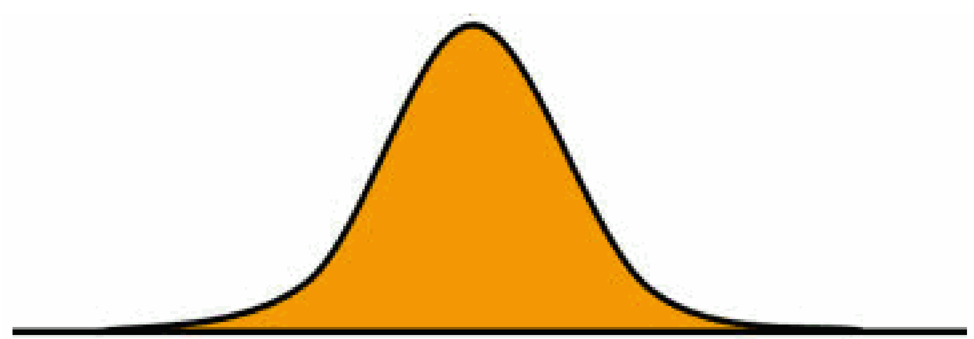

Peak Oil: Regional Impacts and the Role of Toronto and Region Conservation

Prepared for:
Toronto and Region Conservation

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1.0 Introduction

In essence, the peak oil story is about unsustainable use of a finite resource. Increasing scarcity of oil and petroleum products for energy and manufacturing will have far reaching consequences on individual lifestyles, rural and urban land-uses, and broadly upon society, the economy and the environment. There will be pressures to develop new energy sources (both clean and "dirty"), increase the efficiency of energy use through innovation in technology, and reduce demand for energy by changing practices (e.g., shorter commuting distances, more public transit, etc.). Increasing development density and the creation of markets for locally produced fuel crops may threaten protection of greenspace areas, marginal lands and valleys. As such, peak oil has ramifications for both Toronto and Region Conservation's (TRCA's) core flood protection mandate and its future work towards The Living City.

2.0 Overview of peak oil

"Oil is like a girlfriend. You know from the outset of your relationship she will leave you one day. So that she doesn't break your heart, it's better you leave her before she leaves you."

—Faith Birol, International Energy Agency, Director of Economic Studies

Peak oil has gone from being a relatively obscure topic reserved for geologists and the oil industry, to one that has recently been receiving attention in the mainstream media and at the highest levels of government. For instance, the government of Sweden has created a National Commission on Oil Independence with the objective of becoming oil-independent by 2020. The topic has been covered extensively by CNN, with features like *We were warned: tomorrow's oil crisis*. Even the United States House of Representatives has directed its subcommittee on Energy and Air Quality to investigate peak oil.

The basic concept of peak oil is simple — given that oil is a finite resource, there comes a time, whether for an individual field or the planet as a whole, that half of the recoverable oil will have been consumed. From this peak onward, production will decline. How steep the decline will be and its impacts will depend upon a number of variables, including alternative energy sources, demand and new recovery technologies.

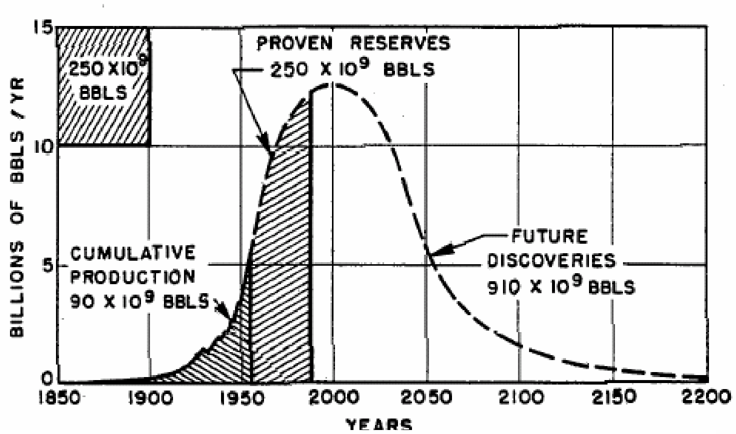

Fig. 1 – Hubbert's Peak showing oil production follows a bell-curve (Hubbert, 1956).

