike garages and – stands could be utilised for the recharging of electrically assisted (“EPAC”) bikes. The electricity for the charging of these bikes would be provided by the energy distribution along the proposed tram corridor, sourced by renewable energy.

Special attention has been given to the topographic difficulties between Caltragh and the town centre where direct cycling routes are difficult to achieve due to steep gradients. A main north - south cycling track can be envisaged at the proposed tram corridor:

-- A cycling track between Carraroe / Caltragh to Chruch Hill can be envisaged.
-- the elevated railway tracks between the Sligo Showgrounds and the Sligo Railway Station cannot be utilised for cycling.
-- the inner-urban section between Wine Street and the Mall can be fully utilised for cyclists if the streets are taken out of the traffic circulation and priority is given to public transport,
-- between the Mall and Ballytivnan a combination of a pedestrian lane and two-way cycling track can be envisaged along the tramline. Especially a light bridge crossing over Ash Lane will significantly enhance walking and cycling from the town centre to the Institute of Technology. The only level crossing of the tramline has to be provided at the access road to the new housing estate of Sligo Corporation at Ash Lane.

12. The tramline section between Ballytivnan and the terminus at the N15/Bundoran Road is using the existing “Old Bundoran Road” where only local residential traffic occurs. Cycling can be enhanced and secured by an on-road cycling track, road marking and sign posts. Special attention has to be given to the main entrance of the “Abbotts” factory and discharging traffic.

Map of proposed radial and connecting cycling routes

3.5.2 **The Bike Station Concept**

Bike stations at the railway stations are well established in European countries like Denmark, Netherlands, Germany, Belgium, and Switzerland as well as in Japan. Governments are increasingly realising the potential of Bike stations as an integral part of the urban infrastructure. Services to be provided by a typical Bike Station include:

- Hire of bikes, protective gear etc.
- Repair services, maintenance of electrically – assisted bikes
- Advice on cycling and public transport in the region
- Guided tours of the city and region
- Services for disabled people using wheelchair bikes
- Courier services to co-ordinate with express deliveries from buses and trains
- Delivery services using bike trailers which can be dropped off or picked up
- Retail sales
- Tourist sales
- Safety training and cycling club activities

A bike station installed at the Sligo Railway – and Bus Station would be the crucial service point for all bike installations along the tram corridor.

Motive 10: Münster service area

3.5.3 EPAC Bikes and Tramline

The aim of a cycling infrastructure including part assisted, electric bikes is:and

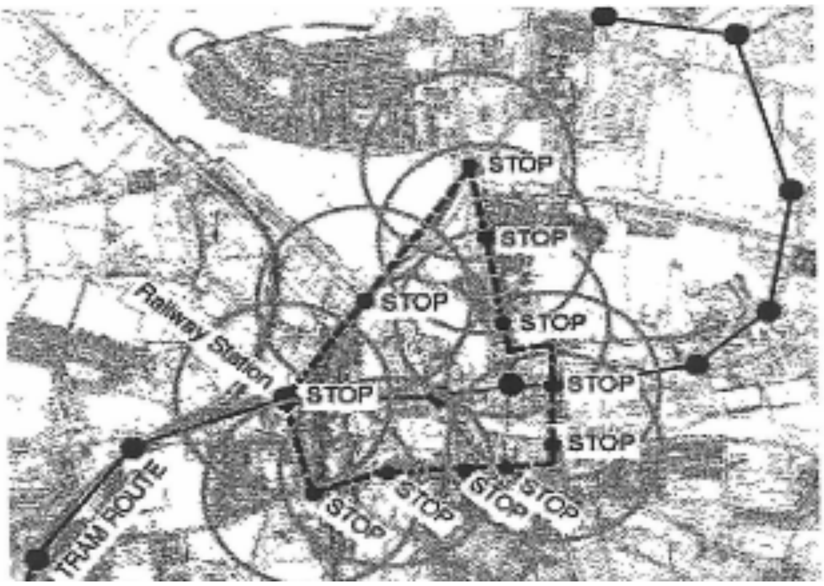
- to offer the bikes for rent or lease,
- to demonstrate and convince city dwellers that there are alternatives to the car for short distances,
- to provide effective, fast cycling feeder routes to the stops of the tramline,
- to demonstrate practically the reduction of “Greenhouse gas” pollutants, especially Carbon Dioxide,

-- to convince local employers that their staff should use these bikes during working hours allowing significant time savings in Sligo's congested city streets,

-- to convince tourists that Sligo places of natural, cultural, archaeological and general tourist interest can be discovered by EPAC - bike without physical exhaustion and in close contact to the people and countryside of Sligo. The interior design of the tram will allow for a limited carriage of bikes thus providing better integration with the services of the bike station and more flexibility for the tourist.

