

**A METEOROLOGICAL INDUSTRY  
STRATEGY FOR CANADA**

**Canadian Meteorological and Oceanographic Society (CMOS)**

**November 27, 2001**

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## Foreword

This document reflects the commitment of many individuals to the advancement of the meteorological profession in Canada. Readers are encouraged to absorb everything contained in this report, including the attached studies.

As the co-chairs of the private sector task force that prepared this document, we would like to thank the many private sector members of the Canadian Meteorological and Oceanography Society (CMOS) who contributed their time, skill and finances to the development of this Canadian Meteorological Industry Strategy. We would also like to acknowledge the courage and vision of the management of the Meteorological Service of Canada for their openness to change and their encouragement, both moral and financial, to the CMOS Private Sector Task Force to develop this strategy paper.

An essential background study for this paper was carried out by Doug Russell and staff of Global Climate Strategies International (GCSI) on very short notice and under very severe time constraints. The GCSI study, done for the Meteorological Service of Canada (MSC) under a contract with CMOS, produced some results that opened many eyes about the state of the weather and climate industry.

David Lewis and the staff of HLB Decision Economics undertook – again under very tight time constraints – a first-ever economic study of the weather industry in Canada. That study opened eyes in other ways by demonstrating graphically how important Canada’s investment in weather is to the economy and by also showing why changes are needed in the way weather data is accessed and priced.

Finally, the co-chairs acknowledge, with special gratitude, the role played by Jeff Carruthers of Sussex Circle Inc.- Le Cercle Sussex as advisor, strategist, writer and presenter in all phases of the development of this strategy. In addition, we thank Ron Jackson of Sussex Circle for his useful advice and his management of the HLB contract.

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## Background

The Canadian Meteorological and Oceanographic Society (CMOS), the national society of individuals and organisations dedicated to advancing atmospheric and oceanic sciences and related environmental disciplines in Canada, has long had an interest in creating the right climate (so to speak) so that new weather and climate products and services flourish in Canada.

With this objective in mind, private sector members of CMOS met with senior officials at Environment Canada in October, 2000. At that meeting, Marc-Denis Everell, the then newly-appointed Assistant Deputy Minister of the Meteorological Service of Canada (MSC), expressed interest in having CMOS provide suggestions on how the private and public sectors could develop a new approach to weather and climate in Canada. This in turn triggered the formation of a special private sector task force, with Environment Canada's participation (primarily in an advisory role), of CMOS, with the express mandate of developing a weather industry sector strategy that could be considered by CMOS and shared with MSC and others within the federal government.

Environment Canada provided a financial contribution to support the work of the task force through the spring and summer. The task force undertook to produce a report recommending the key ingredients and next steps for a weather sector strategy designed to create the right kind of environment for a significant expansion of the weather industry in Canada.

Members of the private sector task force (the "task force") held their first organizing meeting in Ottawa in February 2001 (see Appendix A for membership). One of the first initiatives of the group was to propose a baseline study of the meteorological private sector. EC contracted with CMOS to undertake this study to establish the number and size (including revenue) of the key players. Global Change Strategies International (GCSI) undertook this task, using a survey of Canadian firms and individuals providing meteorological services. The survey results were then used to determine the overall size (in revenue) of the industry.

The GCSI survey also explored issues that industry respondents felt would need to be addressed in the near future. The results of the GCSI study "Baseline Status of the Private Meteorological Services Sector in Canada" are described in some detail in the next section of this report. A copy of the complete report is attached as Appendix B.

During its deliberations, the task force identified a number of issues and irritants that needed to be addressed in any successful weather industry sector strategy. These included issues surrounding access to and pricing of data and information produced by Environment Canada and used by both the private and public sectors to produce "value-added" products and services for use by Canadians and foreign clientele.

As the discussions proceeded into the summer months, the task force used an interim report to the broader CMOS membership at the annual CMOS Congress (in Winnipeg) in June 2001 to raise a number of questions. Participants at the Congress (private sector and Environment Canada) confirmed that the task force was generally on the right track and the task force began work on capturing the various ideas and proposals for a final report, to be published in the fall.

It soon became apparent that an economic assessment of the benefits of weather services for the broader economy, on the one hand, and a comparison with the activities in the United States, where private sector weather services were more advanced, would be extremely helpful. The notion of an economic study was raised in a meeting in June with Dr. Everell of the MSC; he supported the notion, recognizing the value of such a study in providing economic context.

Through the existing EC-CMOS contribution agreement, MSC officials and CMOS subsequently agreed to produce an economic study of the weather industry in Canada. The study, entitled "Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services", was undertaken by HLB Decision Economics Inc. during August and submitted to the task force in mid-September. The key findings of the HLB study are highlighted in the next section of this report. The HLB Report itself is attached as Appendix C.

The conclusions and recommendations of the task force, along with the HLB economic study, were discussed at a special meeting of MSC senior management in Toronto on September 23, 2001. (A copy of the discussion presentation is attached as Appendix D.)

One other survey, an informal e-mail survey of professors and students of meteorology in Canadian Universities carried out by the private sector task force over the summer of 2001, provided important information about the academic portion of the weather sector. (A copy of the e-mail survey questionnaire is attached as Appendix E.)

## The Importance of Weather

Canada's economy is, on the one hand, extremely weather sensitive, given its northern latitude, huge landmass and dependence on resource extraction, primary industry and vulnerable transportation links to distant markets. An estimated \$100-billion+ is at stake in important sectors of the economy like agriculture, transportation, tourism, energy, manufacturing, just-in-time-delivery and retail sales. The financial and insurance sectors, in turn, depend heavily on what happens as a result of good – and bad – weather.

On the other hand, Canada's large land mass and its relatively small and spread-out population and transportation infrastructure make it that much harder and more expensive to gather the weather information that will allow accurate weather forecasting anywhere and everywhere in the country. Thus, it should not be a surprise that Canada spends more per capita for weather infrastructure and forecasting than its neighbor to the south, the United States.

If the suggestions that global warming will result in greater volatility in the weather – more storms, more droughts and floods, more extreme weather – are in fact true, high-quality and accurate weather forecasting will become all the more important for Canada.

Because weather is so important and because the information economy has made it much easier to find out what is happening across the country, major players are increasingly demanding to know more about the weather, both in terms of what is happening now and what is forecast to happen in the days or even weeks ahead. Insurance companies need to anticipate and assess risks of severe storms, as do airlines, trucking companies, Canada Post and couriers. The need to know how to avoid severe weather is an important factor for “just in time” delivery services. Electric utilities and water conservation authorities need to know both short-term and long-term predicted weather so they can regulate water flows and hydro-electric generation and build up inventories to meet heating and cooling demands.

The increasing sophistication of corporate, government and individual users of weather information will increase the demand for faster, more accurate and more customized weather products and services and, in the process, likely place more stress and strain on the existing weather infrastructure.

The Private Sector Task Force believes this stress and strain actually creates an important opportunity for private sector weather providers to take on an increasing share of meeting existing end-use needs, while at the same time creating new products and services to respond to emerging requirements. These same demands will also require greater attention to – and investment in – the core weather infrastructure that gathers the weather information all across Canada and then models all of this information for future timeframes to produce short, medium and long-term weather forecasts.

It would appear that Canada has a considerable amount of “catch up” to play vis-à-vis the United States, where the private sector plays a much greater proportionate role in the

overall weather industry and where the private sector has achieved greater market penetration. The task force also believes that the Canadian weather sector has unique opportunities to pursue in the United States, given its privileged access to the American market. However, it is very difficult to build an export base for these services without a significant home market, something that has been difficult to achieve in part due to the government dominance of the meteorological sector.

## **Weather and the Weather Industry – A Discussion**

As the discussions leading to the final report evolved, each of the studies undertaken by the task force contributed a critical piece of the puzzle that would serve as the basis for the recommendations on the future of the weather industry.

The Baseline study undertaken by GCSI revealed the size and nature of the industry in Canada, along with basic concerns relating to the dominant player in the sector, the MSC. The HLB economic study reflected in economic terms the concerns about the need to change the public/private mix and to address problems of data access and pricing; both concerns were holding back the growth of a viable private weather sector in Canada. The informal e-mail survey of faculty and students in meteorology appeared to contradict the widely held view that the Canadian post-secondary system could not meet the challenge associated with a growth in demand for meteorologists, triggered by potential private sector growth.

The dominance of MSC in the weather industry – something that figured prominently in the other two stories – also appeared in the academic survey, with many of the students preferring government jobs to private sector jobs. The recommendations set out at the end of this report are largely – although not exclusively – derived from the results of these various studies. Readers are urged to review the reports and presentations in the Appendices as though they were in fact an integral part of this report.

### **The Baseline Study**

The Baseline study by GCSI revealed an industry that was smaller than many had thought, less than 100 firms, with aggregate annual revenues of between \$55-million and \$65-million. Pelmorex, is the dominant private sector player. It operates The Weather Network/MétéoMédia and provides weather services to the media and commercial customers and generates some \$30-million in annual revenue. The MSC, which was not covered by the GCSI study, is the other dominant player in the weather sector. It generates some \$74-million in annual revenue, with \$49-million coming from arrangements with NavCanada, Coast Guard and DND, \$10-million in additional “commercial” sales, and the remainder coming from government-to-government, including federal/provincial arrangements.

It is worth noting that the study faced challenges in identifying companies and did not include any large companies that may have in-house capabilities, etc. In this regard, the study may not have captured the whole market in Canada.

According to the GCSI study, the industry players fell into a number of categories, including: climatology/global change; general consulting services; data processing and quality control; training/education; research; software design; modeling; forensic meteorology; operational meteorology; road weather; weather observing; radar services; media weather; and weather derivatives.



More specifically, according to the GCSI report, “Canada’s private Meteorological Sector is small (\$55-\$65M annual revenue) and diverse. The sector as a whole has grown relatively slowly over the past 15 years.”

The information in this report is based on an electronic survey distributed to 77 companies with operations in the sector (37 replies received), 11 in-depth interviews with a representative cross section of firms, and literature and Internet searches.

The GCSI study found that “Firms in the private meteorological sector typically envelop a wide range of disciplines, including meteorologists, engineers, instrument providers, software developers, hydrologists, private weather forecasters, trainers and educators, climatologists, as well as policy analysts and consultants.”

For the purposes of the report, these various firms were categorized as: “traditional” weather service providers (e.g., weather forecasting, briefing, training, weather data gathering and analysis); environmental science and policy development specialists; and instrumentation providers and software developers.

Firms were found to range in size from one-person owner/operator establishments to larger firms that provide meteorological-related services as a part, or branch, of a larger engineering or consulting firm. Very few firms had more than 15 meteorological professionals on staff or generated more than \$5 million in revenue each year. Nearly two-thirds of the respondents indicated they have experienced little-to-no growth in their meteorological staff levels during the past five years. However, of those representing the traditional weather services segment, nearly one half reported moderate to high levels of staff growth. In addition, nearly half of responding firms indicated that they had experienced difficulties in finding qualified Canadians to fill available positions.

“The survey showed that 41% of the responding firms have been in existence for more than 15 years, 27% between 5 and 15 years, and 32% less than five years. Companies are distributed across Canada, but the majority (nearly two thirds) are located in Ontario/Quebec and the Prairie Provinces. Firms conduct the majority of their business in the regions in which they are located, targeting primarily domestic corporations and governments, although nearly two-thirds of responding firms indicated that they also conduct some business outside of Canada.”

The GCSI study identified a number of issues facing the private weather sector as the main impediments to growth, including competition with the MSC for business and staff, the cost of data obtained from MSC and competition with US-based companies. When asked to comment on competitors, respondents claimed that the Government of Canada was their main competitor, while other Canadian and US private sector firms were secondary competitors.

To realize their potential growth, respondents, particularly those in the traditional weather services segment, suggested that it would be necessary to more clearly define the role of the MSC so the MSC is not in direct competition with the private sector. In addition, respondents suggested that increased accessibility and decreased cost of archived and real-time data would lead to improved profitability and opportunities for growth.

To grow, private sector firms also need to attract and retain professional staff. Respondents indicated concern over the capacity of the Canadian education system to provide enough “job ready” graduates in the meteorological/physical sciences. Firms in the sector typically need to conduct focused post-graduate level training to increase the on-the-job functionality of newly recruited staff. In general, the MSC is seen to be able to offer attractive salaries and benefit packages and as a result routinely recruits trained staff away from the private sector, according to the GCSI study.

Several respondents indicated that their ability to compete internationally could be enhanced through increasing levels of formal support from the federal government. Many of these respondents expressed the belief that the increased hiring of Canadian firms by the federal government would enhance their attractiveness to international clientele. Many respondents indicated that enhancements in the relations between the private sector and the MSC are necessary to allow the Canadian private meteorological sector to achieve its full potential. A formal clarification of boundaries between the private and public sectors was seen to be a necessary step in facilitating an improved level of trust that is required for fostering enhancements in this relationship.

In terms of possible future strategies, the GCSI study highlighted the following:

- MSC should clarify its mandate and associated level of services;
- Within the private sector itself, consideration should be given to the re-creation of a private sector meteorological association;
- MSC should, in pricing their services, build in costs covering all expenses borne by the private sector, e.g., taxes to ensure that if they are going to compete with the private sector that they do not artificially lower the price for services in the market place;
- MSC and the private sector should consider joint efforts to improve post-secondary education programs, including possibly taking on a joint responsibility for the operational training of meteorological graduates;
- Canadian government should link with US Government departments and coordinate information gathering and distribution to have a unified North American system;
- CMOS could play a role in helping grow the private sector, including ongoing professional certification, taking on responsibilities akin to those of the American Meteorological Society, and perhaps providing liaison between the government and the private sector.

Many of the conclusions of the GCSI study served as the basis for further discussion by the private sector task force.

## The Academic Survey

The informal e-mail survey of meteorology department heads and students at Canadian Universities by the private sector task force over the summer of 2001 also provided some additional material for review and discussion. Canada's post-secondary institutions produce a small number (fewer than 50 each year) of meteorologists and the respondents believe that the existing academic infrastructure had the capacity to train additional meteorology graduates (and, as a corollary, the current infrastructure does not present a barrier) to meet any increased demand for graduates. This conclusion seemed to contradict some of the assertions by respondents to the GCSI study. The weak job prospects, especially at MSC during the late '90s, had in fact impacted on student enrolments in meteorology. In terms of the attitudes of the students themselves, few saw an opportunity in the private sector; most would prefer to stay in Canada, if possible; most expressed a preference for working in the public sector, because of higher beginning salaries and greater job security.

## The HLB Economic Study

The economic study by HLB Decision Economics Inc., entitled "Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services" viewed the current situation in the weather industry from a different perspective. It applied economic theory and models to the sector.

*Note that as an economic analysis, the study does not address non-economic considerations in the formulation of both private and public policy. Such considerations might include, for example, the government sector's wider mission and commitments in relation to the environment.*

The study posed three questions:

1. What is the economically optimal level of capital investment in meteorological infrastructure?
2. What are the economically optimal roles for the private and public sectors in the provision of meteorological technology, research and services? and
3. What policy options exist for optimizing the public and private sector roles and investment levels in the provision of meteorological infrastructure and prediction services? What are the benefits and costs of these options?

The study yielded five principal conclusions:

1. Just under three-quarters of the expenditures of Environment Canada's Meteorological Services of Canada (\$159 million in fiscal year 2001) involve meteorological infrastructure activities and outputs that address a market failure and thus belong in the federal domain. The remaining expenditures, \$66.5 million in fiscal year 2001, are for the production of value-added services that would be more efficiently provided by private firms;
2. The federal government has permitted the value of the capital stock of meteorological infrastructure to erode over the past 25 years. This erosion has contributed measurably to the nation's sluggish rate of growth in productivity and Gross Domestic Product. Although at one-time Environment Canada's five year capital proposal to Treasury Board<sup>1</sup> of \$280 million would yield net benefits of \$4.6 billion over ten years (a 69 percent annual rate of return), even higher levels of federal infrastructure investment are economically justified;
3. Environment Canada charges more than the optimal price (more than marginal cost) for meteorological infrastructure services, thereby preventing the maximization of the economic and social benefits of weather prediction. Treasury Board guidelines on cost recovery permit the use of the marginal cost pricing framework. On the other hand, the subsidies implied by the marginal cost pricing rule present certain economic and practical problems. Various pricing possibilities are available that serve the interests of public policy (see Box Essay in actual Report);
4. MSC does not impute an allowance for normal profit and commercial risk, taxes, etc. into the prices it levies for its value-added products and services. This places private providers at a competitive disadvantage that limits their growth and inhibits innovation in the private sector supply of such products and services. Treasury Board guidelines permit the use of such imputations; and
5. If the federal government were to withdraw from the provision of products and services in which no evidence of market failure is apparent, the value of private sector output and employment in the production of meteorological services would more than double.