The peak oil concept was pioneered by American geologist Marion King Hubbert. In a presentation to the American Petroleum Institute in 1956, Hubbert proposed that oil production follows a bell-shaped curve, as seen in Figure 1. In 1956, Hubbert predicted that conventional oil production in the United States would peak between 1965 and 1970 (actual peak occurred in 1971) and worldwide production would peak in a half century (Hubbert, 1956).

Predicting the actual date of peak is an uncertain science due to complexities such as trustworthiness of reserve estimates, new technologies and demand destruction. Among geologists there is general agreement that the world is heading for a peak in global oil production. The debate centres on when this will transpire.

The Association for the Study of Peak Oil (ASPO) holds the position that global oil production will peak around 2008, as seen in Figure 2 (Campbell, 2004). The Energy Information Administration (EIA), a branch of the US Department of Energy, offers many possible scenarios ranging from 2021 to 2112 (Belhouse, 2006). Expert opinion seems to be coalescing around the International Energy Agency (IEA) view that peak production of petroleum liquids will occur around 2012 (Campbell, 2004). Regardless of the timing of peak, it will come.

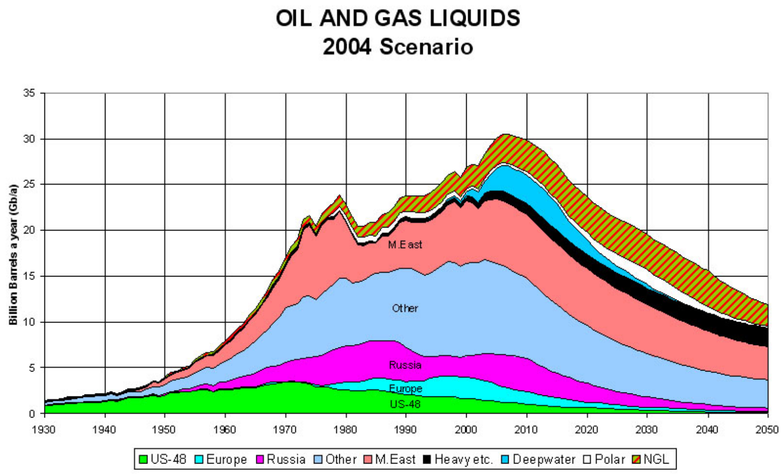

Fig. 2 – International Energy Agency (IEA) predicts peak production of petroleum liquids in 2012 (Campbell, 2004).

To understand why these predictions vary it is worthwhile to briefly review the key factors affecting timing of the peak:

1. How much oil has been found (but not yet used)? Countries and oil companies report on the amount of “proven” and “probable” oil reserves they have in the ground. Finding out how much oil has been found then should be a simple equation of adding up the “proven” and “probable” reserves. The problem is that for various reasons, ranging from boosting shareholder value to gaining production increases under the Organization of the Petroleum Exporting Countries, there are incentives for countries and oil companies to be overly optimistic in their estimates of future production. It has been estimated by energy industry analyst Matthew Simmons that only five per cent of claimed reserves worldwide have been audited by independent agencies (Simmons, 2005a).

2. How much oil has yet to be found? The Association for the Study of Peak Oil has pointed out that despite increases in computer technology, the volume of new fields being found has been in decline for 40 years. As seen in Figure 3, the discovery of oil fields peaked in 1965 and given that large fields tend to be easiest to find, future finds will be harder to locate and likely yield less oil (Campbell, 2004).

It should be noted that between 20 per cent and 35 per cent of oil in a field is typically recoverable due to declining pumping pressure and geological formations (Simmons, 2005b). Of this recoverable oil, it is normally the first half of the resource that is easiest to produce. As the field ages, the oil becomes harder to produce and requires increased infrastructure and natural inputs to keep pumping pressure stable. The global peak in oil production then is, in many regards, the end of the cheap and easy-to-get-to oil, with the remaining oil being harder and more expensive to produce.