3.5.4 Electric bus and Tramline

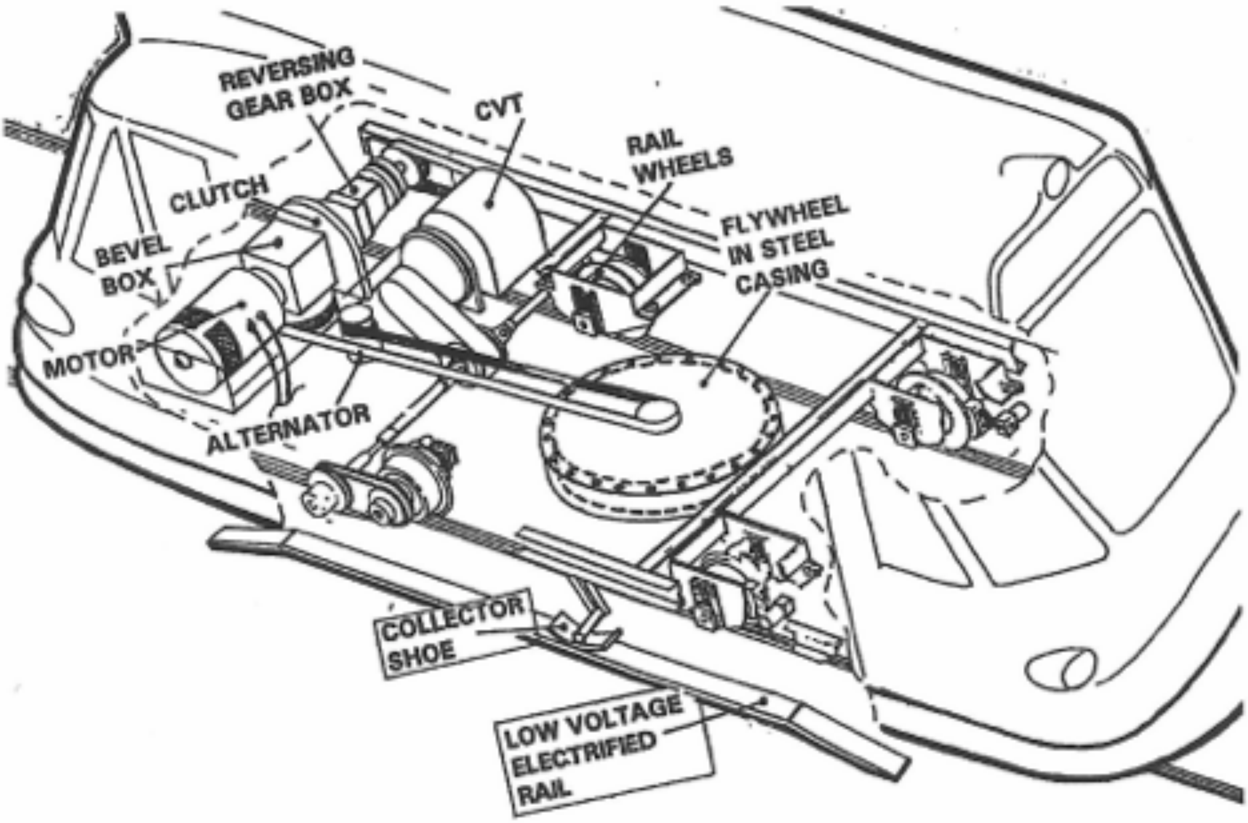
The aim of the e-bus service would be to increase the width of the area served by non polluting the public transport service in the centre. A Gulliver type minibus would be used on the route as shown below. It would intersect with the corridor at the bus station and the General Hospital.



electric minibuses in Florence

3.6 Sligo Urban Transit Corridor: The Energy Concept

3.6.1 Location and Connection of renewable energy supply to corridor



The internals of the Parry Tram are shown above. It works by collecting electricity at low voltage (70V DC) from an electrified rail which is located at the tram stop. This electricity is then used by a motor to increase the speed of the flywheel which powers the tram.
The flywheel stores enough energy to allow the tram to travel for a distance of up to 3 km before it needs to be "recharged". This means that electricity only needs to be supplied at certain tram stops along the route, there is no continuous electrified rail. This obviates the need for a cable to be installed for the continuous length of the track and electricity is provided from the Grid at certain stops via a 75kW AC/DC charging unit. The electricity is sent into the Grid at the Hydro station and under the deregulation of the electricity market, a charge is made for the use of the Grid. The grid is used at all charging points apart from that at Hyde Bridge where minimum engineering work is required to link the water turbine at the lower weir to the tram stop at Hyde Bridge. This method of distribution will be of low intrusion and is inherently safer than alternative power distribution systems that are currently in operation.