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<sup>1</sup> This figure represents a one-time capital proposal to Treasury Board for the Program Integrity Exercise I (July, 1999). MSC subsequently received some funding (5 million over five years) from this request. It should be noted this figure does not represent actual MSC capital spending plans.

The HLB study drew some other economics-based conclusions, among them:

- Each one-percent improvement in weather prediction accuracy yields at least \$1.02 billion in social benefits over a 30-year period and that the deterioration in the capital stock has almost certainly meant foregone opportunities to improve forecasting accuracy and the associated social benefits (an estimated \$2.6 billion).
- Of the \$225.5 million in MSC outlays in fiscal year 2001, a total of \$159 million (71 percent) are found to support infrastructure activities, with the balance, \$66.6 million (29.5 percent) supporting the production of value-added outputs – activities that would be supplied more efficiently by private firms. (This finding was based on information available from MSC during a short study period and may therefore be subject to adjustment. Note that the GCSI study identified \$74 million as the figure for MSC commercial revenues, including revenue from other government agencies.)
- If Environment Canada were to withdraw from the market for value-added commercial products and services, there would likely be a larger number of private firms and privately generated products and services, a greater private sector investment and innovation in value-added commercial forecasting products and services; and lower consumer prices for value-added commercial products and services.
- The HLB study also examined the impact on market size of Environment Canada's withdrawal from the provision of value-added commercial services. Based on its economic analysis, the private sector in meteorological products and services would expand from its current level of about \$60 million in total annual revenues to between \$159.6 million and \$186.2 million annually (depending in part on the nature of the transition period). If average revenues per firm remain at the current level (of about \$2 million in revenues a year), the number of firms in the Canadian market would expand from about 30 today to more than 110.

## Other Issues and Views

A number of other issues arose during the deliberations of the task force and its interaction with MSC. One was a difference of perspective when it came to examining the options open to the government in terms of reducing MSC's current role in providing numerous so-called "value-added services", in competition with the private sector. For the task force and for the sector players interviewed during the Baseline study, the "solution" was for the government to get out of that part of the business and instead focus on its core strength, namely the operation of the core infrastructure of the national weather system. The issue, in this context, was how quickly could this happen – in other words, the need to develop a "transition" plan.

For MSC, the issues (and the potential solutions) are more complex. For one, there is no clear, simple line between infrastructure and value-added services. Over time, revenues from value-added services have been used to support activities that were underfunded through normal appropriations – the example cited is data archiving, including the necessary quality control functions. Sorting out how and where to draw the line could turn out to be a challenging proposition. A related difficulty facing Environment Canada is the fact that net revenues lost when value-added services are eliminated will not automatically be replaced, in part or in whole, through appropriations. In other words, MSC will not be able to easily redirect resources now dedicated to value-added services to core infrastructure services.

MSC also considers that it is important to maintain the "contracting out" (also known as "make or buy") option should MSC phase out providing "value-added" services. However, the task force perspective is that contracting out should be reserved for core infrastructure activities and not used for "value-added" services; for the latter, the task force is recommending that the MSC get out of these businesses altogether as soon as reasonably possible and that it develop, cooperatively with CMOS, a transition plan to manage the devolution.

It is worth noting that some of the "value-added" services are unlikely to be of interest to the private sector in the near-term. Examples cited are the specialized weather services provided by MSC to NavCanada, the Canadian Coast Guard and the Defence Department. At the same time, the task force feels that some other services – such as road weather forecasting – could be provided by the private sector, but that they need to be disentangled from information and infrastructure sharing arrangements that MSC has recently developed with some provinces, territories, municipalities and Crown Corporations.

Another major issue that will require considerable discussion is the nature of – and pricing for – data that the private sector (and academic clients) require from MSC, in order for them to be able to provide products and services (and undertake research). The consensus that emerged during the task force discussions is that unformatted data should be either free or at marginal cost (with the latter related to bandwidth costs). Users

should be prepared to pay an additional fee if they want (or need) special formatting for data feeds from MSC. The task force felt that a not-for-profit intermediary would be a promising option that should be investigated in detail.

The task force also concluded that some changes in data access and pricing and in the withdrawal from “value-added” services could be accomplished quite quickly (say, in months) whereas other issues might take longer to resolve. The strong feeling was that both should be pursued urgently, with the immediate steps being extremely important to demonstrate progress and the longer-term activities and timeframes being the ingredients of a reasonable transition plan. A number of companies are concerned that data access agreements do not remain in limbo until all the issues are resolved.

## **A New Vision**

The underlying assumption of both the task force work and this final report is that the public and private sectors need to work together to maximize the benefits from Canada’s weather sector, for the general public, for commercial clients, for MSC, for the private sector and for academia. This view is reflected in the Vision that the task force is proposing for the weather sector, namely:

“To develop a uniquely Canadian public/private arrangement so that:

- all citizens and all organizations have instant access to the critical weather and climate information they need, at the lowest cost possible, when they need it and wherever they need it, from competitive Canadian suppliers;
- all Canadian entities know about and adapt to the weather-related risks and opportunities better than those of any other country in the world, thus obtaining an important competitive advantage;
- the accuracy of Canadian weather forecasting improves decade over decade, generating net benefits for the economy”.

The Vision, which would serve as the heart of a new sector strategy for the weather and climate industry, reflects the fact that weather and climate are both particularly vital to life and business in Canada.

## **Benefits from Achieving the Vision**

Successful achievement of such a Vision will have many benefits, among them:

- Canadian weather-sensitive organizations will be able to adapt quickly to changing weather conditions and climate, improve their cost structure and efficiencies, and stay ahead of the competition, both domestic and foreign;
- Canadians will have access to new innovative weather and climate “content”, to help them plan their business operations and recreational lives and to protect property and lives;
- The Canadian financial sector will be able to play a greater role in the burgeoning weather derivatives market; and
- The provinces and territories will have access to new and more accurate weather forecasting for managing their resources and for transportation systems optimization;
- Important export opportunities will be opened up.

The weather-sensitive sectors of the economy – and the economy as a whole – will benefit substantially, through the economic and social benefits that flow from improved weather forecasting and its improved availability to weather-sensitive users. And growth of the weather industry will create new jobs in the knowledge economy in Canada, by providing opportunities and high-quality jobs for graduates of Canadian universities.



## Recommendations

### Recommendation #1:

**The Meteorological Service of Canada (MSC) withdraw as quickly as practical from providing “value-added” services that are or could be provided by the private sector.**

This withdrawal should be undertaken in an orderly fashion over the next five years commencing immediately, based on a timetable and transition plan developed collaboratively by the MSC and private sector representatives nominated by CMOS. This would allow MSC to focus on providing and improving its core infrastructure activities and services.

To implement this recommendation, MSC should agree to the establishment of a joint MSC/Private Sector Committee to:

- Establish immediately and fund a nine-member tri-partite committee, to:
  - Establish the principles that will guide the withdrawal;
  - Review, in detail, the lines of business carried on by MSC and to identify those that potentially should be included in the withdrawal plan;
  - Oversee, as appropriate, the division between value-added and core services;
  - Identify priorities and sequencing;
  - Establish firm dates for MSC to exit commercial services.

Membership of the committee should consist of three persons from MSC, three persons from the ADM’s advisory committee and three nominated by CMOS from the Private Sector Task Force. The first meeting of the committee should be held as soon as possible, with a progress report to be tabled by the end of the following three months.

## **Recommendation #2:**

**The MSC implement as soon as possible (i.e., early in 2002) a new pricing and data access policy, based on “marginal cost pricing”, for companies and institutions to obtain both data and modeling services from MSC, for use in creating “value-added” services for sale to public and private clients.**

A first discussion with industry representatives nominated by CMOS should take place as soon as possible: To establish the principles for the new pricing and data access policy;

- To agree on a definition of “marginal cost pricing” that reflects the concept used in the HLB study; and
- To establish a timetable for implementation that is both speedy and reasonable.

For the purposes of this first discussion, “marginal cost pricing” would mean no-charge for the actual information/data (which is being developed for use by the public), with at-cost charges for access.

To oversee the ongoing development of the new pricing and data access policy, MSC should establish an implementation task force to interface with CMOS representatives of the private sector and the academic community. The task force should be funded by MSC and be charged with developing a consensus draft policy by the end of fiscal year 2001/02, i.e., March 31, 2002.

## **Recommendation #3:**

**The Government of Canada approve the proper funding/investment in Canada’s core weather infrastructure over the next five years, to rectify the erosion since 1976 and to serve as a base for a viable improvement of public-good forecast services by government and “value-added” services by the private sector.**

**This should include an appropriate amount (initially estimated at \$10-million per year) in new appropriations funding, to allow MSC to withdraw from value-added services and to stop using associated revenues to invest in A-base activities.**

To support this recommendation, MSC should undertake to refine the HLB economic study if deemed necessary and, at the appropriate time, share the study with officials of the Finance Department and Treasury Board.

MSC should also identify those resources (human, capital and operating) that are essential to the core infrastructure that are currently being funded (directly or indirectly) by revenue derived from value-added services. This in turn will require a careful and urgent assessment of what services are “core” and should continue to be undertaken by MSC and what services are “value-added” and should be covered by Recommendation 1.

Given the direct relationship between Recommendation 1 and 3, the committee established under Recommendation 1 should oversee the MSC activities in this area.

The MSC should report quarterly to CMOS and other interested parties on both the progress of and basis for its funding requests.

#### **Recommendation #4:**

**The meteorological sector (public/private/academic) develop a multi-year cooperative employment and training plan and examine the benefits of professional certification of Canadian meteorologists, including the standards, testing and organization to be used.**

The multi-year plan would be designed to forecast and advertise job employment opportunities and maximize the use of Canadian graduates, in order to stabilize hiring from year to year. It should include a cooperative plan on hiring and job postings and could include joint forecasting of job hirings, apprenticeships and co-op programs with the private and public sector, and a sector-wide system for posting job opportunities at universities. A small committee should be established to oversee this work and report back with recommendations within six months; membership might include one private sector and one academic member (both nominated by CMOS), a DG-level MSC member and a MSC employee representative.

This same committee should examine the pros and cons of professional certification of Canadian meteorologists and include recommendations on this issue in its report. In both cases, its recommendations and reasoning should be made available publicly.

#### **Recommendation #5:**

**The public and private sector examine how best to encourage innovation and technology transfer, on an on-going basis, to ensure continued improvements in weather forecasting accuracy.**

This work, which should involve both MSC and CMOS, should:

- Engage Industry Canada, Granting Councils, research foundations (federal and provincial) to develop an approach to tackle this issue, including the possibility of undertaking the development of an Industry Canada-sponsored “roadmap” exercise that would examine future directions and barriers to weather and climate science and technology.
- Examine the feasibility (and financing) of a study on the barriers preventing greater commercial sector support of research and development; on the pros and cons of establishing a not-for-profit institution to act as the catalyst for commercializing new science and technology; and on the role of tax incentives for R&D on weather and climate.

**Recommendation #6:**

**The weather sector, both public and private, should work collaboratively to develop a communications/marketing plan to raise the public's appreciation of the value of weather-related services.**

This should include development of cooperative advertising and surveying, to sensitize target markets to value-added weather services, and development of a collaborative web site strategy, to highlight opportunities, detail available services and link to the web sites of public and private weather sector partners.

## Next Steps

The private sector task force is committed to pursuing the implementation of all of the recommendations in this report. This will be accomplished in a number of ways, including:

- Meeting with politicians and senior government officials to promote a dialogue on the importance of the appropriate mix of public and private sector participation in the weather sector, of improved access and pricing of critical weather data, and of enhanced investment in the core weather infrastructure;
- Using the studies undertaken as part of this sector strategy study to help key decision makers recognize the urgency of action by the federal government; and
- Participating in the ongoing dialogue needed to move the strategy forward;
- Determining whether the weather industry needs a private sector association, apart from the CMOS private sector committee, and if yes, determining what role the new organization would fulfill.

In this regard, the private sector task force members believe that considerable progress can be made in a very short period of time (weeks, not months) by building on the work and the dialogue that has already taken place.

## **Appendix A: Membership of the CMOS Private Sector Task Force**

- Ian Rutherford, Canadian Institute for Climate Studies (co-chair)
- Susan Woodbury, Seimac Limited (co-chair)
- Beverly Archibald, True North Weather Consulting Inc.
- Robert Boggs, World Weather Watch
- Neil Campbell, CMOS
- Philip Jacobson, Environment Canada
- Jean-Jacques Rousseau, Centre de Recherche en Calcul Appliqué (CERCA)
- Ambury Stuart, Weather Research House
- Peter Taylor, York University
- Paul Temple, Pelmorex

**Appendix B: “Baseline Status of the Private  
Meteorological Services Sector in Canada” by Global  
Change Strategies International**

# Baseline Status of the Private Meteorological Services Sector in Canada

*Prepared for:*

Canadian Meteorological and  
Oceanographic Society (CMOS)

July 5, 2001  
*Final Report*



**Global Change Strategies International**

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## ***EXECUTIVE SUMMARY***

Canada's private Meteorological Sector is small (\$55-\$65M annual revenue) and diverse. The sector as a whole has grown relatively slowly over the past 15 years.

This study is intended to provide a profile of the private meteorological sector, its past, present and views on its potential in the future. The information in this report is based on an electronic survey distributed to 77 companies with operations in the sector (37 replies received), 11 in depth interviews with a representative cross section of firms, and literature and Internet searches. A profile of the sector in 2001 emerged and is presented in section 4 of the report. Issues raised during the interviews are summarized in section 5 and some considerations for development of future strategies to enhance the private sector are contained in section 6.

### **Baseline Profile**

Firms in the private meteorological sector typically envelop a wide range of disciplines, including meteorologists, engineers, instrument providers, software developers, hydrologists, private weather forecasters, trainers and educators, climatologists, as well as policy analysts and consultants. For the purposes of this report, these various firms have been categorized as:

- "Traditional" weather service providers (e.g. weather forecasting, briefing, training, weather data gathering and analysis);
- Environmental science and policy development specialists; and
- Instrumentation providers and software developers.

Firms range in size from one-person owner/operator establishments to larger firms that provide meteorological-related services as a part, or branch, of a larger engineering or consulting firm, and on to very few firms with more than 15 meteorological professionals on staff generating more than \$5 million in revenue each year. Nearly two-thirds of the respondents indicated they have experienced little-to-no growth in their meteorological staff levels during the past five years. However, of those representing the traditional weather services segment, nearly one half reported moderate to high levels of staff growth. In addition, nearly half of responding firms indicated that they have experienced difficulties in finding qualified Canadians to fill available positions.

The survey showed that 41% of the responding firms have been in existence for more than 15 years, 27% between 5 and 15 years, and 32% less than five years. Companies are distributed across Canada, but the majority (nearly two thirds) are located in Ontario/Quebec and the Prairie Provinces. Firms conduct the majority of their business in the regions in which they are located, targeting primarily domestic corporations and governments, although nearly two-thirds of responding firms indicated that they also conduct some business outside of Canada.

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Most firms provide a wide range of services. More than three-quarters of respondents indicated that they provide services in the area of climatology and climate change. Approximately 50% of the firms provide general consultancy services, while the same number provide data processing and quality control services. Roughly one-third of firms provide services in each of the following areas: training and education, research, software design and air quality services.

The total size of the private meteorological sector is difficult to estimate accurately, but would appear to be in the order of \$55 – \$65 million in annual revenue.<sup>1</sup> Approximately two thirds of this reported revenue is attributable to the traditional weather services segment. Although 90% of responding firms reported making a profit, nearly three quarters indicated that they have experienced low to moderate growth over the past five years. Nevertheless, looking to the future, two-thirds of respondents expect to achieve moderate to high growth in the coming five years, driven largely by climate and climate change-related opportunities and support to ongoing oil and gas exploration operations.

In considering factors contributing to growth, the key factors that firms felt assisted in facilitating growth included the depressed value of Canada's currency, government subsidies or incentive programs and the declining cost and increased availability of appropriate information technology. Business and salary competition with the Meteorological Service of Canada, the cost of data, and competition with US-based companies were identified as the main impediments to growth. When asked to comment on competitors, respondents claimed that the Government of Canada was their main competitor, while other Canadian and US private sector firms were secondary competitors.

## **Issues**

Respondents, particularly those in the traditional weather services segment, suggested that it will be necessary to clearly define the role of the Meteorological Service of Canada so MSC is not in direct competition with the private sector, before they can realize their potential growth. In addition, respondents suggested that increased accessibility and decreased cost of archived and real-time data would lead to improved profitability.

To grow, private sector firms also need to attract and retain professional staff. Respondents indicated concern over the capacity of the Canadian education system to provide enough "job ready" graduates in the meteorological/physical sciences. Firms in the sector typically need to conduct focused post-graduate level training to increase the on-the-job functionality of newly recruited staff. In general, the MSC is seen to be able to offer attractive salaries and benefit packages and as a result routinely attracts trained staff away from the private sector.