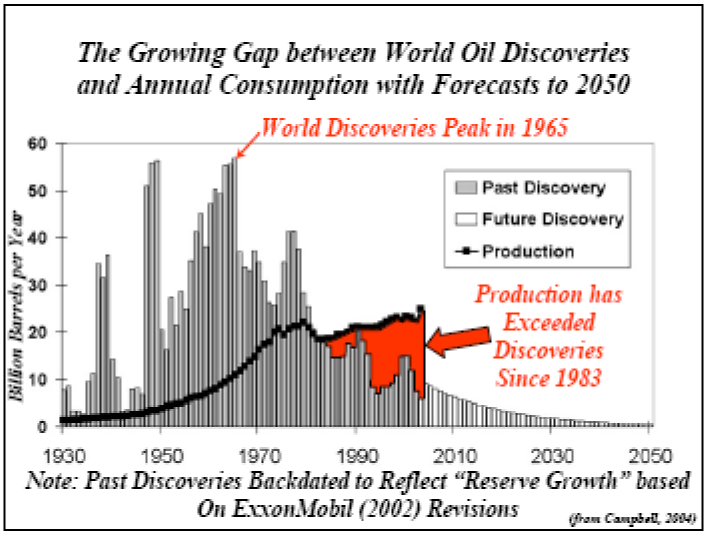

Fig. 3 – Global oil discoveries versus discoveries (Campbell, 2004).

3. How fast will global demand increase? With countries like China and India industrializing at a fast pace, the demand for oil is increasing. These developing nations' thirst for oil has been playing itself out in geo-politics in Central Asia and even in North America where China's state oil company, China National Offshore Oil Corporation (CNOOC), was rebuffed by US lawmakers in their attempt to buy the American oil company Unocal. Both ASPO and EIA have mid-range forecasts for global oil demand to increase by two per cent a year.

It should be noted that peak oil is not necessarily about oil disappearing forever — we will never completely run out of oil because there will always be a little more to find and small amounts might continue to be extracted for a couple of hundred years. The crux of peak oil is an economic issue — it's that once supply and demand diverge, presumably somewhere near the peak of production, the price of oil will go from being relatively stable and cheap to exponentially more expensive.

The stable and cheap price of oil has been the driver for transportation technologies, housing patterns, food production and economic development for the past 50 years. When cheap oil disappears, as it will when supply is over-run by demand, radical changes could be in-store for society. There are various opinions on how steep the decline could be; however, given the pervasiveness of oil in everyday life, there is potential for a steep decline and rough landing if governments and citizens do not start planning for an energy future beyond oil.

3.0 Energy sources and patterns of use

"Between here and where we need to be, there is something like 10 miracles. The good news is that miracles do happen."

—Dr. Richard D. Smalley in Energy and Nanotechnology:
Prospects for Solar Energy in the 21st Century

3.1 Importance of oil

The development of western society has been greatly influenced by supplies of abundant, inexpensive oil. Transportation networks, food production, water recovery and distribution, modern medicine and many consumer products are almost entirely fuelled by oil and petroleum-derived chemicals. This dependence on oil can be highlighted in the Canadian food system — fossil fuels are used for powering irrigation pumps; in petroleum-based pesticides and herbicides; and even more oil is eaten up in the harvesting, processing, storage and transportation of foods to their final consumer outlets. According to one calculation, about 10 to 15 calories of fossil fuel energy are used to create one calorie of food (Tomczak, 2005).

3.2 Other energy sources

There are other energy sources; however, all of them have their challenges. Oil represents 39 per cent of world energy consumption and the majority of the distribution infrastructure is not easily adapted to other fuels (EIA, 2006). Extensive research and development is needed before any energy source will supply an equivalent quantity of energy at the low price that oil has historically provided. Making these sources commercially viable will require new infrastructure, necessitating huge investments and, in many cases, decades to build. While adoption of alternative energy sources is expanding, they currently account for such a small overall percentage that their role in energy supply remains minimal. Furthermore, many of these alternative sources have challenges of their own:

1. **Fossil fuel sources** – As conventional oil becomes less abundant, other fossil fuels such as coal, natural gas and oil sands, will be looked to as alternatives. Natural gas combustion results in less air pollution than oil, but its long-term supply is in question; North American supplies peaked in the mid-1990s (Laherrere, 2004). Coal is more plentiful than oil, but it's expensive to trap and store the CO_2 that is released. Oil sands are a form of unconventional oil, but they are expensive to extract, have a high environmental impact and require large amounts of clean energy inputs, such as natural gas, to produce (Woynillowicz et al, 2005).