Lower Weir: Minimum engineering work is required to link the water turbine at the lower weir to the urban transit corridor as the weir is located off Hyde Bridge which becomes utilised by the tram route. The link wire will have a length of approx. 20 m and the bed of the Garavogue river can be used for trenching before a connection is made from one of the arches of hyde bridge to the road surface.
Upper Weir: An underground wire has to be provided between the water turbine and the tram route

at Sligo Grammar School with a length of up to 200 m. The new pedestrian / weir bridge and the pedestrian lane linking Calry Church and the Garavogue river are providing a feasible route.

3.6.2 Distribution of Renewable Energy to all Modes of Transport

The power line of the tram corridor is stretching over the entire length of the tram route covering all stops of the tram. Highest flexibility should be provided for the placement and futures changes of recharging facilities of the trams and the electro-bikes.
The installation of the power line to both ends of the proposed route will allow for an extension of the system and the option to enlarge the power supply from other sources of renewable energy, especially from wind turbines, is maintained.

3.6.3 Determine location points for recharging of tram and electro-bike

Tram: The proposed flywheel concept of the Parry tram will allow for a travelling distance of up to 3 km without charge. In the interest of short recharging intervals and short times spent at the stops (recommended: 30 sec.) the recharging facilities for the tram should be place in less than 2 km distance and where steeper gradients occur the distance should be further reduced.

The tram section starting at Carraroe to the Sligo Railway Station (around 3 km railway track) will require chargers at Carraroe and Caltragh. The envisaged tram ramp at the railway station of 100 m length and up to 7% gradient will require continuous charging over its entire length for trams climbing up to the railway bed. For trams entering the urban streetscape out of the railway station a charger should be placed at Wine Street.

After leaving the tonw centre and climbing up the Mall (up to 5% gradient) a charger should be placed at the Sligo Grammar School. A further charger should be installed at the St. Joseph tram stop before the route shows a further gradient at the Old Bundoran road. The terminus at the Main Bundoran Road will provide the sixth and final charging facility of the tram system.

.6 Location of batteries /recharging points for e-bus and e-taxi

The back-up facilities for the charging and maintenance of e-bus and e-taxi will require dedicated space, skills and supervision. It is proposed that such facilities be concentrated at suitable areas of the Sligo Railway- and Bus Station. The current access area south of the railway building is suitable for installations supporting local transport and is situated only a few meters from the proposed tram route.
As the outlined capacity of the hydro – turbines is just sufficient for the operation of the tram and recharging facilities of electro-bikes, it may be advisable to allow for additional power supplies from the public grid for the recharging of e-buses and e-taxis.

3.8 Energy demand and profile

3.8.1 Tram System

There is a 75kW charger at each charging point. This is used to provide a point charge to bring the flywheel up to its required speed. The period for each charge is a maximum of 30 seconds. There are 8 charging points on the line and the times when charging occurs is detailed on table. From this

it can be seen that there are 16 charge periods per hour, per charger, apart from at the ends of the line, where there are only 8 charge periods. There is a fairly even spread of charging periods and there are only 6.7% of periods, which coincide.
I can be seen that each charger is estimated to be only using electricity intermittently for a maximum of 8 minutes per hour. The maximum demand period for the electrical utilities in Ireland is the integrated demand over a 15 or 30 minute interval. This means that the metered maximum demand per charging point would be 10kW.
The average electrical consumption of the tram has been measured on trials in Bristol UK and Himley UK. The results were 0.75kWh/km and 0.50kWh respectively. Therefore it can be expected that the maximum consumption will be 0.75kWh/km and using this figure, with the anticipated annual mileage of 532224 km travelled by the 8 trams, gives a consumption of 399,168 kWh.

CHARGER No.