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<sup>1</sup> These figures are derived from the responses to the survey, and input from CMOS members. Revenues from small media outlets providing weather information were not included, and there may be additional revenue attributable to the instrument providers. GCSI estimates this additional revenue would amount to no more than 10% higher than the estimated range presented here.

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Several respondents indicated that their ability to compete internationally could be enhanced through increased levels of formal support from the federal government. Many of these respondents expressed the belief that the increased hiring of Canadian firms by the federal government would enhance their attractiveness to international clientele.

Many respondents indicated that enhancements in the relations between the private sector and the MSC are necessary to allow the Canadian private meteorological sector to achieve its full potential. A formal clarification of boundaries between the private and public sectors was seen to be one way of facilitating an improved level of trust that is necessary for fostering enhancements in this relationship.

### **Considerations for Future Strategy**

In the interviews and surveys, respondents were given the opportunity to provide their observations and suggestions as to what might be done in the future to realize more fully the potential market growth in the private meteorological sector. Highlights of their responses follow:

- Within the private sector itself, consideration should be given to the re-creation of a private sector meteorological association;
- MSC should clarify its mandate and associated level of services;
- MSC should, in pricing their services, build in all their costs to ensure that if they are going to compete with the private sector that they do not artificially lower the price for services in the market place;
- MSC and the private sector should consider joint efforts to improve post-secondary education programs, including possibly taking on a joint responsibility for the operational training of meteorological graduates;
- Canadian government should link with US Government departments and coordinate information gathering and distribution to have a unified North American system;
- CMOS could play a role in helping the private sector grow, including ongoing professional certification, taking on responsibilities akin to those of the American Meteorological Society, and perhaps providing liaison between the government and the private sector.

## **1.0 PURPOSE**

The Canadian Meteorological and Oceanographic Society (CMOS) has contracted Global Change Strategies International (GCSI) to research and develop a profile of Canada's private sector in meteorological services<sup>2</sup>. This report addresses the past, present and potential roles of the private sector. It includes summary information on revenues, staffing levels and markets, for past and present markets and their projections, as related to the GCSI review team by representatives of the Canadian private sector in meteorology. The report also provides information on private sector activity in other countries, including the United States, United Kingdom and New Zealand.

## **2.0 METHODOLOGY**

The assessment of the baseline of Canada's private meteorological services sector involved:

- A review of available literature and databases, both in Canada and internationally;
- An e-mail survey of 77 firms in the Canadian private meteorological services sector; and,
- Telephone interviews with 11 of the leading and largest firms in this sector.

Among the key sources consulted in the literature review were the 1983 Report of the Task Force on Level of Weather Services, the 1987 Atmospheric Environment Service (AES) Five Year Plan for Fostering Growth of Private Meteorology in Canada, the 1998-1999 AEP Alternative Service Delivery Review, and the 1998 AES International Comparison Study of National Meteorological and Hydrological Services. A summary of the results of the international scan (including Internet references) and the historical perspective is also found in Annex I of this report.

A detailed survey was prepared and reviewed by both CMOS and the Meteorological Service of Canada (MSC) before being distributed to relevant firms, as identified by CMOS and MSC. A listing of the firms contacted is included as Appendix A. A copy of the survey questionnaire is included as Appendix B to this report. A total of 37 completed surveys were received. Both quantitative and open-ended survey results have been analyzed.

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<sup>2</sup> The scope of Canada's private sector in meteorology is described in detail in section 3.3 of this report. The scope of the sector ranges from small, one-person operations through to significant units of well-established engineering and consulting firms to specialized "boutique" firms offering products and services to corporate and public sectors in Canada and abroad. This study examined firms who offer services in weather forecasting and data gathering and analysis, services in air quality, climate change science and policy, instrument manufacture and development, and consulting services related to environmental issues.

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An in-depth questionnaire was developed and approved by CMOS and MSC for use in the telephone interviews that were conducted with 11 representative firms in this sector, as identified by CMOS and MSC. A listing of the firms that participated in the telephone interviews is included as Appendix C, and a sample of the interview guide is attached as Appendix D.

Results from the research, survey and interview stages were compiled and consolidated and preliminary findings prepared. A review session was held with members of the project advisory team to discuss the appropriate interpretation of the findings and to decide their importance in relation to the terms of reference for this study. This final draft report has taken into account the comments from the project team.

### **3.0 BACKGROUND INFORMATION – KEY ORGANIZATIONS IN METEOROLOGY IN CANADA**

#### **3.1 Meteorological Service of Canada (MSC)**

The Meteorological Service of Canada is part of Environment Canada. Its mission is to anticipate and respond to the evolving needs and expectations of Canadians and their institutions for meteorological, hydrological and related information and prediction services thereby helping Canadians adapt to their environment in ways that safeguard their health and safety, optimize economic activity and enhance environmental quality.

With total 1999-2000 gross expenditures of \$308 million, and net expenditures of \$247 million on Weather and Environmental Predictions, MSC also oversees a \$375 million infrastructure and:

- Provides weather forecasts and warnings of extreme weather events and hazardous air quality;
- Monitors atmospheric conditions and the quantity of water in Canadian lakes and rivers;
- Forecasts ice and wave conditions on navigable oceans and inland waters;
- Monitors and predicts the state of the climate;
- Leads the development of atmospheric science and related environmental prediction in Canada; and
- Is Canada's official source for public weather warnings and the principle scientific authority for standards, information and advice on the past, present and future states of the atmosphere, hydrosphere and cyrosphere.

### **3.2 Canada's Private Meteorological Services Sector**

Canada's private meteorological services sector can be described as having a high level of breadth and heterogeneity. Firms range in size from one person owner/operator establishments, to larger firms which provide meteorological related services as a part, or branch, of a larger engineering or consulting firm, and on to firms with more than 15 meteorological<sup>3</sup> professionals on staff generating more than \$10 million in revenue each year. Total size of the private meteorological sector is difficult to estimate accurately, but is somewhere in the order of \$55 – \$65 million in annual revenue.<sup>4</sup>

Activities conducted and services provided by these firms cover a broad range and include instrumentation providers, software developers, hydrology experts, private forecasters, trainers and educators, climatologists, as well as policy analysts and developers. For the purposes of this report, these various firms have been categorized as:

- “Traditional” weather service providers (e.g. weather forecasting, briefing, training, weather data gathering and analysis);
- Environmental science and policy development specialists; and
- Instrumentation providers and software developers.

### **3.3 Canadian Meteorological and Oceanographic Society (CMOS)**

The Canadian Meteorological and Oceanographic Society (CMOS) is the national society of individuals and organizations dedicated to advancing atmospheric and oceanic sciences and related environmental disciplines in Canada. CMOS was officially created in 1967 as the Canadian Meteorological Society and adopted its present name in 1977. However, CMOS history dates back to 1939 when it was known as the Canadian Branch of the Royal Meteorological Society.

The Society's aim is to promote meteorology and oceanography in Canada, and serve the interests of meteorologists, climatologists, oceanographers, limnologists, hydrologists and cryospheric scientists in Canada. The Society comprises some 1100 members and subscribers, including students, corporations, institutions, and others who are involved in the educational functions, communications, the private sector and government.

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<sup>3</sup> For the purposes of this study, “meteorological professionals” included individuals trained in meteorology (either in university, post-secondary institutions, or in government) or who are professionals (e.g. engineers, administrators, etc.) with experience in the delivery of services related to weather, air quality, instrument design and development and environmental policy.

<sup>4</sup> These figures are derived from the responses to the survey, and input from CMOS members. Revenues from small media outlets providing weather information were not included, and there may be additional revenue attributable to the instrument providers. GCSI estimates this additional revenue would amount to no more than 10% higher than the estimated range presented here.



## 4.0 BASELINE PROFILE

The analysis of the survey and the 11 in-depth telephone interviews suggest classification of three segments of company activities: “Traditional” Weather Services<sup>5</sup>, Environmental Science and Policy Development<sup>6</sup>, and Instrumentation and Software Design<sup>7</sup>. The following baseline profile provides a description of the characteristics and trends of the overall sector and points out any significant variations across each of the above three segments. The profile is based on the responses received to the electronic survey, and confirmed by the 11 in-depth interviews.

### 4.1 Response to Survey

The survey was distributed to seventy-seven Canadian organizations involved in the delivery of private sector meteorological services. Responses were received from 37 organizations. Of these, 46% are involved in the provision of “Traditional” Weather Services, 38% are involved in Environmental Science and Policy Development, and 16% in the area of Instrumentation and Software Design.

The majority of the largest known Canadian private firms involved in provision of “Traditional” Weather Services responded to the survey. There is confidence that responses have been received from more than 80% of the business in this segment. The response rate dropped off for the Environmental Science and Policy Development segment, and dropped off further for the Instrumentation and Software Design segment. On follow-up, many of the instrument suppliers commented that they do not consider themselves as a part of the private meteorological sector *per se*, and as such saw little benefit from completing the survey.

### 4.2 Size of the Private Meteorological Sector

Responses were requested for both total company revenue<sup>8</sup>, and specifically for the provision of direct meteorological services. Based on survey responses, it is estimated that annual revenue in Canada’s private meteorological sector is in the range of \$55 to \$65 million. More than two-thirds of the reported revenue is derived from the provision of traditional weather services. Figure 1 provides a complete revenue breakdown by service segment.

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<sup>5</sup> Traditional Weather services include, *inter alia*, weather forecasting and briefings, training, data gathering and analysis

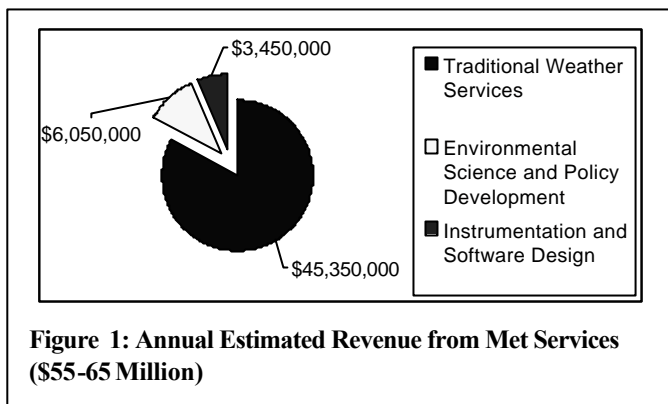
<sup>6</sup> Environmental Science and Policy Development services include, *inter alia*, consulting and engineering services addressing air quality, climate change and other environmental policy issues.

<sup>7</sup> The Instrumentation and Software Development segment is comprised of firms involved in the design and production of infrastructure required to support meteorological activities and includes, *inter alia*, radar design and construction, monitoring equipment production and the software development for operation of the equipment.

<sup>8</sup> In many cases, the “meteorological services division” is part of a much larger corporation offering a wide range of other services. To avoid skewing revenue results, only the revenue directly attributable to the provision of meteorological services is reported in this study.

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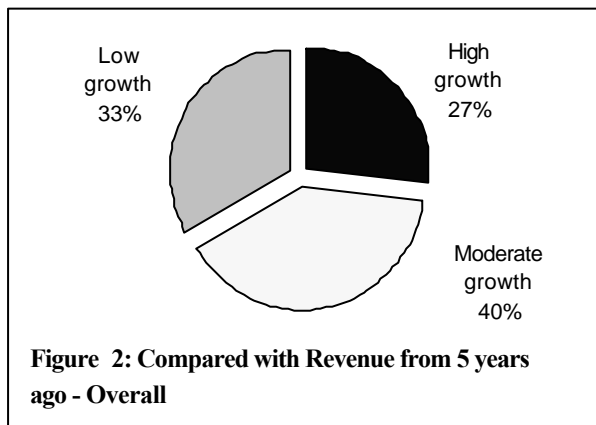
When asked to comment on revenue growth over the last five years, nearly three quarters of the respondents indicated low to moderate growth, whereas the remaining quarter reported a doubling, or more, of annual revenues over that period. Eighty-six percent of respondents reported that they were making a profit, and 29% described themselves as profitable and growing quickly. Among segments, all



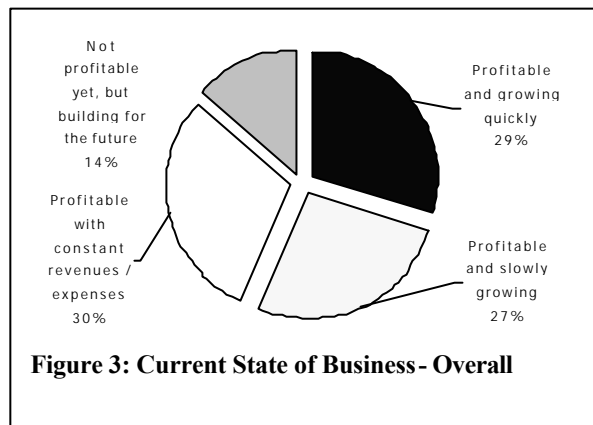
**Figure 1: Annual Estimated Revenue from Met Services (\$55-65 Million)**

Environmental Science and Policy Development firms indicated that they were making a profit, with 70% of the firms reporting growth. However, less than 50% of the Traditional Weather Service providers indicated that they were both profitable and growing.

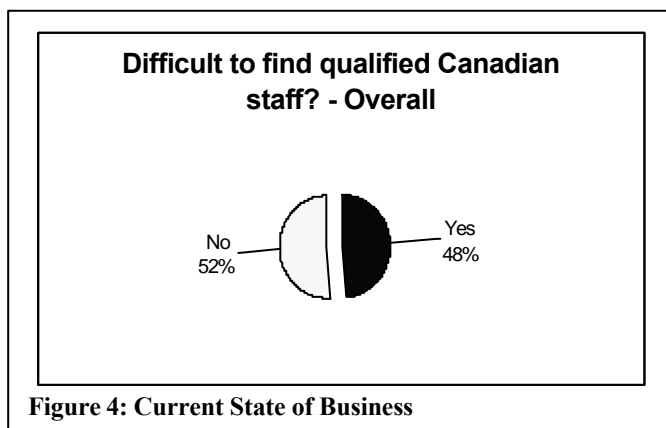
**4.3 Maturity of Sector**



**Figure 2: Compared with Revenue from 5 years ago - Overall**



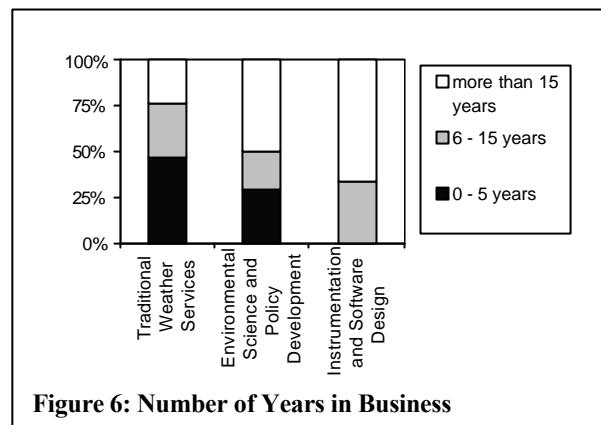
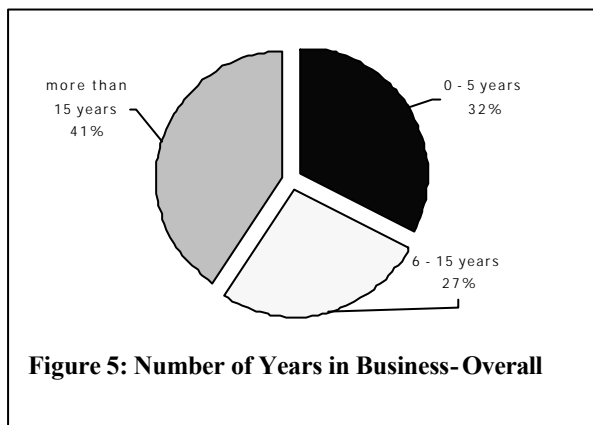
**Figure 3: Current State of Business - Overall**



**Figure 4: Current State of Business**

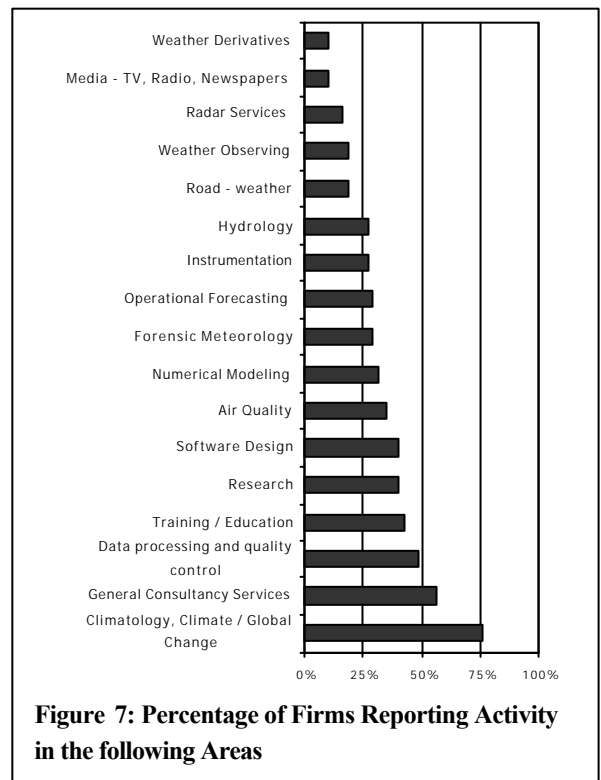
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Figure 5 shows that 41% of the responding firms have been in existence for more than 15 years, 27% between 5 and 15 years, and 32% less than five years. Among segments, the Instrumentation segment is seen to be particularly well-established, with two thirds of the firms in existence for over 15 years, while nearly half of the Traditional Weather Services firms have been in existence for less than 5 years.