2. **Renewable fuel sources** – Rising oil prices will have the effect of spurring on the search for renewable fuel sources. The potential expansion of hydro power isn't large because in North America and Europe most hydro-electric power opportunities have been developed (Baird, ND). Biofuels, such as ethanol from corn, are making some headway in the market, but there is concern that the amount of energy and land required to produce them are not sustainable. Hydrogen as fuel storage requires many technical breakthroughs and investment in infrastructure to become feasible on a large scale. Nuclear power creates fewer air pollutants, but storage techniques are not totally fail-safe and would require more facilities to be constructed. Other sources such as solar, wind, tidal,

wave and heat exchange have potential, but current deployment is very small and expansion will require time.

Further economic, technological and environmental factors which effect the replacement of conventional oil with other energy sources are summarized in Appendix 1.

The transition to renewable energy sources must be accelerated immediately in order to prepare for peak oil. While innovations are making wind and solar energy more economical and technologically feasible, they are still more expensive than conventional sources. Even more important, it requires large amounts of oil to produce solar panels, windmills, nuclear power plants and infrastructure, thus the economic feasibility of converting to alternative energies will become even more difficult as oil scarcity starts to drive prices higher. As William Rees put it, “Industrial civilization faces a paradox: we need oil to move beyond the age of oil” (Rees, 2000).

It is apparent from the above exploration of alternatives that no sole source of energy will replace conventional oil in the near future. A variety of energy sources will continue to be developed to mitigate peak oil, and these will need to be coupled with an increased effort to raise energy efficiency and reduce energy consumption.

3.3 Efficiency and consumption patterns

The chances of fulfilling our energy needs with alternatives to oil will be much greater if consumption is reduced. With the correct motivation, significant reductions in energy use can be achieved — this was witnessed in the early 1980s when, with escalating oil prices, the average efficiency of cars, furnaces and insulation doubled in the US (Lemonick, 2005).

Canada has made some efficiency gains within the last decade in a variety of sectors. An energy efficiency report by Natural Resources Canada (NRCan) showed that while total energy use between 1990 and 2003 increased in all sectors, there were efficiency gains in the residential and industrial sectors, but little or no efficiency gains in the commercial/institutional and transportation sectors (NRCan, 2005). Fuel consumption for new cars and light trucks has remained the same since 1985 and energy efficiency improvements have changed little since 1994 for the transportation sector (NRCan, 2005). The popularity of minivans and SUVs has significantly increased the activity share of light trucks compared to other modes, resulting in an 18.7 PJ increase in energy consumption and a 1.3 Mt increase in related greenhouse gas emissions (NRCan, 2005). Higher oil prices due to peak oil may again spur increased energy efficiency gains in all sectors, especially the transportation sector.

Provincially, some progress in energy efficiency has been made — Ontario’s per capita electricity consumption peaked in 1990 and has been trending lower ever since (Ontario Conservation Bureau, 2006). Despite these decreases, and because of an overall increase in demand/consumption of electricity, greater reduction is necessary or shortages will be felt at the local level. The Independent Energy System Operator (IESO) has predicted that the City of Toronto will face electricity shortages unless 250 megawatts of generation capacity is added by 2008, 500 megawatts are built by 2010 and energy conservation is maximized (IndEco Strategic Consulting Inc., 2006).

In response, Toronto city council adopted a “Conservation First” energy strategy that positions conservation and demand management as the preferred first action to meet the energy needs of the city (City of Toronto Staff Report, 2006). The City of Toronto has a number of current initiatives aiming to increase energy sustainability, including development of a Renewable Energy Action Plan, partnerships with the building and transportation sectors to promote energy efficiency, a Fuel Cell Generation Project, a Green Roofs program, city building retrofit program and the Mayor’s Megawatt Challenge (IndEco Strategic Consulting Inc., 2006).

Adjusting our energy use for peak oil will require a fundamental change in the way we plan and build our communities. Communities will be planned to accommodate less energy-intensive modes of transportation. Buildings will be constructed, retrofitted, and operated to use less energy — or better yet, to create more energy than they use. Reductions will also come about with changes in technologies, in purchasing choices, and in day-to-day activities. With impending oil shortages, lifestyles will likely change as there will be no other choice. However, preparation will help to ease the social and political stress that will accompany these changes.