TIME AFTER HOUR

1	2	3	4	5	6	7	8
0	5	1.5	1	2	2.5	3	0.5
	6	5	5.5	6	6.5	4.5	
7.5	12.5	9	8.5	9.5	10	10.5	8
	13.5	12.5	13	13.5	14	12	
15	20	16.5	16	17	17.5	18	15.5
	21	20	20.5	21	21.5	19.5	
22.5	27.5	24	23.5	24.5	25	25.5	23
	28.5	27.5	28	28.5	29	27	
30	35	31.5	31	32	32.5	33	30.5
	36	35	35.5	36	36.5	34.5	
37.5	42.5	39	38.5	39.5	40	40.5	38
	43.5	42.5	43	43.5	44	42	
45	50	46.5	46	47	47.5	48	45.5
	51	50	50.5	51	51.5	49.5	
52.5	57.5	54	53.5	54.5	55	55.5	53
	58.5	57.5	58	58.5	59	57	

3.8.2 Electrically assisted bikes

The manufacturers of EPAC - bikes specify that one charging cycle needs between 600Watt and 900Watt. This full charge will allow for power-assisted cycling of up to 30 km. If the commuting distance is an average of 10km then a full charge would last 3 days. If there were 100 bikes in use, operating 300 days per year, the energy consumption would be between 6000 kWh and 9000 kWh per year. The maximum electricity use per day would be 30kWh and as it is expected that the majority of bikes would be placed on charge overnight, the maximum demand is expected to be 6kW (base on a 5hr charging period).

3.8.3 Electric Bus

The Gulliver electric bus has a range of 70km on a charge of 33.5kWh. The charging period is 7 to 8 hours to charge fully. The maximum demand depends on the actual charger but 10kW would be the average, which is similar to the tram. There is a quick change facility for the batteries so that they can be changed within 3 minutes therefore by using 2 sets of batteries, the duty for the bus is such that it can operated during the day and charged overnight. The annual energy usage over 300 days at 144km/day is expected to be 20,674 kWh.

3.8.4 Overall situation:

	Maximum Demand		Annual Consumption
	Theoretical	Daytime	
Tram (8 vehicles)	80kW	80kW	399,168 kWh
Bikes	6kW	0kW	9,000 kWh
Bus	10kW	0kW	20,674 kWh
	96kW	80kW	428,842 kWh

4 DISSEMINATION

There has been considerable interest in the project and the details of the project have been disseminated on local, national and European levels:

- Local - The project was officially launched, by the Mayor of Sligo, on 25 March 1999 at a public meeting held in the Silver Swan Hotel, which is on the bank of the Garavogue River. The Details of the project were also printed in the local newspaper at various times during the project, one such press cutting is contained in the Annex. The details of development s on the project were presented to the Council meeting of the Corporation of Sligo 1 November 1999.

- National - An article on the project was published in the national newspaper, The Irish Times (see cutting in the Annex). The project was also covered by a TV film crew for TV3 and featured on the national evening and late night news on 30 march 1999.

- European - A paper on the project was presented to the Altener sponsored "Rebuild Conference" held in Barcelona in October 1999. A further presentation was made at the "Sustainable Hotels for Sustainable Locations" EU Conference held in Maspalomas, Gran Canaria in October 2000.

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[14] *Public Enquiry report on EIS "Sligo Inner Relief Road", p.70ff.*

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[16] W. Bodewigs: City Development and Mobility – Proposals for Sligo City,
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[17] Sligo Corporation 1999
Integrated Area Plan for Sligo