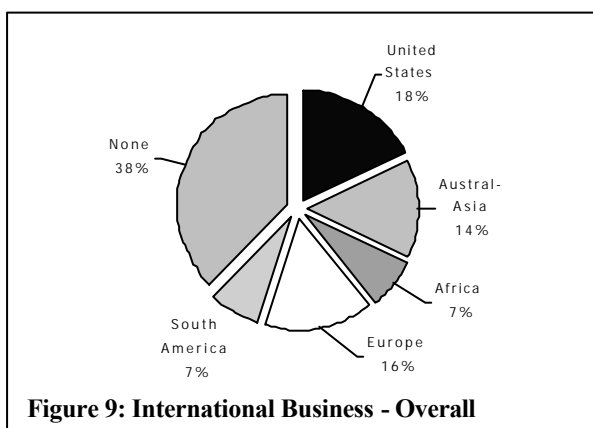
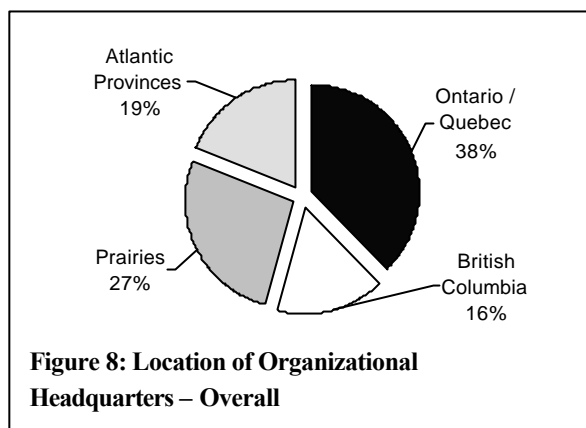
**4.4 Range of Business Activities**

Figure 7 suggests that the responding firms conduct a wide range of activities. More than three-quarters of responding firms indicated that they provide services in the area of climatology and climate change. Approximately 50% of the firms provide general consultancy services, whereas the same portion provides data processing and quality control services. Roughly one-third of firms provide services in each of the following areas: training and education, research, software design, and air quality services.



#### 4.5 Geographic Distribution of Operations and Markets

As shown in Figure 8, responding organizations' headquarters are distributed across Canada, with 38% of organizations based in Ontario/Quebec, 27% in the Prairie Provinces, 19% in the Atlantic Region, and 16% in British Columbia. While the Traditional Weather Services sector is roughly evenly distributed by region, nearly half of the Environmental Science and Policy organizations are based in Ontario/Quebec, and approximately one-third of the Instrumentation and Software Design firms who responded to the survey are headquartered in British Columbia.



Responses suggest that business activity is distributed in roughly equal proportions to the distribution of the organizational headquarters. However, although none are headquartered there, approximately 7% of the responding organizations indicated that they do conduct business in the Territories.

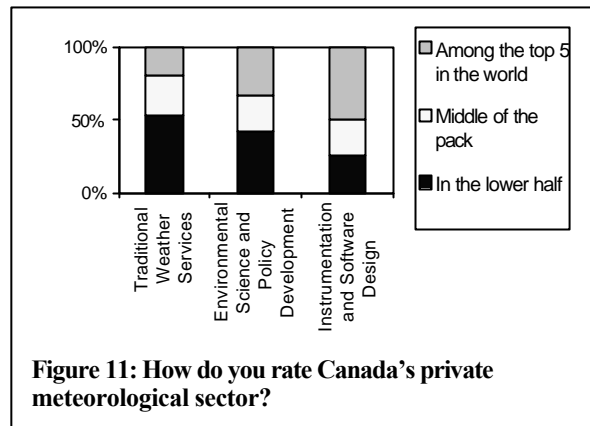
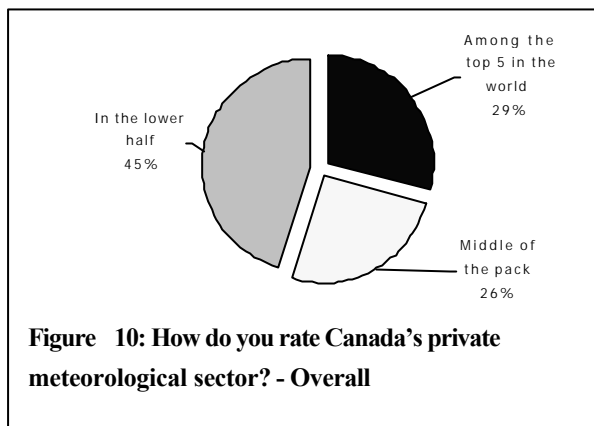
Nearly two-thirds of responding firms indicated that they do business overseas (figure 9). In the Traditional Weather Services segment, however, there is a limited penetration of

Canadian firms in foreign markets weather services, owing in large part to the highly developed United States private sector. In fact, out of the 17 respondents within this segment, 14 indicated they did not conduct business internationally.

#### 4.6 Perception of Canada's Private Sector Compared to Other Countries

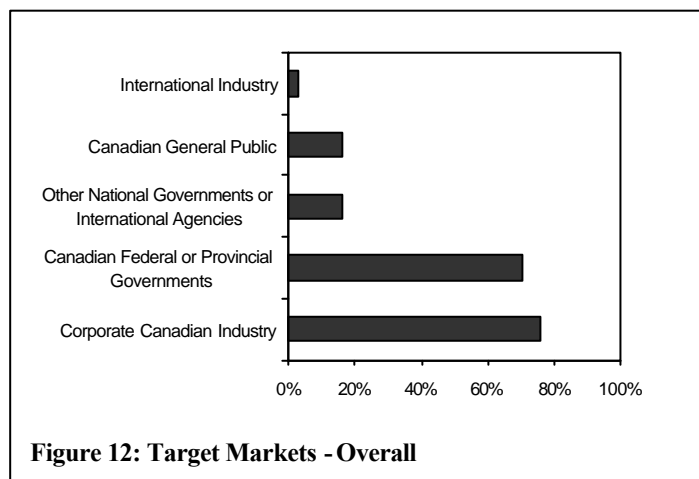
In comparing Canada's private meteorological services sector to those of other countries, half of respondents considered the Canadian sector to be in the bottom half, whereas nearly one third felt that the sector was among the top five in the world. Among segments however, the Instrumentation and Software Design segment had the most positive opinion of the Canadian private meteorological sector relative to that of other nations; less than a quarter of the Traditional Weather Services segment rated Canada highly in this regard. Nearly half of all respondents felt the United States had the most advanced private sector.

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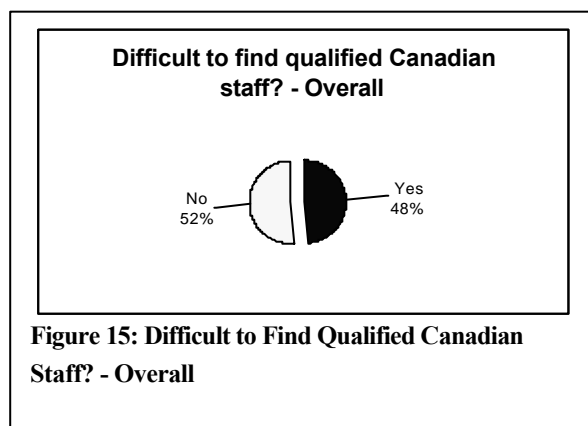
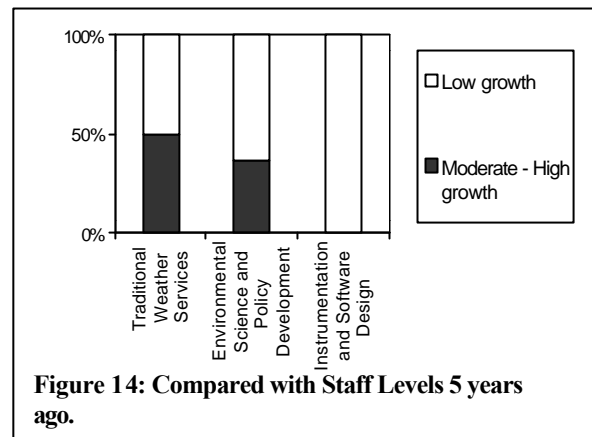
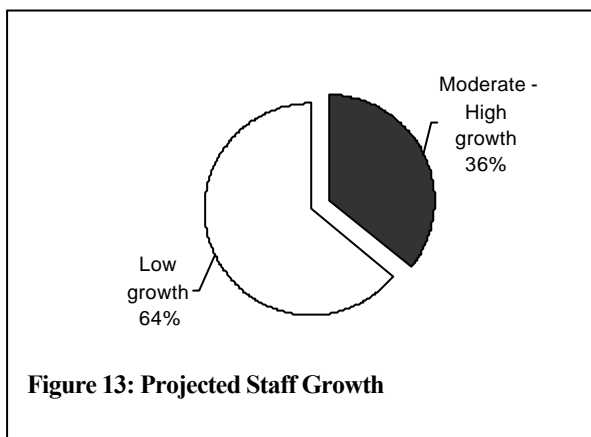
4.7 Target Markets by Economic Sector

Three quarters of responding firms indicated that domestic corporations, primarily in the energy and transport sectors and domestic governments formed their principal target markets. Whereas two thirds of responding firms indicated that they conduct business overseas, less than one in five firms considered other national governments and international agencies to be key target markets, and less than one in ten see international industry as a key target market.



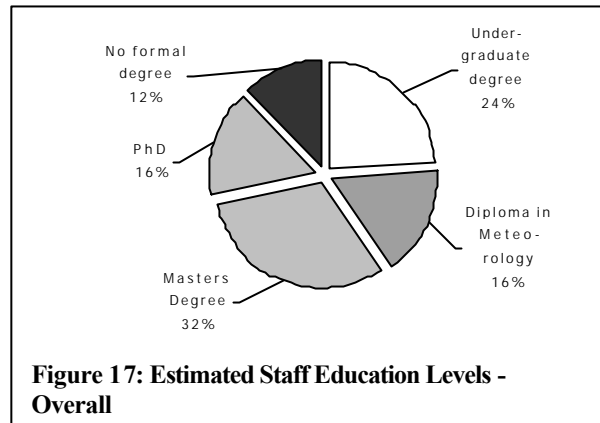
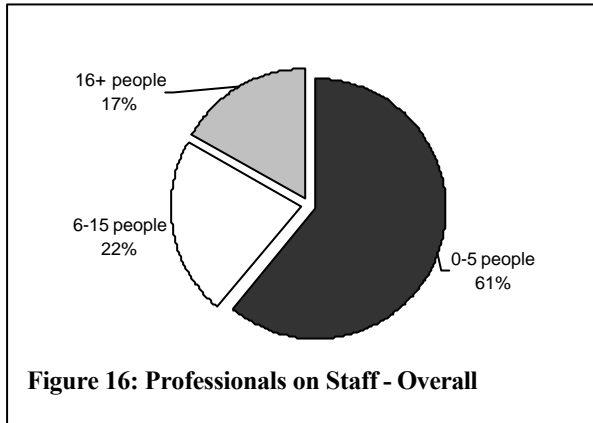
#### 4.8 Staffing Profiles

Nearly two-thirds of the respondents indicated they have experienced low growth (0-25%) in their meteorological staff levels during the past five years. However, of those representing the Traditional Weather Services segment, nearly one half reported moderate to high (25-100%) levels of staff growth. In addition, nearly half of the responding firms indicated that they have experienced difficulties in finding qualified Canadians to fill available positions.

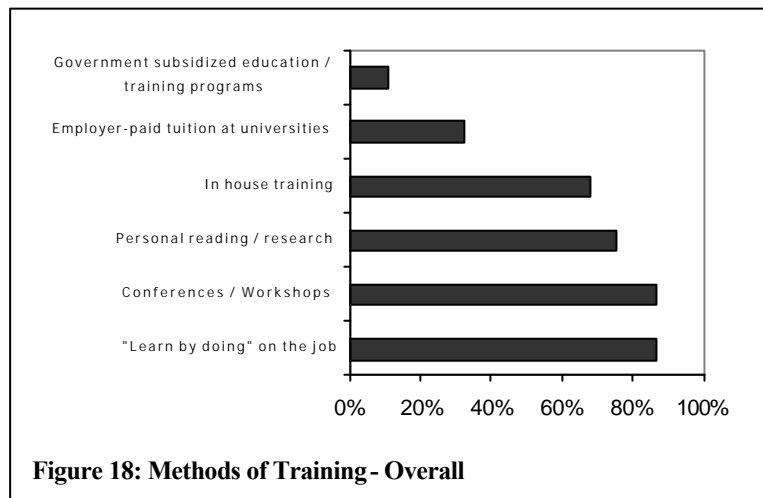


Private sector meteorology firms are typically small, with 61% consisting of less than 5 people. Of the larger firms, only 17% have more than 15 professionals on staff. The Traditional Weather Services segment is made up of especially small firms, with approximately 75% having fewer than 5 professional staff. Among meteorological staff in all three segments combined, 16% are PhD holders, 32% have Master's degrees, 24% Undergraduate degrees, 16% Diplomas in Meteorology and 12% are reported as holding no formal degree.

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When reporting on approaches used to train and update professional staff, most firms indicated they relied on learning by doing on the job, conferences/workshops, personal reading/research, in-house training (see Figure 18). Limited use was made of government subsidized education/training programs.

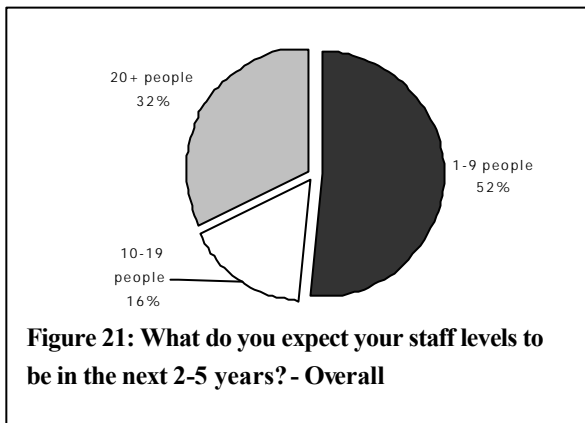
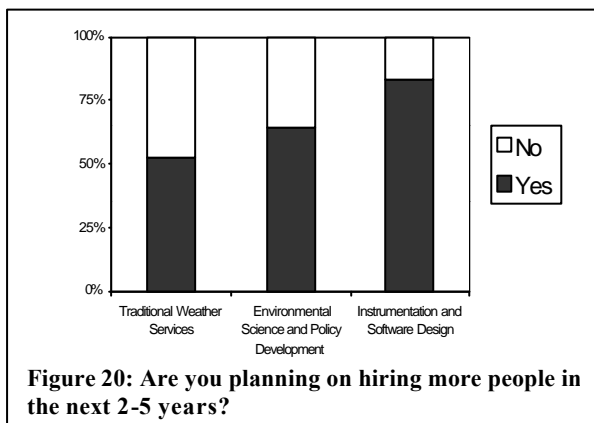
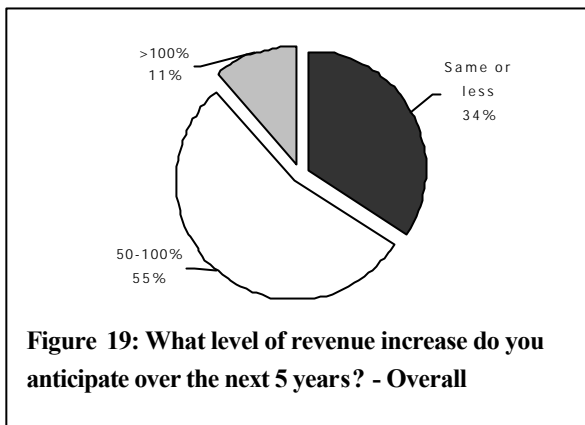


Members of the private meteorological sector consider themselves to be part of the “knowledge economy”. Roughly 80% of respondents indicated that information technology is a key component of their work environment. About 90% of respondents were confident in their levels of comfort in using advanced information technology.