4.0 Impacts of peak oil on the Greater Toronto Area

“We lean toward [the] view that our survival depends not only on engaging in long-term planning but also on the extent to which we are able to replace certain core values. One such core value is that moving people and goods farther and faster in ever-increasing amounts is inherently desirable, a value manifested in the ‘predict and provide’ paradigm that has inspired transport policy for at least three generations.”

—Richard Gilbert and Anthony Perl, Energy and Transport Futures, 2005

Oil-based fuel shortages and rising prices will have a dramatic effect on life in the Greater Toronto Area (GTA) at all scales, from individual lifestyle choices to the urban form and function to changes in the regional economy. It has been suggested that Toronto could face rotating blackouts by the summer of 2008 if energy supplies and demand aren’t balanced (IndEco Strategic Consulting Incorporated, 2006). A report prepared for the City of Hamilton indicates that the odds are better than even that the cost of gasoline could quadruple (to $4/L) by 2018 (Gilbert, 2006). The extent and spatial and temporal distribution of the impacts of peak oil will be determined, in part, by the timing of the peak, the current and future mix of energy sources, technological advances in renewable energy and efficiency, and how rapidly institutions, politicians, and the average person responds to fuel shortages and higher fuel prices.

4.1 Lifestyle

At the scale of an individual resident of the GTA, peak oil will be felt as higher and more volatile energy prices (Belhouse, 2006; Gilbert, 2006). These higher prices for gasoline, electricity and natural gas could, over time, dramatically increase the proportion of household income devoted to transportation and home heating and cooling. As this shift occurs, there may be less spending on other goods and services, with resulting impacts on the local economy. For example, long-distance vacations may become less frequent (e.g., RVing, air travel). Residents of the GTA may demand more fuel-efficient vehicles, home energy retrofits, better access to public transit and infrastructure for active transportation (e.g., walking and cycling paths) and location of amenities closer to home (Belhouse, 2006; City of Portland, 2006; Gilbert, 2006). An Australian study predicts that the socio-economic impacts of rising fuel prices will be unevenly distributed across the populations of cities, with the most vulnerable populations being those that are already socio-economically disadvantaged and those living in outer-suburban locations (Dodson and Sipe, 2005).

4.2 Urban and rural form

Higher energy costs and the changing demands of GTA residents will influence rural and urban form. Higher transportation costs will result in greater demand for housing in city centers and mixed-use areas, where it's more likely that employment could be reached on foot, by bicycle or by public transit. The pressure to increase development densities through infilling and brownfield development will rise while the demand for greenfield development in the suburbs will decline (Belhouse, 2006; Gilbert, 2006). In fact, some authors predict an emptying of suburbia (Kunstler, 2005). Additional changes in land use patterns could result from the economic impacts of peak oil on sectors heavily dependent on oil products for fuel or feedstocks, such as airport-related services, light and heavy industry and manufacturing (City of Portland, 2006). Changes in land-use patterns and population densities will have implications for municipal infrastructure and servicing: roads, transit, health care, education, energy distribution, and water and wastewater services. To offset rising home cooling costs, GTA residents may demand more urban tree planting and green roofs.

The composition of the near-urban area also is likely to change. Not only does agriculture use oil-based fuels, but also it relies on many products for which petrochemicals are feedstocks (e.g., fertilizers and pesticides). As the cost of producing and distributing food rises, demand for locally-produced foods will rise (Belhouse, 2006; Gilbert, 2006). This could lead to a revitalization of agriculture in the urban fringe and increased demand for community gardens within the city. A market for fuel crops (e.g., soybeans for biodiesel) grown in the near-urban area may also develop.

4.3 Economy

Changes in personal lifestyle choices and the resulting impacts on rural and urban form, and municipal servicing, in aggregate, will have implications for the economy. The potential impacts are far ranging, but difficult to determine with confidence. In general, peak oil is expected to result in a drive to "re-localize" the economy. In other words, there will be greater demand for goods and services produced locally, and with a minimum of petroleum-based inputs and lesser demand for those with heavy reliance on oil products (Belhouse, 2006). This kind of broad shift could slow the economy and lead to higher unemployment, at least in the short term. Other impacts will be felt on specific sectors of the economy (Belhouse, 2006; Gilbert, 2006).

- **Energy**
    - Increased interest in developing local sources of renewable energy (e.g., biogas from landfills or manure, solar and wind power, energy from waste incineration, deep lake water cooling).
    - Pressure to ease environmental regulations to facilitate development of new energy sources (e.g., coal, hydro, nuclear).
    - Demand to bring marginal or protected lands into agricultural production for local fuel or food crops.