Annex

Jennings & O'Donavan, Upper Weir Site Survey Drawing No1

Jennings & O'Donavan, Upper Weir Site Survey Drawing No2

Jennings & O'Donavan, Upper Weir Site Survey Drawing No3

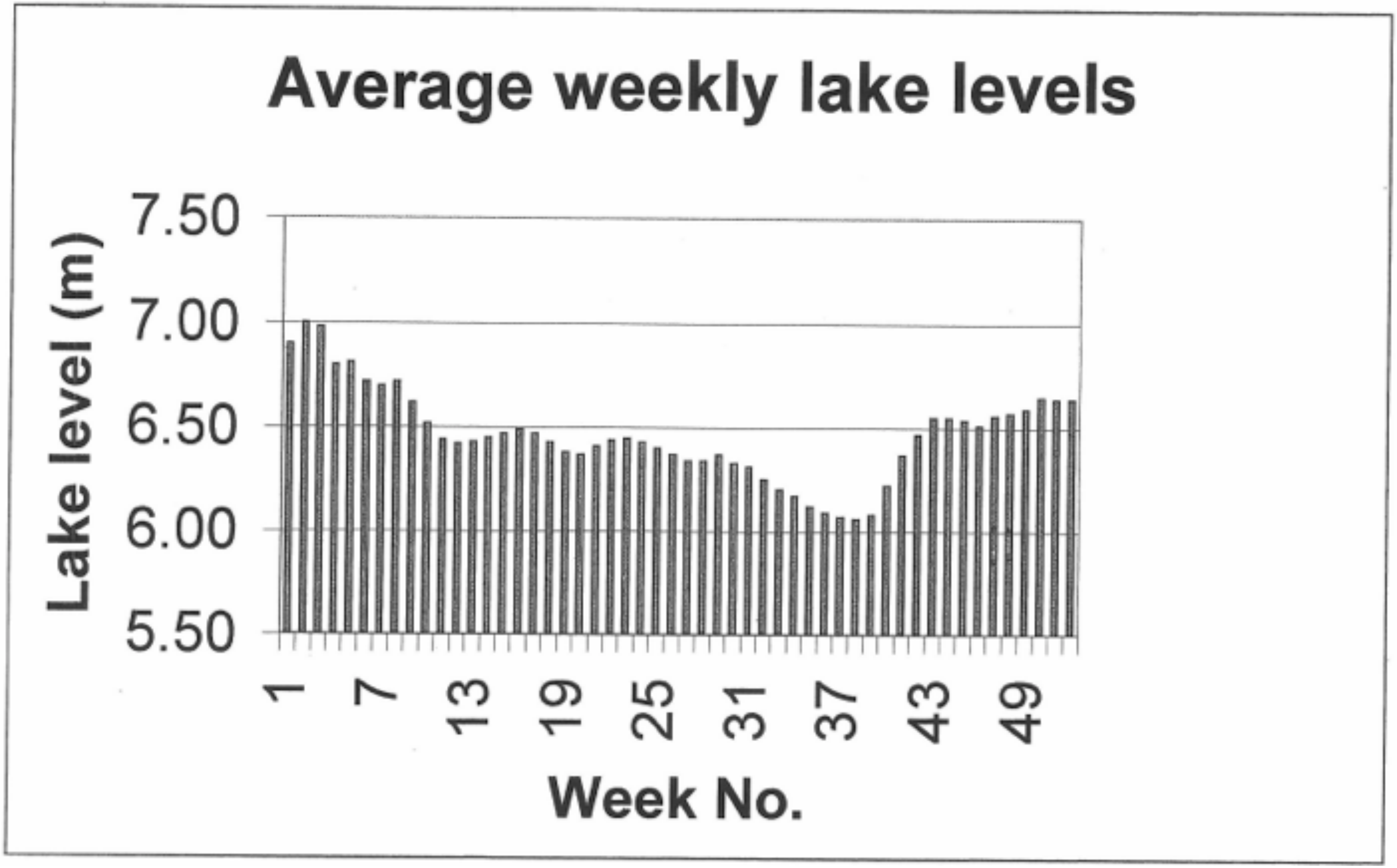
Record Drawing of Lower Weir

Calculation of the average annual tidal variation

Average weekly lake level on Lough Gill

Press cutting Sligo Champion

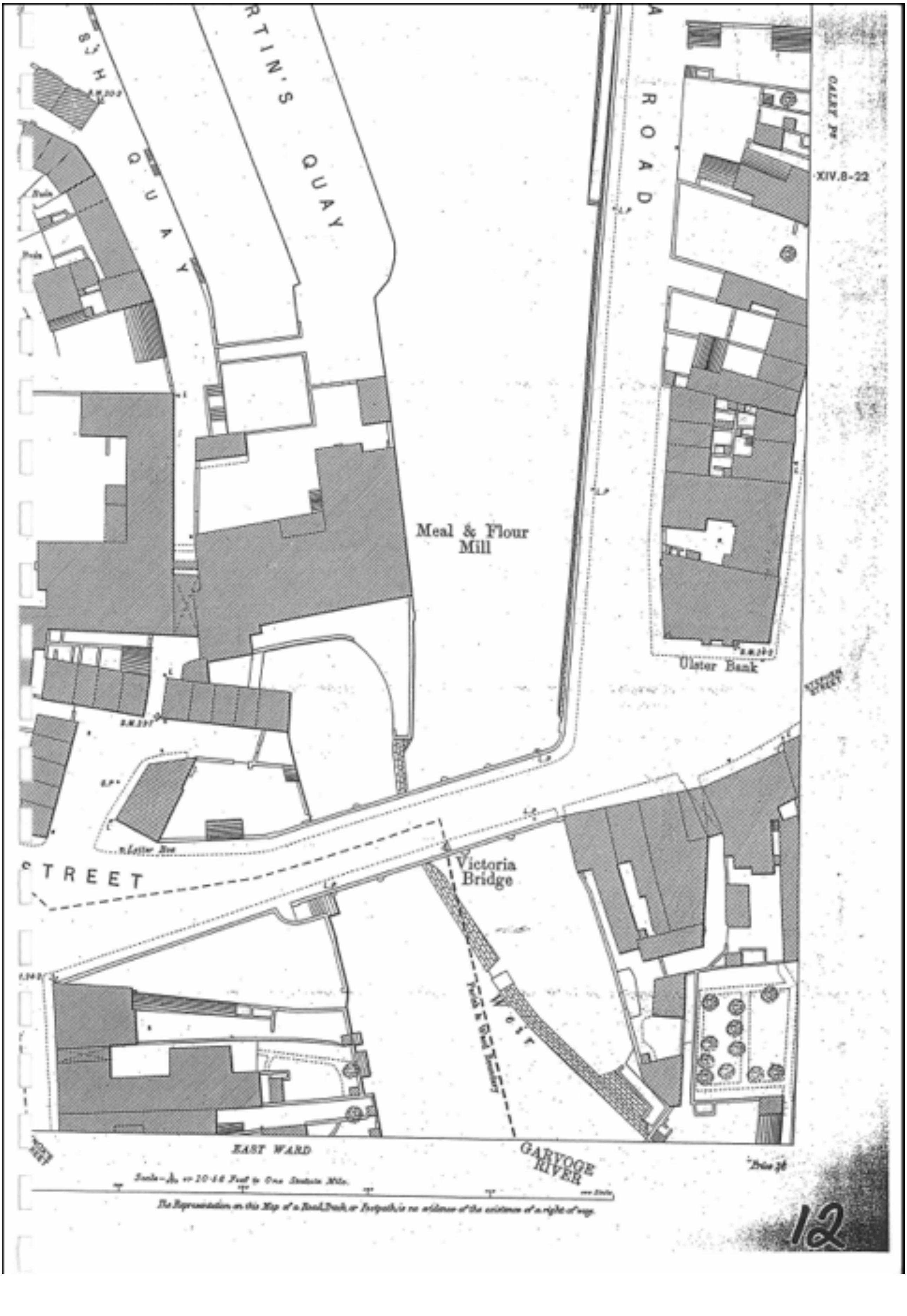
Press cutting Irish Times


Average weekly lake levels
Lake level (m)
7.50
7.00
6.50
6.00
5.50
1
7
13
19
25
31
37
43
49
Week No.

Calculation of average annual tide difference using tides from year 2000

Level of tide			Numbers of tides			
high	low	difference	am	pm	am+pm	
4.6	0	4.6	0	0	0	
4.5	0.1	4.4	3	0	3	13.2
4.4	0.2	4.2	6	6	12	50.4