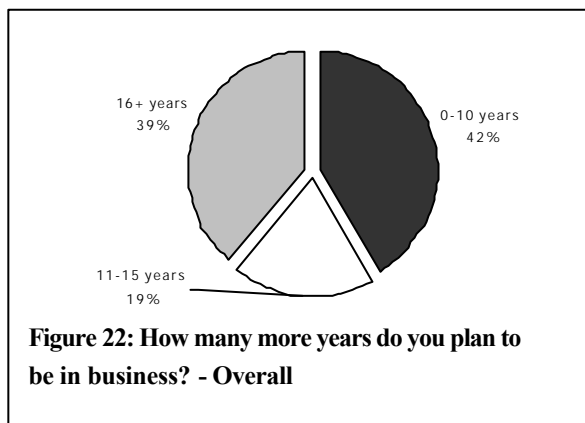
#### 4.8 Outlook for the Future

Looking to the future, two-thirds of respondents expect to achieve moderate (5 to 20% per year) to high growth (more than 20% per year), whereas the remaining third expect revenues to remain constant or decline.

Regarding growth of staff, nearly two-thirds of respondents indicated that they expect to hire additional staff in the next two to five years. In the Instrumentation and Software Development segment, approximately three-quarters of the firms plan to hire, whereas 50% of those in the Traditional Weather Services segment expect to increase staff levels. Despite these expectations for growth, half of the firms expect to “top out” at less than 10 staff.



Forty-two percent of firms expect only to be in business for the next ten years, 19% see their organizational life continuing for up to 15 years, and the remaining 39% expect to be in business for more than 15 years.





#### 4.9 Factors Affecting Future Growth

Respondents were asked to classify a range of potential factors as being either helpful to, or a hindrance to, the growth of their firm. Key factors that helped in their growth include the depressed value of Canada's currency, government subsidies or incentive programs and the declining cost and increased availability of appropriate information technology. Business and salary competition with the Meteorological Service of Canada, the cost of data, and competition with US-based companies were identified as the main impediments to growth. When asked to comment on competitors, most respondents indicated that most competition came from the Government of Canada and other firms in the private sector (Figure 23). Finally, although only 27% of respondents indicated that salary competition with the US affected their business, nearly half felt that salary competition with the Canadian government affected their business.

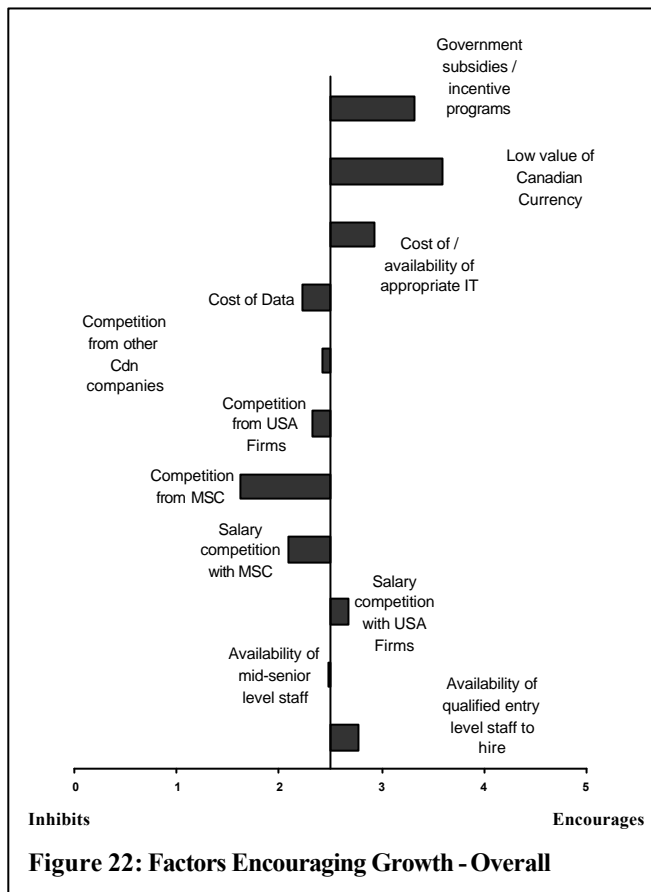


Figure 22: Factors Encouraging Growth - Overall

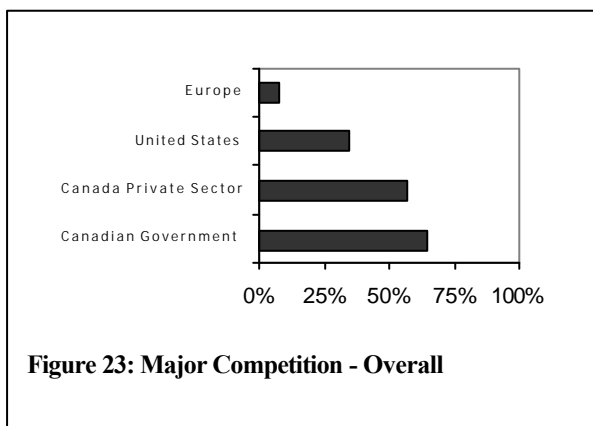


Figure 23: Major Competition - Overall

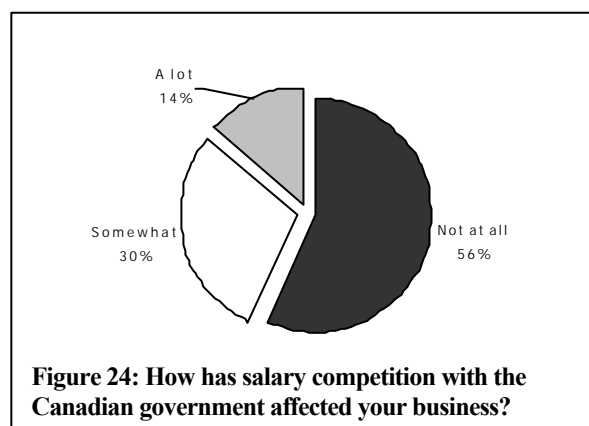


Figure 24: How has salary competition with the Canadian government affected your business?

#### 4.10 Open-ended questions related to the Future

The survey concluded with four open-ended questions on future prospects of private sector meteorology in Canada. The following summarizes the most common responses.

***“What are the main things that would need to change for your company to increase its profitability in the meteorological sector?”***

Twenty-five respondents (about 68% of the total) provided answers to this question. Considering respondents gave multiple answers, three issues received the highest response frequency:

- Decreased competition with the Canadian government / a clear definition of the role of the Meteorological Service of Canada (40% response frequency).
- Increased accessibility and decreased cost of archived and real-time data (32%).
- Increased opportunities to provide services to the federal and provincial governments, including government referral of services (24%).

Other common responses included: awareness of the importance of (private) meteorological products and services available (8%); removal of inter-provincial trade barriers (8%); investment on behalf of the government and the private sector in training (4%); and more effective links to research (4%).

***“What are some key trends you anticipate happening in the Canadian Meteorological Private sector?”***

Seventeen responses (about 46%) were received for this question. Numerous trends were identified, but four commonly mentioned responses included:

- Growth related to climate and climate change opportunities (24% response frequency).
- Greater use of the Internet and wireless applications in knowledge distribution (17%).
- Greater capacity of the private meteorological sector to fulfill other industry needs (12%).
- Change in public' expectation that government will provide all products and services (12%).

***“What can the Canadian government do to help private sector meteorology in Canada?”***

Twenty responses (54%) were received, with four issues being widely noted:

- Provide only basic services and information consistent across the country and adhere to a certain mandate on the level of services (65% response frequency).
- Improve access (at little or no cost) to data archives and real-time data streams, ensuring that data quality and cost regime is equitable internationally (35%).

- Undertake meteorological research and development and transfer the technology to the private sector (35%).
- Support the private sector by awarding jobs to Canadian companies, including initiatives like the referral of MSC customers to private companies (20%).

***“What can the Canadian Meteorological and Oceanographic Society do to help private sector meteorology in Canada?”***

Only six respondents (about 16%) addressed the question. Four of these suggested that CMOS assist in the promotion and capacity building of the private sector, by educating the general public and other industry sectors.

## **5.0 ISSUES**

The 11 in-depth interviews conducted as part of this study were intended to seek the opinions of senior executives in Canada’s private meteorological sector. These interviews, plus the open-ended questions in the e-mail survey, provide a glimpse into a number of issues, in the following categories:

1. Uncertainty regarding government policy
2. Data Issues
3. Staffing Issues
4. Lack of Formal Support for a strong private sector

### **5.1 Uncertainty regarding government policy**

Many respondents, including 40% of those who addressed the open-ended survey question regarding changes required to increase corporate profitability indicated that a formal clarification of boundaries between the private and public sectors would facilitate their growth. A clear delineation of roles would allow an improved level of trust, which interviewees viewed as necessary for fostering effective cooperative interaction between the public and private sectors.

Many interview respondents indicated that enhancements in the relations between the private sector and the MSC are necessary to allow the Canadian private meteorological sector to achieve its full potential. Of those who answered the open-ended survey question in relation to changes necessary for business growth, eight percent of respondents highlighted the existence of regulatory barriers that limited the ease and efficiency of conducting business outside of their home province.

## **5.2 Data Issues**

Data issues constituted a significant element of the concerns raised by the respondents. Approximately one third of respondents to the question of changes necessary to build private sector meteorology indicated that the Canadian government has an opportunity to enhance their efficiency through an improvement in the management of the considerable data resources it has at its disposal. The “speed of business” has accelerated throughout virtually every aspect of the global economy and the meteorological sector is no exception. Many respondents expressed the belief that both the speed of transfer and the ease of use of data received from MSC need to be enhanced.

Concerns about the speed of information transfer is potentially accentuated by limitations on data manipulation in the form that it is received from MSC. Some respondents revealed during interviews that they had to develop their own software in order to convert MSC data into a more easily manipulated format.

Improvements in the efficiency of data transfer are seen as necessary to prevent reliance by the Canadian private sector institutions on information sources in the United States. If these improvements are made it will allow MSC to play the role of “insurance agent” for the collection, archiving and distribution of meteorological data that several respondents have envisioned as an appropriate one for MSC. Thirty-five percent of respondents to the open-ended survey question regarding what the Canadian government could do to help private sector meteorology believe data accessibility (archives and real-time data), data quality monitoring and ensuring that data cost regimes are comparable internationally are governmental issues.

## **5.3 Staffing Issues**

As with any specialized field of science, trained professionals are always in demand. Respondents indicated two primary issues that have affected their ability to acquire and retain the human resources.

The first staffing issue relates to the capacity of the Canadian education system to supply enough “job ready” graduates in the meteorological/physical sciences. As a result, extensive post-graduate training is required in order to increase their on-the-job functionality.

A second, and not unrelated, issue is the cost of labour. The relatively high cost of training both new and existing personnel is accentuated by perceived salary competition with MSC, which is able to offer attractive salaries and benefit packages. Interviewees have identified the loss of skilled professionals, and the associated investments in training, as an issue facing private sector organizations in the meteorological field.

Several firms interviewed reported that they had, as a result of these concerns, engaged in attempts to attract professionals from outside the country. A few respondents indicated that salary competition with the MSC was an impediment to growth. Some firms complained that the MSC had made overtures to attract their trained staff away from them and into the government.

#### **5.4 Lack of Formal Support for a strong private sector**

Several respondents indicated that their ability to compete internationally could be significantly enhanced through increasing levels of formal support from the federal government. About 20% of respondents to the open-ended survey questions concerning changes necessary for growth and the role of the Canadian government in the development of private sector meteorology expressed the belief that the increased hiring of Canadian firms by the federal government would enhance their business. Some interviewees felt that this type of governmental support would increase their attractiveness to international clientele.

### **6.0 CONSIDERATIONS FOR FUTURE STRATEGY**

In the interviews and surveys, respondents were given the opportunity to provide their observations and suggestions as to what might be done in the future to fully more realize potential market growth in the private meteorological sector. From the feedback received and the analysis of the current and past situation, there are a number of issues and opportunities that future work on the private sector strategy may want to consider. These considerations are elaborated in the following section under the headings of what group could/should take the lead in developing them into actions.

#### **6.1 The Private Sector**

The rather small and disperse size of the private meteorological sector is both an asset (in that fewer competitors are in the market place) and a liability (in that it lacks the appearance of a “critical mass” capable of stepping in to fill vacancies left by government if and when it decides to pull out of certain service areas). As well, the relatively small size of the individual companies tends to dampen the enthusiasm to share openly information among themselves companies for fear of ideas being ‘stolen’ or for fear of potential loss of market opportunities. Consequently, there appears to be no one voice to speak on behalf of the private sector. Those respondents who had been familiar with the short-lived 1987 Private Sector Meteorology Association (PSMA) commented that the PSMA had potential but when government policy shifted, the PSMA lost focus and relevance. Now may be the time to re-consider an industry association as part of the overall strategy.

Others commented that more frequent exchange of personnel between the government and the private sector would be of value. Some remarked that such exchanges would only work if an increased level of trust were to be established between the government (in particular, the MSC) and the Traditional Weather Services segment in the private sector.

## **6.2 The Canadian Government**

A majority of respondents, particularly those in the Traditional Weather Services segment of the sector, felt that the Canadian Government must clarify the mandate and associated level of services to be provided by the Meteorological Service of Canada. In fact, between 40 and 60% of overall respondents to the open-ended survey questions relating to private sector growth stated growth would be likely, provided a clear MSC mandate existed on level of service – a mandate which would decrease competition between the public and private sectors. Many felt that a renewed MSC mandate should not only limit the MSC to the provision of weather services for the safety and security of the general Canadian public, but that it should also contain a clause similar to the USA's NOAA to 'not compete with the private sector' in provision of value-added services.

Other specific suggestions made by respondents are as follows:

- MSC should, in pricing their services, build in all their costs to ensure that if they are going to compete with the private sector, then they do not artificially lower the price for services in the market place.
- Redirect efforts to improve post-secondary education programs, as well as raising awareness of the availability of meteorological jobs for graduates.
- MSC and the private sector should consider taking on a joint responsibility for the operational training of meteorological graduates.
- Canadian government should link with US Government departments and coordinate information gathering and distribution to have a unified North American system.

Many interviewees felt that the government of Canada was in the best position to maintain core research and development activities. However, some noted that smaller projects could be 'farmed out' to the private sector where quality, timing, and expertise were more advanced than that of the government. Thirty-five percent of respondents to the open-ended question about the role of the government in helping private meteorological sector development suggested the government should carry out meteorological research and development and transfer the technology to the private sector. Technology transfer includes the transfer of both "hard" - equipment, etc. and "soft" - training and capacity building - technology.

### **6.3 Canadian Meteorological and Oceanographic Society**

Most interviewees felt that even though CMOS was not an industrial association, there were a number of activities it could pursue to help the private sector meet its objective of growth. Some interviewees felt that CMOS could act as a certification board for news service people and other individuals in the meteorological service sector that do not already have certification. Others believe that CMOS has the capacity to continue to act as the liaison between the Private Sector and MSC. Some interviewees cautioned that if CMOS were to take on a more active role in the government-private sector interface, there may be an inherent conflict of interest owing to the large number of government employees who are also members of CMOS. A few interviewees felt that CMOS should benchmark the best of the American Meteorological Association's activities and take on a similar role to the Canadian Private Sector as the American Meteorological Society (AMS) does for their members. One suggestion put forth was the idea of a North American Meteorological Society that advocates for the entire continental North America. Some other suggestions that were made by respondents include:

- CMOS could act as an educator to private sector to enlighten them on other services and activities taking place in other countries.
- Act as a clearinghouse and establish a more active website that has available contracts and opportunities for private sector to pursue.

## ***ANNEX I: SCAN OF INTERNATIONAL SITUATION FOR PRIVATE SECTOR METEOROLOGY AND A SUMMARY OF THE HISTORICAL PERSPECTIVE ON PRIVATE SECTOR METEOROLOGY IN CANADA***

### **1. Overview of private meteorological services abroad: United States, United Kingdom, and New Zealand**

Given that the atmosphere knows no political boundaries, international cooperation is prevalent with respect to meteorological services and products on sectoral, regional, national and international levels. On the international front, the World Meteorological Organization (WMO) is the authoritative scientific voice on the world's atmosphere and climate. As such, the WMO facilitates worldwide cooperation in the establishment of stations charged with making meteorological and applied observations, promotes the standardization of observations and their dissemination and encourages research and training in meteorology and related fields<sup>9</sup>. WMO guidelines regarding the relationship between National Meteorological Services (NMSs) and the private sector urge the latter to respect the principles of international data exchange and encourage their mutual collaboration to achieve the maximum information use.