- **Construction**
    - Higher demand for residential and commercial buildings, sites and communities designed with energy conservation in mind. The focus will be on minimizing in-building energy use: heating, cooling, lighting, appliances.
    - More demand for sustainable energy sources and technologies in buildings and district energy systems.
    - Changes in the real estate market to reflect increasing demand for urban housing.

- **Transportation**
    - Transit services may find that demand increases while revenues decline due to higher operating costs.
    - Greater demand for high-occupancy vehicle lanes and changes to traffic flows to increase efficiency (e.g., roundabouts instead of traffic lights, lower speed limits).
    - Higher parking fees to discourage personal vehicle use.
    - Less investment in road capacity increases.
    - Less demand for freight and passenger traffic, with resulting impacts on industry linked to the airport (e.g., express delivery services).

4.4 Summary

The impacts of peak oil on the GTA are liable to be far reaching due to the current heavy reliance on personal vehicle use and goods and services produced using fossil fuel-based feedstocks and energy. The potential impacts outlined above would result in broad changes to the structure and functioning of our society, which could be accompanied by considerable social and political stress. At a recent community forum held in Ottawa and attended by the mayor, participants cited potential socio-psychological impacts of peak oil, such as denial, scapegoating, fear, social stratification, scarcity, personal security and political instability (Gibson, 2006). Municipalities across North America are becoming increasingly aware of the peak oil issue. In Canada, the cities of Burnaby, British Columbia, and Hamilton, Ontario, have prepared briefing reports on peak oil as a first step to responding to the issue (Belhouse, 2006; Gilbert, 2006).

5.0 Connecting peak oil to Toronto and Region Conservation

"… the age of fossil fuels is finally over."

—From a description of The Living City Vision for the Toronto region in the year 2100,
TRCA Strategic Plan Summary, 2006

Peak oil is not itself an environmental issue. It is an economic issue of supply and demand that is profoundly connected to the environment because of the environmental implications of the product in question. Peak oil is relevant to anyone concerned with building a healthy, sustainable urban region because our collective response to the peak oil situation will have profound environmental, economic and social consequences.

5.1 Toronto and Region Conservation can help choose the right path

One common conclusion among authors, academics and commentators examining peak oil, is that the impending oil shortage represents an economic and social crisis. An alternate, less cited conclusion is that it represents a crossroads. One path leads to energy production that is environmentally destructive, but easier because it conforms to existing infrastructures. The other leads to renewable alternatives and smart growth (Roberts, 2005).

Accepting the crossroads analogy, it is clear the peak oil issue itself will not define the right, environmentally responsible path. Informed policy makers, environmental advocates and business innovators will. Drawing on The Living City vision, the Strategic Plan Summary and many of its existing activities, TRCA is ideally positioned to be a leading proponent in the GTA of the right path in response to the peak oil issue.

5.2 Peak oil presents an economic argument for The Living City

As an environmental organization, TRCA does not have a mandate to address peak oil specifically, but it can integrate the issue, its projected impacts and solutions into its work towards The Living City vision, as outlined in its 2006 Strategic Plan Summary. In doing so, it will strengthen the argument for The Living City by augmenting the environmental basis for the vision with an economic one.

In short, our current urban infrastructures are not only environmentally unsustainable, due to looming high oil prices, but also they are economically unsustainable. Owing in part to peak oil, The Living City is a vision that can be framed both in terms of economic and environmental sustainability.

5.3 Peak oil and TRCA service areas

The peak oil issue touches all TRCA service areas. Some, however, have particular relevance.

1. **Education:** One of the goals of TRCA's Education programs is to "change individual and collective behaviours towards a more sustainable society by improving environmental knowledge and skills…" (2001–2006 TRCA Business Plan, p. ED-3). Understanding the implications of and viable solutions to the peak oil situation are integral to a building a sustainable society. The more widespread this understanding, the better prepared we can be to meet the challenges presented by peak oil. Integrating peak oil and the subject of societal dependence on oil into related school and adult education programs offered by TRCA will contribute to deeper understanding of the challenges ahead.