4.3	0.3	4	11	17	28	112
4.2	0.4	3.8	26	20	46	174.8
4.1	0.5	3.6	24	20	44	158.4
4	0.6	3.4	22	19	41	139.4
3.9	0.7	3.2	28	27	55	176
3.8	0.8	3	23	27	50	150
3.7	0.9	2.8	17	30	47	131.6
3.6	1	2.6	30	28	58	150.8
3.5	1.1	2.4	25	27	52	124.8
3.4	1.2	2.2	28	23	51	112.2
3.3	1.3	2	19	29	48	96
3.2	1.4	1.8	26	24	50	90
3.1	1.5	1.6	25	20	45	72
3	1.5	1.5	12	17	29	43.5
2.9	1.6	1.3	11	9	20	26
2.8	1.7	1.1	7	6	13	14.3
2.7	1.8	0.9	8	4	12	10.8
2.6	1.9	0.7	1	2	3	2.1
2.5	2	0.5			0	0
			352	355	707	1848.3

Average tidal variation in metres = $\frac{1848}{707}$ = 2.6


QUAY
QUAY
ROAD
Meal & Flour Mill
Ulster Bank
STREET
Victoria Bridge
Weir
XIV.8-22
EAST WARD
GARVOGE RIVER
The Representation on this Map of a Road, Track, or Footpath, is no evidence of the existence of a right of way.
12