Traditionally, basic meteorological services, i.e. data collection and data quality assurance, and publicly issued forecasts and warnings and all aspects related to national security, have been provided by National Meteorological Services (NMSs). However, the advent of advanced telecommunication networks as well as cutting edge technology and equipment has not only facilitated the exchange and availability of real-time or archived data but has also expanded the range of meteorological products and services beyond just the weather. Environmental concerns such as air and water quality, global warming and ozone layer depletion have also created a demand for applied meteorological/atmospheric science services. In some countries, NMSs have ventured into the provision of specialized meteorological services and value-added products, which, in some cases, has resulted in confusion concerning the roles of the public and private sectors. In other cases, the NMSs have refrained from provision of specialized services and have referred requests for such services to the private sector. In order to gauge some international activities in private sector meteorology an internet scan was conducted for the following countries: the United States, the United Kingdom and New Zealand. The terms of this contract limited the scan to information that is publicly available in other countries. The GCSI research team conducted a search of the World Wide Web for this information, and the web sites visited as part of this study are footnoted in the section that follows.

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<sup>9</sup> <http://www.wmo.ch>



## **United States**

The National Weather Service (NWS) is the U.S. federal agency supplying:

*“weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters, and ocean areas for the protection of life and property and the enhancement of the national economy”<sup>10</sup>.*

The NWS receives policy direction and funding from the department of Commerce and the National Oceanic and Atmospheric Administration (NOAA) and appears to foster and support private sector organizations, considering them *“critical intermediaries to make NWS information available to all and to provide specialized services outside the NWS mission”*.<sup>11</sup> To this effect the NWS website contains a list of (over fifty) links to U.S. based commercial meteorological service providers. The list was compiled in conjunction with the American Meteorological Society, the National Weather Association and the Commercial Weather Services Association.

The scope and size of private sector meteorological operations in the U.S. covers a wide spectrum. A large number of companies provide meteorological intelligence in one or more of the following areas: agriculture, forestry, energy, the environment, telecommunications, transportation (Intelligent Transportation Systems and road forecasting), aviation, agribusiness, construction, leisure events and film. Also, weather risk management and weather forecasting as applied to legal and insurance industries are common markets. Services and products fulfilling the environmental engineering/atmospheric sciences areas include: research, water management and flood control, air quality and noise pollution, air modeling, and remote sensing applications. Media services are not restricted to radio and television broadcasts but are also provided for Internet and wireless markets. A few companies design and develop meteorology-related prototype hardware; others develop software and analyze data. Client bases range from small-scale farmers, homeowners affected by adverse weather and film producers to the U.S. Department of Defense and NASA.

## **United Kingdom**

The Met Office<sup>12</sup> is the United Kingdom’s (UK’s) national meteorological service, initially formed in 1854 as a department within the Board of Trade. In 1996 it became a Trading Fund, the closest a government department can get to a commercial company, and in 2000 it launched a new corporate identity. Traditionally focused on the weather, the new Met Office also looks at environmental impacts and offers a series of consultancy services. Consultancy services include: certified statements and legal reports, sewer flooding, fog studies, weather sensitivity analyses, Geographic Information Systems applications, climate change applications, among others. The

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<sup>10</sup> <http://nws.noaa.gov>

<sup>11</sup> <http://nws.noaa.gov>

<sup>12</sup> <http://www.metoffice.gov.uk>

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Met Office's Services for Business<sup>13</sup> web page indicates they serve these sectors: academia, agriculture, building and construction, energy, the environment, health, insurance, legal matters, marine and offshore, media, new media (web-based), transportation, retail and manufacturing, leisure, telecommunications, utilities and weather forecasting companies. Unlike the U.S. NWS, the Met Office does not offer links to private services; Internet searches generate very few company names involved in the provisions of weather consultancy services.

### **New Zealand**

In New Zealand's case, the 1980s represented a period of increased pressures on government funding for meteorology, a concomitant governmental "user pays" philosophy for specialized services and a move towards increased autonomy and accountability for government departments. Competition with the private sector and reforms of publicly funded science resulted in the formation of MetService in 1992<sup>14</sup>. MetService, a State-Owned Enterprise, focuses on operational meteorology and weather forecasting services geared towards the Minister of Transport, civil and military aviation, the media and industry. Services listed on their Corporate Information page include: information presentation services (from weather data to stock market data), aviation services (for domestic and international airlines), national weather services (data collection and analysis), and systems development. MetService is also equipped with a meteorological consulting service division consisting of one meteorologist. Internet scans for private meteorological companies give few results: subscription-based weather forecasts (for the horticultural sector, for example) and software vendors.

## **2. Historical Perspective of Meteorological Services in Canada: State of the Private Sector**

For the last three decades, increasing expectations of levels of service accompanied by decreasing financial and human resources have placed pressures on Canada's national meteorological service. The issue of allocating more responsibility for provision of services to the private sector has arisen several times but clear government policies on the demarcation between public and private roles are lacking. Three publications assessing the level of service of Canada's national meteorological service and also containing suggestions and actions regarding the interface between public and private sector meteorology provide a historical context with respect to meteorological services in Canada.

In 1983 the Atmospheric Environment Service (AES) of Environment Canada (the forerunner to today's MSC)<sup>15</sup> commissioned a Task Force to recommend the appropriate level of meteorological services that the federal government should provide to the Canadian public. The

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<sup>13</sup> <http://www.metoffice.gov.uk/business/index.html>

<sup>14</sup> <http://www.metservice.co.nz/index.asp>

<sup>15</sup> Report of the Task Force on Level of Weather Services, July 1983. Environment Canada – Atmospheric Environment Service.

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Task Force described a series of challenges the AES had been facing since the mid seventies including: increasing demands for more specialized and localized meteorological services; new computer, satellite, weather radar, communication and automated weather station technologies in relation to data acquisition and forecasting; a period of fiscal restrictions resulting in cutbacks in terms of services and weather centres; and the onset of program evaluations and reviews, which were aimed at trimming government spending. The AES was able to maintain its general level of service by taking advantage of new technologies. Although new demands were not always met, programs in existence took on increased responsibilities and were able to satisfy some expectations. In the late 1970s, service cutbacks, particularly the closure of weather offices, resulted in a strong public reaction forcing several decisions to be reversed. The government's inability to implement the public weather service cutbacks led to a decline in infrastructure with regards to observing programs, research and training. The demands of larger user groups were met by formal working agreements between government departments. Private sector meteorology emerged during this period, initially as one-person shops, then as parts of larger U.S. based firms and finally as Canadian consulting firms. The nascent private meteorological sector was regarded by the AES as supplementary to their service.

Based on company listings with CMOS, the Task Force on the Level of Weather Services, in 1983, found that the majority of private companies:

*“[were] not involved primarily in the provision of weather services. Rather they offer[ed] services in other aspects of meteorology: the design, manufacture and sale of meteorological instruments; the undertaking of environmental quality studies; the conduct of research and development; and engineering consultation. There [were] only a handful of large companies whose business [was] the provision of weather services, who [had] infrastructures comparable to a forecast office of the Atmospheric Environment Service. The remaining firms, which appear[ed] to be numerous. . .[were] small companies with one or two professionals. . .usually retired federal meteorologists who [had] set up a consulting firm. The most visible and talked about private meteorological firms [were] those based in the United States, but providing weather services in Canada. They [were] most visible because of the market they [sought] – the provision of tailored and personalized weather forecasts to radio and television stations[.] Finally, there [were] meteorologists working for large, highly weather -sensitive corporations such as hydro companies, and some provincial departments such as the Environment Ministry of Quebec and the Forestry Service of Alberta.”<sup>16</sup>*

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<sup>16</sup> Report of the Task Force on Level of Weather Services, July 1983. Environment Canada – Atmospheric Environment Service. p 62-63.

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At that time, the **potential** market for Canadian private sector meteorological services was estimated at a hundred million dollars, of which only a fraction had been tapped. The Task Force identified four major private sector concerns that had the potential to inhibit their growth:

- Competition for business with the AES and the need for role definition;
- Difficulty in attracting professional meteorologists to the workplace due to the lack of graduates and salary competition with government services;
- The need for the federal government to provide professional accreditation, allowing their penetration into international markets; and,
- Some form of protection from U.S. based meteorological firms.

The Task Force recommended the modification of the “single service” system to one recognizing the roles and responsibilities of other bodies, including the private sector. The Task Force recommended the definition of core, selective and miscellaneous services, suggesting that private sector meteorologists could perform the miscellaneous services and the AES could contract-out selective services. The Task Force recognized that the AES had had a policy to support the private sector that was never implemented. Finally, to help the development of the private sector, the Task Force offered the following concrete steps: the formulation of a clear government policy, fostering open lines of communication (between the public and private sector); the development of an accreditation system and setting of standards to ensure the quality of meteorological services; and the deferral (on behalf of the AES) of miscellaneous services to the private sector.

In 1985, the Nielsen Task Force and the Auditor General recommended that the AES delineate the services they could provide Canadian public from general revenue and the services the private meteorological sector could supply. In May 1986 the Minister of the Environment approved AES’ Level of Service policy, and the AES began developing a five-year plan to strengthen private sector meteorology in Canada<sup>17</sup>. The five-year plan had the dual objective of fostering the growth of Canadian private sector meteorology while improving the quality, quantity and applications of meteorological products and services. The Plan assumed that equal efforts would be made by the private sector and strong commitments for continued collaboration on behalf of the government and industry would remain constant. A Private Sector Meteorological Association was formed for these purposes. The Plan enumerated the challenges and agenda for action for the following rubrics:

- 1) communications, involving open lines of idea exchange, accessibility to federal training and funding programs;
- 2) policy development and implementation, creating a clear boundary between basic and specialized services, covering data accessibility issues, personnel and technology transfer;

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<sup>17</sup> Fostering Growth of Private Sector Meteorology in Canada: A Five-Year Plan, April 1987. Atmospheric Environment Service – Environment Canada.

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- 3) market and product development, including market identification and marketing strategies and joint pilot projects in R&D; and
- 4) increased access to meteorological data, creating better dissemination systems via private sector distribution.

The 1987 Five-Year Plan was left unimplemented. In fact, further budgetary constraints in the late 1980's gave way to a period of aggressive cost recovery on behalf of the Atmospheric Environment Service. As a result, the private meteorological sector experienced little growth between 1988 and 1996, especially among those companies providing traditional meteorological services.

As part of government-wide downsizing and the move to examine alternative means for delivery of service to the public, Environment Canada, with the assistance of a number of recognized consulting corporations, conducted an Alternative Services Delivery (ASD) study of the newly named Atmospheric Environment Program (AEP), beginning in the spring of 1997<sup>18</sup>. The ASD study not only addressed the challenges jeopardizing the AEP's sustainability but also reported on relationships between the various stakeholders and analyzed the AEP's mandate, financial sustainability, organizational structure and human resources management. National consultations covering a wide range of concerned Canadian stakeholders were held across Canada in the spring of 1998. Findings were summarized into four major categories: AEP's importance as a National Program, AEP's mandate and role, program funding strategies, and required program characteristics.

The majority of stakeholders agreed on the fact that the AEP fulfils an important role in the quality of life of Canadians and should be maintained as a national program. However, comments were made regarding the fragmented nature of the AEP's service delivery mechanisms, providing examples such as inter-regional price discrepancies and levels of service. Stakeholders saw the need for the AEP to have a clear mandate, favoring a legislated approach with allowances for flexibility in case of new requirements and issues. Definitions of public good services (e.g. quality forecasts, hazard warnings, national data quality standards, research support, etc.) and AEP's involvement in commercial activities were considered essential. Regarding funding, most participants agreed that public good services should be fully supported by tax revenues but many strongly disagreed to any tax-based subsidizing of commercial activities. Partnerships between the public and private sector were seen as ways to deal with funding issues. In general, participants felt the AEP should have the following characteristics:

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<sup>18</sup> Environment Canada National Consultation on the Atmospheric Environment Program conducted by Price Waterhouse Coopers, August 1998.

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*“a coherent national program, a clear mandate, a strong scientific base, financial flexibility, effective partnerships, staffing and compensation flexibilities, client responsiveness, [and] program visibility.”<sup>19</sup>*

In 1999, the AEP became the Meteorological Service of Canada and, in an effort to revive a collaborative spirit between the Meteorological Service of Canada (MSC) and the private sector, the Canadian Meteorological and Oceanographic Society (CMOS) has formed a private sector steering committee with the express purpose of engaging the private and public sectors in support of the development of Canadian private sector meteorology.

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<sup>19</sup> Environment Canada National Consultation on the Atmospheric Environment Program conducted by Price Waterhouse Coopers, August 1998, p 4.

**APPENDIX A: ELECTRONIC SURVEY DISTRIBUTION AND RESPONSE**

**38 Surveys Received**

1 Responded  
 2 Did not respond

**Company**

1 Campbell Scientific (Canada) Corp.	1 WeatherWorks Consulting	2 Cormorant Ltd.
1 Canadian Institute for Climate Studies	1 Wm.C.Thompson & Associates Ltd.	2 Oceans Limited
1 Coastal Ocean Associates	1 World Weatherwatch	2 Unitec Canada Ind. Ltd.
1 Enviromet International Inc.	1 Zephyr North	2 LMI Automotive
1 Fulford Meteorological Services Ltd.	1 Acres (St. John's NF office)	2 Info-Electronics H.P. Systems
1 G.S. Strong, Meteorological Consultant	2 ATC Management Systems / CAE	2 Adga Group
1 Global Change Strategies International	2 Interior Weather Services Ltd.	2 Environmental Remediation Eq't Cda
1 Houle-Rutherford Consulting Inc.	2 J.P. Management Consulting	2 JF Sabourin & Associates
1 John D. Reid	2 Alconsult International Ltd	2 Envirometrex Corporation
1 Kipp & Zonen Inc.	2 AMEC Earth & Environmental	2 Frontec Logistics Corp.
1 KNOWeather Consulting	2 ARA Consulting Group Inc.	2 Hallam Knight Piesold Ltd.
1 Levelton Engineering Ltd.	2 Array Systems Computing Inc.	2 Lockweed Aie Terminals
1 Michel Houde Dynamics	2 Axys Technologies Inc	2 McDonald Dettwiller Associates
1 PAL Environmental Services	2 DONMEC Consulting Inc.	
1 PCI Enterprises Inc.	2 Dr. T.F. Consultants Ltd.	
1 Pelmorex/Weather Network	2 Environ-Man Services Inc.	
1 Rodshaw Environmental Consulting Inc.	2 EOA Scientific Systems, Inc.	
1 Rowan Williams Davies & Irwin Inc.	2 Geophysical Disaster Computational FDC	
1 Saskatchewan Research Council	2 Penwell Group	
1 Satlantic Incorporated	2 PFL Offshore & Arctic Technology Inc.	
1 Sea Scan International Inc.	2 Presentey Engineering Products Limited	
1 Seimac Limited	2 Serco Facilities Management Inc.	
1 SENES Consultants Limited	2 Sigma Engineering Ltd.	
1 Soilcon Laboratories Ltd.	2 SNC-Lavalin Environment Inc.	
1 Tech-Knowlogy Consulting Services	2 Spectrum Educational Enterprises	
1 The Weather Van	2 STR Speech Technology Research Ltd.	
1 True North Weather Consulting Inc.	2 AGRA Earth & Environmental Limited	
1 Water Resource Consultants Ltd.	2 GENEQ Inc.	
1 Weather Modification Inc. Canada	2 Geophysique G.P.R. International Inc.	
1 Weather Research House	2 Labbate Climate Control Systems Inc.	
1 Weather-Sense	2 Oracle Telecomputing	
1 WeatherTec Services Inc.	2 William I. Pugsley	

## **APPENDIX B: ELECTRONIC SURVEY**

### **Section I – Corporate Profile**

Company Name:  
President / CEO: Email:  
Meteorology Contact: Email:  
Company Headquarters Address:  
City:  
Province:  
Postal Code:  
Telephone: Fax:  
Website:

### **Section II - Current Status**

1. In what regions of Canada does your business operate / have offices?
  - a. British Columbia
  - b. Saskatchewan, Alberta, Manitoba
  - c. Yukon, North West Territories, Nunavut
  - d. Ontario, Quebec
  - e. Atlantic Provinces (PEI, New Brunswick, Nova Scotia, Newfoundland)
  
2. In what other locations does your business operate?
  - a. United States
  - b. Austral-Asia (including Australia, New Zealand, and all of Asia)
  - c. Africa
  - d. Europe
  - e. Other (please specify)
  
3. Numbers of years in business
  - a. 0 – 5
  - b. 6 – 10
  - c. 11 – 15
  - d. 16 +
  
4. Estimated total annual company revenue
  - a. \$0 – \$100,000
  - b. \$100,001 – \$500,000
  - c. \$500,001 – \$1,000,000
  - d. \$1,000,001 - \$5,000,000



**Final Report July 3, 2001**  
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- e. \$5,000,001- 10,000,000
  - f. more than \$10,000,000
5. Estimated revenues from meteorological activities
- a. \$0 – \$100,000
  - b. \$100,001 – \$500,000
  - c. \$500,001 – \$1,000,000
  - d. \$1,000,001 - \$5,000,000
  - e. more than \$5,000,000
6. Compared with your revenue from 5 years ago, does this represent
- a. A significant (> 100%) increase
  - b. A modest (25 – 100%) increase
  - c. A slight (0-25%) increase
  - d. Staying the course
  - e. A decrease
  - f. Doesn't apply – company is less than 5 years old.
7. How would you describe your business today?
- a. Profitable and growing quickly
  - b. Profitable and slowly growing
  - c. Profitable with constant revenues / expenses
  - d. Not profitable yet, but building for the future
8. In what type of partnerships are you currently engaged? (please check all that apply)
- a. Long-term joint-ventures
  - b. Project by project partnerships
  - c. International joint-ventures
  - d. International partnerships
9. Please check all the categories that best describe your target market(s) for your meteorological activities and then estimate what percentage of your total revenue that these categories represent.