2. **Conservation lands:** The stewardship of Authority lands should take into account the long-term implications of peak oil. Though environmental protection and regeneration of natural areas has been the traditional focus of TRCA's land-use activities, peak oil suggests that urban and near-urban organic agriculture could be a pressing need in the future. Urban agriculture should factor into TRCA land-use strategies in response to the challenges presented by peak oil.

3. **Development services and regulation:** Environmentally sound land-use policies should take into account the long-term implications of peak oil on residential, commercial, industrial and social needs that stem from the prospect of decreased oil supply. In providing expertise and resources to the municipal planning processes, and working with other governments and agencies, TRCA is ideally positioned to promote development policies that address the implications of peak oil (e.g., transit supportive development).

   A potential impact of peak oil will be pressure to ease environmental and development regulations to accommodate development in areas that were previously off-limits. Toronto and Region Conservation's core responsibilities under Section 28 of the *Conservation Authorities Act* could be threatened under such a scenario. Development pressures on hazard lands should factor into initiating policies that address the impacts of peak oil on urban growth.

4. **Sustainable communities:** Toronto and Region Conservation's Living City programs, including the Sustainable Technologies Evaluation Program (STEP) and Sustainable Schools program, fulfill more than an environmental need. They respond directly to a growing demand in the GTA for more fuel-efficient transportation, home and institutional energy retrofits and location of amenities closer to home, spawned by higher energy costs. Toronto and Region Conservation brings expertise and infrastructure to help individuals and governments implement technologies and policies that minimize the impacts of peak oil.

5. **Sustainable Management System:** Toronto and Region Conservation's Sustainable Management System (SMS) measures TRCA's own organizational progress toward environmental, social and economic sustainability. Through programs such as the Energy Management Plan, TRCA is demonstrating its commitment to sustainable practices and showing sustainable management leadership. With the prospect of increasing energy costs, the urgency of these internal programs may extend beyond their environmental impact and respond to financially necessity. By intensifying its own energy conservation practices, TRCA may in fact be safeguarding itself from severe financial constraints brought on by peak oil.

6.0 Recommendations

"The world has never faced a problem like this. Without massive mitigation more than a decade before the fact, the problem will be pervasive and will not be temporary. Previous energy transitions (wood to coal and coal to oil) were gradual and evolutionary; oil peaking will be abrupt and revolutionary."

—Robert Hirsch, Peaking of World Oil Production:
Impacts, Mitigation and Risk Management, 2005

The potential ramifications of peak oil on both the GTA and TRCA's core mandate and new vision could be extensive if proper planning for a new energy future is not undertaken in the near future. With these impacts in mind, the recommendations of this report relate both to TRCA's programs and corporate operations, and to its relationship with municipal and other partners:

1. **Toronto and Region Conservation** – The following recommendations pertain to policies and planning for TRCA in particular, and address the organization's core mandate under the *Conservation Authorities Act* and its work towards The Living City.

   - Dedicate resources to organizational learning about the issue of peak oil. Learning may take the form of lunch-and-learn sessions, literature and speakers on energy and peak oil.
   - Peak oil should be included in all existing energy programs as an economic driver for renewable energy development and deployment.
   - Additional research into the planning impacts of peak oil should be undertaken. This research should investigate links to sustainable community form and design, transportation networks, housing design and development, and potential pressures on valley land development.
   - Toronto and Region Conservation's Sustainable Management System should be expanded to consider the future challenges of peak oil, with a focus on identifying potential impacts on TRCA and additional adaptation strategies for the organization.

2. **Municipal partners, government agencies and NGOs** – Given TRCA's role as a leader in sustainable development and environmental issues, the organization should aid its municipal partners and other government agencies in understanding the issue and impacts of peak oil.

   - Raise awareness of peak oil with partner municipalities. This could include workshops, outreach and speakers on energy and peak oil.
   - Encourage municipal partners to explore the impacts of peak oil within their jurisdictions. Municipalities across North America are undertaking Energy Descent Plans and passing resolutions for more study in order to prepare for a post-peak economy.