<b>Canadian</b>	<b>% of your Revenue</b>	<b>International</b>	<b>% of your Revenue</b>
Canadian Federal or Provincial Governments		Other national governments or international agencies	
Private Sector Transport / Travel Industry		Private Sector Transport / Travel Industry	
Energy / Fossil Fuels Industry		Energy / Fossil Fuels Industry	

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General Public		General Public	
Forestry, agriculture industry		Forestry, agriculture industry	
Financial / Insurance Industry		Financial / Insurance Industry	

10. Please check all that describe your company's activities with respect to your meteorological work.

- a. Climatology, Climate / global change
- b. Forensic meteorology
- c. Operational forecasting
- d. Road weather
- e. Air quality
- f. Media – TV, Radio, Newspapers
- g. Training /education
- h. Radar services (equipment, processing, image analysis, etc)
- i. Research
- j. Weather derivatives
- k. Numerical modeling
- l. General consultancy services
- m. Weather observing
- n. Instrumentation - development and manufacture
- o. Instrumentation - sales
- p. Data processing and quality Control
- q. Software design
- r. Hydrology
- s. Other (specify) \_\_\_\_\_

11. On a scale between 1 and 5 (1= not very dependent and 5 = absolutely critical to your business), please indicate how your company views the relevance of advances in information technologies. **1 2 3 4 5 NA**

12. On a scale of 1 – 5 with 1 = impediment to growth 5 = facilitates growth (and NA = that it does not affect your business at all), how would you view each of the following?

Criteria	
Availability of qualified entry level staff to hire	<b>1 2 3 4 5 NA</b>
Availability of mid-senior level staff	<b>1 2 3 4 5 NA</b>
Salary competition with USA based Companies	<b>1 2 3 4 5 NA</b>
Salary competition with Meteorological Service of Canada	<b>1 2 3 4 5 NA</b>
Competition from Meteorological Service of Canada	<b>1 2 3 4 5 NA</b>
Competition from USA Companies	<b>1 2 3 4 5 NA</b>

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Competition from other Canadian Companies	<b>1 2 3 4 5 NA</b>
Cost of Data	<b>1 2 3 4 5 NA</b>
Cost of / availability of appropriate information technology	<b>1 2 3 4 5 NA</b>
Low value of Canadian currency	<b>1 2 3 4 5 NA</b>
Government subsidies / incentive programs	<b>1 2 3 4 5 NA</b>
Others? Please specify	<b>1 2 3 4 5 NA</b>

13. Where does your major competition come from? (Please check all that apply)

- a. Canada private sector
- b. Canadian Government (either federal, provincial, or municipal)
- c. United States
- d. Europe
- e. Other \_\_\_\_\_

14. How has salary competition with the United States affected your business?

- a. Not at all
- b. Somewhat
- c. A lot

15. How has salary competition with the Canadian Government affected your business?

- a. Not at all
- b. Somewhat
- c. A lot

**Section III - Staff Profile**

16. Total Staff involved in Meteorological Activities?

- a. 1-2
- b. 3-9
- c. 10-19
- d. 20+

17. Compared with your meteorological staff of 5 years ago, does this represent

- a. An infinite increase (we didn't have any meteorological staff 5 years ago)
- b. A significant (> 100%) increase
- c. A modest (25 – 100%) increase
- d. A slight (0-25%) increase
- e. Staying the course
- f. A decrease
- g. Doesn't apply – company is less than 5 years old

**Final Report July 3, 2001**  
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18. Professionals (University Trained) on Staff?
- a. 0-5
  - b. 6-10
  - c. 11-15
  - d. 16+
19. Percentage with formal training/education in meteorology?
- a. 0-25%
  - b. 26-50%
  - c. 51-75%
  - d. 76-100%
20. What is the education level of your meteorological staff? Give numbers in each category
- a. Undergraduate degree
  - b. Diploma in Meteorology (1 year beyond undergraduate degree)
  - c. Masters Degree
  - d. Ph.D.
  - e. No formal degrees, but proven experience
21. Of the formally trained professional staff employed by your company, about how many people do you have in the following age brackets?
- a. \_\_\_ 20 years – 30 years
  - b. \_\_\_ 31 years – 40 years
  - c. \_\_\_ 41 years – 50 years
  - d. \_\_\_ 51 years – 60 years
  - e. \_\_\_ 61 years +
22. On a scale of 1 –5, one = not at all and 5 = very high, how would you rate your staff's level of comfort in dealing with information technology devices, complex databases, large amounts of electronic data, and complex software applications?
- 1 2 3 4 5 NA
23. Please check all of the following approaches that are used in your training and updating of staff knowledge and skills?
- a. In house training
  - b. Conferences / workshops
  - c. Employer-paid tuition at universities
  - d. Personal reading/research
  - e. "Learn by doing" on the job
  - f. Government subsidized education/training programs

24. Has it been difficult for you to find qualified Canadian staff to work within your company?
- Yes
  - No

#### **Section IV - Future Outlook and Expectations**

25. Are you planning on hiring more people in the next 2 – 5 years?
- Yes
  - No
26. What do you expect your staff level to be in the next 2-5 years?
- 1-2
  - 3-9
  - 10-19
  - 20+
27. What level of revenue increase do you anticipate in the next 5 years?
- Same or less
  - 50% higher
  - 100% higher
  - >100% higher
28. How many more years do you plan to be in business?
- 0-5 years
  - 6-10
  - 11-15
  - 16+
29. How do you view Canada's private meteorological industry today in relation to the private sector meteorological industries of other developed countries?
- Among the top five in the world
  - Middle of the pack
  - In the lower half
30. Which of the following countries do you feel have more advanced private sector meteorological services (please check all that apply):
- United States
  - United Kingdom
  - Germany
  - France
  - Japan

**Final Report July 3, 2001**  
**Baseline Status of the Private Meteorological Services Sector in Canada**

- f. Australia
  - g. New Zealand
  - h. Italy
  - i. Others (please indicate) \_\_\_\_\_
31. Over the next 5 years do you expect that Canada's private sector meteorological industry will improve in relation to that of other countries?
- a. Yes
  - b. No

**Section V - Open ended questions**

32. What are the main things that would need to change for your company to increase its profitability in the meteorological sector?
33. What are some key trends you anticipate happening in the Canadian Meteorology Private Sector? And in the International Meteorology Private Sector?
34. What can the Canadian government do to help private sector meteorology in Canada?
35. What can the Canadian Meteorological and Oceanographic Society do to help private sector meteorology in Canada?
36. Are there any other comments you would like to share?

**APPENDIX C: INTERVIEWEES**

<i>Company</i>	<i>Contact Person</i>	<i>Phone #</i>
Campbell Scientific	Brian Day – CEO	780-454-2505
Enviromet International Inc.	Claude Levlievre - CEO	514-384-9990
Levelton Engineering	R.G. Humphries - Met	604-207-5122
Pelmorex – The Weather Network	Pierre Morrissette	905-566-9511
Seimac Limited	Susan Woodbury - Met	902-468-3007
Zephyr North	Jim Salmon – CEO	905-335-9670
Weather Research House	Ambury Stuart - CEO	416-226-3675
World Weather Watch	Mory Hirt – CEO	905-477-4120
True North Consulting	Beverly J. Archibald - CEO	780-472-3664
SENES Consultants	James W.S. Young – Met	905-764-9389 x337
Rowan Williams Davis Irwin Inc.	Mike Lepage - Met	519-823-1311

## ***APPENDIX D: INTERVIEW GUIDE***

### **1. Canadian Private Meteorological Services Sector**

- How would you describe the current state of the Private Meteorological Services Sector in Canada? How does this compare with 5 years ago? With ten years ago?
- What do you expect the state of that sector to be in 5 years? In 10 years?
- What are the key competitive influences affecting market opportunities in Canada? Internationally?
- Where do you see new or expanding opportunities for the MPS?
- Are you aware of any activities, if any, is the private sector, or the Government of Canada are undertaking to promote the products and services of Canada's private meteorology sector? In North America? Globally?
- What do you see as current issues of training in meteorology? Is it a problem to engage trained professionals to work with you? How could MSC and the private sector resolve this issue?
- How can certification be administered? Should CMOS hand it out? MSC? Private Sector?
- How often had you had to turn down work because of a lack of capacity? How quickly could you increase capacity if a market opportunity created a need for it?

### **2. Government of Canada**

- What do you see as the role for the Meteorological Service of Canada?
- What services or products (currently being provided by MSC) could be delivered through private sector meteorology service providers? Please explain why.
- Does the private sector have the capacity to reliably deliver these products and services? If not, what needs to be done to build capacities in the relevant areas?
- Are there functions that MSC is not carrying out, but perhaps should be? Please explain why.



- Are there services that are currently provided without charge by MSC but that should be charged for?
- Are you aware of any programs operated by other government departments (i.e. Industry Canada, DFAIT) that provide support to the private meteorology sector?
- What could/should the Government of Canada do to strengthen the private meteorology sector?

### **3. International Jurisdictions**

- What do you feel is the international market for Canadian private sector meteorological services? Who do you feel are/would be the main clients? What are the main services provided?
- What needs to be done in the Canadian Meteorological Community to assist Private Sector companies to capture more of the international market?
- Are you aware of the roles played by public and private sector meteorological service providers in other countries?

### **4. Canadian Meteorological and Oceanographic Society**

- What do you think the role of CMOS should be in supporting private sector meteorology?
- Does CMOS fulfill this role appropriately?
- What activities or programs would you like CMOS to develop to assist in the advancement of Private Sector meteorology in Canada?
- Is there anything else you would like to add?

**Appendix C: Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services; a Study by HLB Decision Economics Inc.**



**Canadian  
Meteorological and  
Oceanographic Society**

**Optimizing the Public  
and Private Sector Roles  
in the Provision of  
Meteorological Services**

**HLB Decision Economics Inc.**

**November 19, 2001**

HLB DECISION ECONOMICS INC.

RISK ANALYSIS • INVESTMENT AND FINANCE  
• ECONOMICS AND POLICY



**Canadian Meteorological and Oceanographic Society**

**Optimizing the Public and Private Sector Roles in  
the Provision of Meteorological Services**

**HLB Decision Economics Inc.**

**November 19, 2001**

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## EXECUTIVE SUMMARY

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This study, commissioned by the Canadian Meteorological and Oceanographic Society of Canada, poses three questions relating to the formulation of a viable and effective private meteorological industry strategy in relation to economically optimal federal government provision of weather services:<sup>1</sup>

1. What is the economically optimal level of capital investment in meteorological infrastructure?
2. What are the economically optimal roles for the private and public sectors in the provision of meteorological technology, research and services? and
3. What policy options exist for optimising the public and private sector roles and investment levels in the provision of meteorological infrastructure and prediction services? What are the benefits and costs of these options?

As an economic analysis, the study does not address non-economic considerations in the formulation of both private and public policy.

The study draws on financial, budgetary and market data from Environment Canada and industry publications and reports. Some unpublished information was supplied by Environment Canada. As such, the data used here do not necessarily reflect recent changes in MSC finances and services. Environment Canada has indicated that any such differences are unlikely to change the study's overall conclusions.

The study yields five principal conclusions:

1. Just under three-quarters of the expenditures of Environment Canada's Meteorological Services of Canada (\$159 million in fiscal year 2001) involve meteorological infrastructure activities and outputs that address a market failure and thus belong in the federal domain. The remaining expenditures, \$66.5 million in fiscal year 2001, are for the production of value-added services that would be more efficiently provided by private firms;
2. The federal government has permitted the value of the capital stock of meteorological infrastructure to erode over the past 25 years. This erosion has contributed measurably to the nation's sluggish rate of growth in productivity and Gross Domestic Product. Although Environment Canada's proposed \$280 million,<sup>2</sup> five-year capital investment plan would yield

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<sup>1</sup> The findings and conclusions presented here are those of HLB Decision Economics Inc. and do not necessarily represent the views of the CMOS or of Environment Canada.

<sup>2</sup> . Note that the investment program on which the analysis of optimal capital spending is based a one-time submission by MSC to the Treasury Board Program Integrity 1 exercise on July 24, 1999. Out of the total \$216 million in incremental capital and associated operating and maintenance dollars requested over five years, MSC has received \$20 million (over five years) to address critical occupational and health safety issues. It should also be noted that the investment plan employed in the optimality analysis does not reflect the most current MSC investment planning assumptions. Use of the Program Integrity 1 plan are used here to analyze optimal capital sums required and associated benefits, incremental to the reference levels in 2000/01.

net benefits of \$4.6 billion over ten years (a 69 percent rate of return), even higher levels of federal infrastructure investment are economically justified;

3. Environment Canada charges more than the optimal price (more than marginal cost) for meteorological infrastructure services, thereby preventing the maximization of the economic and social benefits of weather prediction. Treasury Board guidelines on cost recovery permit the use of the marginal cost pricing framework. On the other hand, the subsidies implied by the marginal cost pricing rule present certain economic and practical problems. Various pricing possibilities are available that serve the interests of public policy (see Box Essay);
4. MSC does not impute an allowance for normal profit and commercial risk into the prices it levies for its value-added products and services. This places private providers at a competitive disadvantage that limits their growth and inhibits innovation in the private sector supply of such products and services. Treasury Board guidelines permit the use of such imputations; and
5. If the federal government were to withdraw from the provision of products and services in which no evidence of market failure is apparent, the value of private sector output and employment in the production of meteorological services would more than double.

**BOX ESSAY: THE ECONOMICS OF PRICING PUBLIC GOODS -- AN OVERVIEW**

The term “public good” is used in two different, albeit overlapping senses in the economics literature. One has to do with “non-excludability.” The other concerns “absence of rivalry in consumption.” Early on in the literature, a broadcast from a radio or television tower was a commonly used example of public goods in both senses of the term. On non-excludability, the literature observed that once a station’s signal is transmitted from its tower, any of its neighbours could receive it; no mechanism existed with which to provide it only to those who were willing to pay for it. Regarding absence of rivalry in consumption, the time one neighbour spent being entertained by the signal was observed to have no effect on the quality of the signal any other neighbor received.

Technology has altered this state of affairs in the last decade or so. DirecTV uses a satellite over the Gulf of Mexico to beam a signal toward Canada and the United States. The reception of that signal by one person neither increases DirecTV’s costs nor reduces the quality of the signal anyone else receives. But these signals *are* subject to excludability. Any household can authorize someone answering a phone at DirecTV to charge its credit card and, in return, instantly receive access to a fraction of the signal that is “striking” its home. If the household pays an additional amount, it receives a bit more of the total signal. The cost of billing the household is DirecTV’s total cost of serving it; if DirecTV provided the service free, serving the additional household would cost DirecTV nothing.

For a large and growing fraction of what is produced these days, the marginal cost of an extra unit of output is trivial in comparison to its average total cost. The copy of the paperback novel that sells for \$3.95 at the supermarket checkout counter costs on the order of 20 cents to produce. Computer programs that cost millions of dollars to develop are distributed on compact disks that cost 25 cents or so. Knowledge collected by MSC that costs it many thousands of dollars to produce can be sent to an additional radio station or newspaper or producer of highly specialized weather reports for a tiny fraction of many thousands of dollars. Suppose that MSC were to employ a DirecTV-type technology to provide weather knowledge only to those willing to pay a price that, when added over all paying customers, would cover its costs of producing and distributing this knowledge. Such a procedure would exclude—possibly very many—customers whose benefits from this knowledge fall short of this average-cost price but who would happily pay the marginal-costs of serving them.