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Appendix 1 Alternatives to Conventional Oil

Energy Source	Economic and Technical Barriers	Environmental Impacts	Supply
Natural Gas	Cambridge Energy Resources Association (CERA) now finds that "The North American natural gas market is set for the longest period of sustained high prices in its history, even adjusting for inflation" (Hirsch et al, 2005).	Lower emissions than oil or coal.	Production in Alberta peaked at 5.1 trillion cubic feet in 2001 (Hirsch et al, 2005). Liquefied natural gas can be brought over the ocean, but not efficiently.
Oil Sands	Oil sands production hampered by, 1) much higher costs than conventional oil, 2) significant quantities of energy are required to recover and transport. Currently uses large amounts of natural gas for heating and processing. Oil sands producers are considering building coal or nuclear plants as substitute energy sources to replace natural gas.	Deep oil sands cover Alberta — approximately 138,000 km2, which equals 21 per cent of Alberta (Woynillowicz et. al, 2005). The processing releases three times more greenhouse gases than a barrel of conventional oil (Woynillowicz et. al, 2005). Other environmental impacts are destruction of boreal forest, SOX and NOX emissions, water depletion and pollution, and brine and coke disposition.	Projections for oil sands in Canada range from 2.2 million barrels per day by 2015 (National Energy Board, 2004) to 4 million barrels per day by 2020 (Cavallo, 2005). The 2005 number shows world consumption of oil at 83.7 million barrels per day (Woynillowicz et. al, 2005).
Coal	It could take over a decade to build a large coal liquefaction plant.	Emissions from coal are very high. "Clean" coal plants produce less emissions, but they are costly to build, and it is costly to separate the CO2 and dispose of it (Benner, 2004).	At the current rate of consumption, the coal reserve will last about 250 years (Weisz, 2004). However, coal production will peak long before the total supply is exhausted and the rate will increase if used to replace oil.
Solar	Technology is improving but the cost still cannot compete with grid power.	Solar technology is developed enough to play a major role in fending off global warming, but only if we increased its use 700-fold in the next half-	Intermittent in nature.

Energy Source	Economic and Technical Barriers	Environmental Impacts	Supply
		century, which is a 14 per cent annual increase, less than half the current global rate (McKibben, 2004).	
Wind	The cost of installing wind generation capacity has fallen and large wind farms, especially, are more economically feasible (Natural Resources Canada, 2005).	If renewable, non-GHG producing wind power was to displace conventional fuels used for electricity generation — it would result in significant energy and GHG savings. For example, if the Canadian Wind Energy Association's (CANWEA) goal of 10,000 MW were achieved, it would result in energy savings of up to 170.7 PJ and avoid 10.9 Mt of associated GHGs (Natural Resources Canada, 2005). Research has found increased bat deaths around large wind turbines.	Wind strengths vary and cannot guarantee continuous power and need energy storage techniques and/or backup sources of power.
Hydro	In Canada, hydroelectric power is abundant and represents two-thirds of electricity supplies (Canadian Hydropower Association, 2004).	The most obvious impact, for large hydro-electric dams is the flooding of vast areas of land, much of it forested or used for agriculture.	In North America and Europe, a large percentage of hydro power potential has already been developed (Baird). Small-scale capacity may increase in the future as technology improves.
Biofuel	Ethanol from biomass is currently utilized in the transportation market, although it is subsidized in the US.	Land availability for growing biomass sources, such as corn and switchgrass, is a concern for many, although some biomass comes from waste. To be truly renewable, the harvesting of biomass fuels should not exceed the rate at which they're grown. Analyses of the energy	The International Energy Agency estimates that bio-energy, if properly developed, could meet more than a third of the world's current energy consumption (Barlow, 2004).

Energy Source	Economic and Technical Barriers	Environmental Impacts	Supply
		used and emissions created in producing the biofuel, as well as in burning it, vary depending on raw materials biofuel.	
Hydrogen	May be good for small-scale level; however, converting to hydrogen would need extensive and costly retrofitting of global transportation and fuel distribution networks. Specific barriers: ➢ platinum supply ➢ high cost of storage ➢ energy sink ➢ high cost of conversion Still in the experimental stages.	To avoid the carbon emissions from creating hydrogen with natural gas, hydrogen may be produced from non-fossil resources, such as water, using a renewable energy source such as solar energy.	Hydrogen is abundant but needs to be separated from other elements.
Nuclear	Large cost of building nuclear power plants. It would take many power plants to replace the energy we get from oil.	Question of the safety of storage of nuclear materials, along with possibility of radiation from nuclear accidents.	Some predict a uranium shortage.