Micro-economics textbooks invariably point out that, when the price of a commodity exceeds the incremental or marginal cost of producing it, additional output would generate additional consumer benefits that would exceed the additional costs of producing this additional output. This being the case, the textbook prescription is, “Set price equal to marginal cost.” This prescription is costly when, as in the cases presently at hand, the revenue from marginal-cost prices would fall short of total costs. Under such circumstances, price could always equal marginal cost only if someone or some entity willingly always subsidizes the resulting deficits. In textbook discussions, governments are almost always assumed to be the subsidizing entities.

**BOX ESSAY: THE ECONOMICS OF PRICING PUBLIC GOODS -- AN OVERVIEW ...  
con't**

Governmental subsidies to equate price and marginal cost have at least two problems: First, subsidies require tax revenues. Taxes imposed on goods and services inevitably result in buyers paying more for them than their sellers receive. Even in markets where prices would otherwise equal marginal costs, taxes introduce the sorts of gaps between consumer value and supplier cost that subsidies designed to equate prices and marginal costs in other markets are aimed at eliminating. Conclusion: At a maximum, the subsidy required to reduce the gap between price and marginal cost in one market should yield benefits in that market no greater than the costs the necessary taxes impose in other markets.

The second problem with governmental subsidies to individual markets: Their costs are borne by taxpayers in general; their benefits go in considerable measure to those most actively involved in the subsidized markets. Almost all of us benefit from the general weather reports we read in newspapers, hear on the radio, or see in TV. Were these the only benefits that MSC provides, its optimal level of output would probably be considerably lower than it is presently. But it provides many other beneficial services. For example, frost alerts from MSC or independent entrepreneurs who use MSC data give fruit farmers time to set up sprinklers, smudge spots, or other equipment to repel frost. The primary beneficiaries from such reports are those who produce them, those who use them to reduce crop damage and, perhaps, fruit consumers. Taxpayers in general are not likely to be enthusiastic about such income transfers.

Because of such problems, subsidies designed to reduce gaps between prices and marginal costs in markets are unlikely to eliminate these gaps substantially even when they are very large. Fortunately, sophisticated pricing techniques have been developed in the economic literature that promise to reduce gaps between prices and marginal costs in many types of market. Two techniques are particularly prominent in this literature – “bundling” and “two-part tariffs.” Bundling: if consumers differ in the values they attach to individual products in a related group of commodities, charging a single price for each of a group of carefully designed bundles can increase both revenues and buyer benefits from the group. Two-part tariffs: Charge an up-front fee that is independent of total purchases in a market together with a unit price per unit that is closer to marginal cost than an average-cost price. The up-front fee could, alternatively, be associated with a group successively lower per-unit fees.

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# 1 INTRODUCTION

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Commissioned by the Canadian Meteorological and Oceanographic Society of Canada, this study poses three questions relating to the formulation of a viable and effective private meteorological industry strategy in relation to federal government provision of weather services:<sup>3</sup>

- What is the economically optimal level of capital investment in meteorological infrastructure?
- What are the economically optimal roles for the private and public sectors in the provision of meteorological technology, research and services? and
- What policy options exist for optimising the public and private sector roles and investment levels in the provision of meteorological infrastructure and prediction services? What are the benefits and costs of these options?

An “optimal” investment plan is one that maximizes the economic and social benefits of various capital projects relative to their cost (where cost includes both one-time capital outlays on facilities and equipment and the yearly expense of maintenance and operations). Similarly, an optimal public-private mix of activities is one that yields maximum economic growth and social well-being at minimum-possible costs and consumer prices. While, in practice, economic analysis does not reveal the single-best investment plan, or the single-best public-private mix of activities, it can identify major mismatches between existing and optimal investment levels and market arrangements. Economic analysis can also identify those policies and investment levels most likely to redress such mismatches. These are the purposes of economic analysis in this study.

As an economic analysis, the study does not address non-economic considerations in the formulation of both private and public policy. Such considerations might include, for example, the government sector’s wider mission and commitments in relation to the environment.

Throughout the study, HLB employs financial, budgetary and market data as available in Environment Canada and industry publications and reports. Some unpublished information was supplied by Environment Canada. As such, the data used here do not necessarily reflect recent changes in MSC finances and services. Environment Canada has indicated that any such differences are unlikely to change the study’s overall conclusions.

## 1.1 The Context

Like roads, sewers and other foundational public infrastructure, meteorological infrastructure (satellite stations, radars, super-computers and related facilities and equipment) commands a significant commitment of economic resources. Every year the analysis and prediction of weather and environmental conditions require millions of dollars in capital investment; in salaries for scientists and

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<sup>3</sup> The findings and conclusions presented here are those of HLB Decision Economics Inc. and do not necessarily represent the views of the CMOS or of Environment Canada.

other professionals, in research funding, and in the purchase of specialized forecasts by farmers, transportation companies, radio and television stations and the many other end-users of weather and environmental services. In the year 1999/2000, the capital stock of meteorological infrastructure was worth almost \$300 million (over 95 percent of which was owned by the federal government). In the same year, governments, private meteorological firms and households spent fully \$285 million on new prediction-related facilities and equipment, research and development, and forecasting products and services, or about \$919.00 for every 100 Canadian residents.<sup>4</sup>

*How much is enough?* Notwithstanding the financial magnitude of the resource commitment summarized above, capital investment in weather-related infrastructure is small compared to spending on other economically foundational public infrastructure. For example, government (federal, provincial and other) expenditures in 1999/2000 on roads, airports, harbours and other transportation infrastructure totalled \$4.7 billion, the federal share of which was \$1.4 billion.<sup>5</sup> Private firms (toll road authorities, airlines and so on) invested an additional \$3.2 billion. Government investment alone on transportation infrastructure exceeded total public and private spending on weather-related infrastructure more than 16-fold in 1999/2000 (\$4.7 billion versus \$285 million).<sup>6</sup>

*Ensuring the right level of investment* in foundational public infrastructure ranks highly in the federal government's national priorities. Economic studies prove that growth in national productivity – the key to improved living standards in Canada -- hinges foremost on the rate of capital investment. This is because higher rates of capital investment introduce better machinery, equipment and technology into the economy which in turn enables workers to produce more output and higher quality output per hour worked. Studies demonstrate that *public* capital (roads, sewers, weather stations etc.) is no less important than private sector investment (automobile plants, housing starts etc) in stimulating productivity growth. Better roads, for example, mean lower distribution costs, making Canadian firms more competitive. More accurate weather predictions reduce the need for farmers to hold “shock stocks” of seed inventories, and airlines can route aircraft around bad weather more safely and cost-effectively. Whether the current level of investment in meteorological infrastructure is optimal from an economic and social perspective is a question posed in this study.

*Who should do what?* Federal policy makers also recognize that the way in which public infrastructure services are delivered effects the influence they exert on national economic growth and social well-being. Meteorological infrastructure and services are supplied to the Canadian economy by both the public sector – principally the federal government, and by private firms. The roles played by government and firms in the “supply chain” of weather-related services are rooted in the history (dating back to the late 19<sup>th</sup> century) of weather forecasting as a scientific endeavour. Public and private roles also reflect the evolution and institutionalisation of weather prediction as a publicly provided service and, beginning in the 1950s, the emergence of some meteorological services as commercially viable businesses. The mix of public and private provision of weather services, like all foundational public infrastructure, has an important influence on the efficiency and quality of meteorological services

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<sup>4</sup> HLB from Environment Canada and Statistics Canada sources. See Section 2 for details.

<sup>5</sup> Transport Canada, *Transportation in Canada 2000*, Annual Report, 2000

<sup>6</sup> See Table 1 in Section 2.

available to industry and households. The wrong mix can inhibit innovation, cause higher than necessary prices and, ultimately, weaken the rate of growth in the national economy. Compared with the United States, where 55 percent of the value of weather-related infrastructure and related services is supplied by private firms, the private share in Canada is 21 percent. Whether this share is “too low,” “too high,” or “about right” is another question posed in this study.

## **1.2 Plan of the Report**

The report is presented in six sections. Section 2 examines investment levels and market arrangements as they exist today. It then analyzes the economic and social benefits arising from existing meteorological services and market arrangements.

Section 3 explains the conditions for achieving optimal investment and market arrangements and examines the current situation in that context. Section 4 outlines alternative directions for federal policy in relation to optimizing capital investment and the mix of public and private market activities. The policy alternatives are evaluated and compared in Section 5 and Section 6 presents the study’s conclusions. Technical details and bibliographic information are given in the appendices.

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## 2 MARKET STRUCTURE TODAY

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This section examines total spending in the provision of meteorological services and provides a summary analysis of the federal government's record of capital investment since 1976. The respective roles of the public and private sector are examined, followed by an analysis of the economic benefits associated with the provision of meteorological services.

### 2.1 Total Spending

As shown in Table 1, total spending on meteorological services in fiscal year 2000-2001 was \$281-291 million (the range reflecting uncertainty in the spending levels of private firms). Fully 79 percent of the total represented federal expenditures of the Meteorological Service of Canada (MSC), a branch of Environment Canada. The balance, about \$60 million (21 percent), represented the activity of private firms (measured on the basis of revenues - see Table 1).

(It should be noted that the Meteorological Service of Canada (MSC), the organizational entity responsible for delivering Environment Canada's *Weather and Environmental Products (WEP)* line of business, budgets for approximately \$8 million on non-WEP related activities over and above the \$225.5 million shown in Table.)



**Table 1: Spending on Meteorological Services in Canada and United States (FY 2000-2001)**

	Canada		United States	
	(Millions of Current Dollars)	% of GDP <sup>1</sup>	(Millions of Current Dollars)	% of GDP <sup>2</sup>
Total Private Spending	\$55-65 <sup>3</sup>	0.005%	\$1,855-2,616 <sup>4</sup>	0.012%–0.017%
Total Public Spending	\$225.5 <sup>5</sup>	0.021%	\$1,787 <sup>6</sup>	0.012%
Total Spending	\$280.5 – 290.5	0.026%	\$3,642–4,403	0.024%–0.029%

**Notes to Table 1**

All values expressed in millions of Canadian dollars, using an exchange rate of \$1 Can = \$0.6535 US.

1. Canadian GDP, FY 2001: \$1,095,100 Million (Can\$), Source: Statistics Canada, August 2001.

2. U.S. GDP, FY 2001: \$15,426,434 Million (Can\$), Source: U.S. Department of Commerce, Bureau of Economic Analysis, August 2001.

3. Baseline Status of the Private Meteorological Services Sector in Canada, Global Change Strategies International for the Canadian Meteorological and Oceanographic Society, July 5, 2001.

4. Estimates of annual revenues of the U.S. private meteorological sector are somewhat uncertain. They were estimated at \$780–1,100 million (U.S.\$) in 1995 by Spielger David B., “A History of Private Sector Meteorology”, Historical Essays on Meteorology, 1919-1995, American Meteorological society, 1996.

HLB estimated the annual revenues in 2001 based on the following information: the number of weather services firms is currently estimated at 267 according to the NWS, up from 200 in 1995; and the U.S. CPI grew by 16.4% over the period 1995-2001. The estimates were computed as follows:

- Lower bound:  $\$780 * (267/200) * (1 + 16.4\%) / 0.6535 = \$1,855$  million

- Upper bound:  $\$1,100 * (267/200) * (1 + 16.4\%) / 0.6535 = \$2,616$  million

5. Planning Database, Pivot Table Version – January 5, 2001.

6. Breakdown:

- NWS: \$1,087 million (Source: Budget appropriation for National Weather Service in FY 2001, “Congressional Marks Table 2001”, National Weather Service, December 2000)
- Other Departments (Agriculture, Aviation, Defence, Energy and Environment): \$700 million

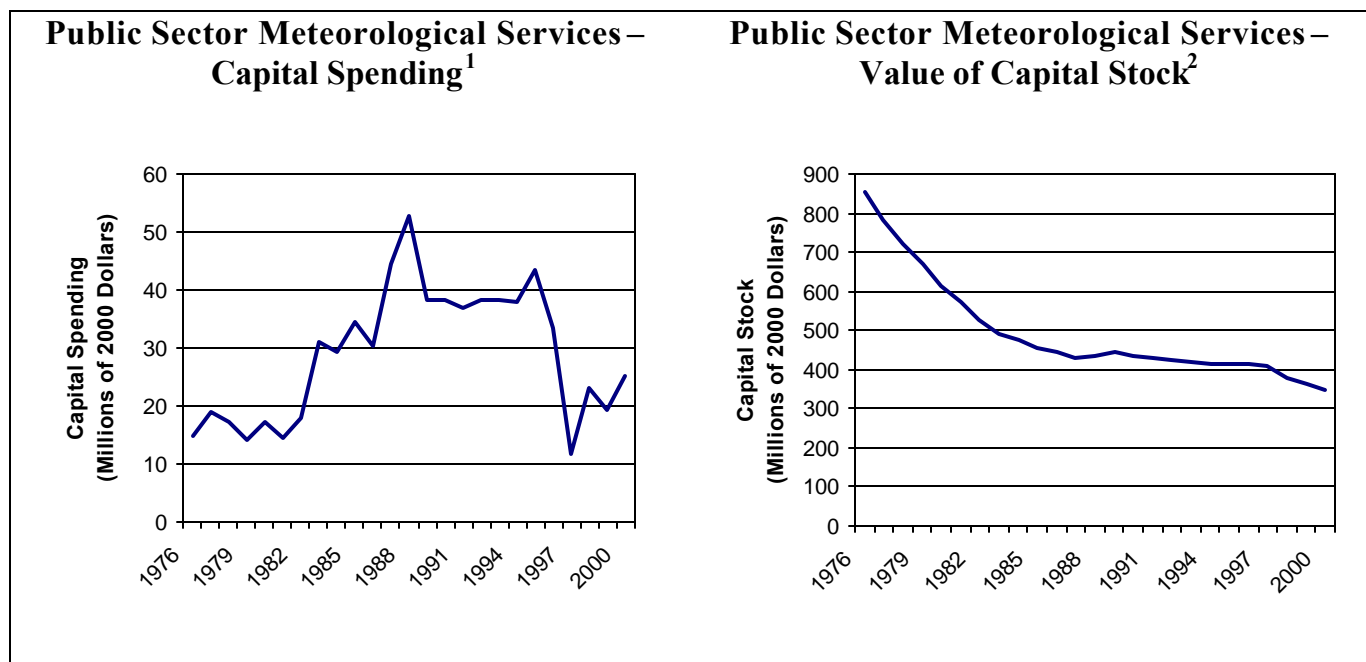
Spending on meteorological services in the United States and Canada is proportionately about the same while the private share of total U.S. spending is proportionately greater. Total U.S. (public and private) spending of \$3.6-\$4.4 billion in fiscal year 2000-01 (Table 1) represented about \$24–29 for each \$100,000.00 of Gross Domestic Product (about \$1,277–1,544 for every 100 residents). Total public and private spending that year in Canada was an estimated \$26.00 for each \$100,000.00 of GDP (about \$919.00 for every 100 residents). An estimated 55 percent of the value of U.S. weather-related infrastructure and related services is supplied by private firms; the corresponding percentage in Canada is 21 percent.

## 2.2 Capital Investment

The government of Canada has allowed the value of its capital stock in meteorological infrastructure to erode over the past 25 years. Over the period 1976 to 2001, federal capital investment in meteorological infrastructure failed to keep pace with depreciation in the capital stock and price inflation (Figure 1-left panel). Since virtually all such investment is federal, Canada’s stock of meteorological

assets (satellite stations, radars, lightning detection equipment and so on) has declined continuously for the past quarter century. Worth an estimated \$850 million in 1976, these assets are worth less than half as much today (Figure 1-Panel 2). Although declines in the value of infrastructure are not unique to the weather sector (roads, wastewater systems and other urban infrastructure have also been allowed to deteriorate relative to historic values), the weakening value of meteorological assets brings into question whether agricultural and other weather-sensitive sectors are optimally served by weather forecasting service providers.

**Figure 1: Canadian Public Sector Meteorological Services- Flows and Stocks of Capital, FY 1976 – 2000 (in constant 2000 dollars)**



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#### Notes to Figure 1

- Public Accounts of Canada
- Gross Capital Stock, Weather services business lines, Environment Canada. Calculated using depreciation rate of 10% [3], reference capital stock of \$333.405M in FY 1998 [from note 4 below, as provided by MSC], and annual capital expenditures [from note 5 below]. End-year, millions of constant dollars.
- Weather and Environmental Predictions Business Line Plan 2000/2001 – 2002/2003, Environment Canada, January 26, 2000.
- “Estimated Value of AEP Assets by Functional Usage”, Environment Canada, June 21, 1998, provided by MSC. Includes WEP and air quality related assets.
- Public Accounts of Canada, FY1976 – FY2000.

## 2.3 Public and Private Roles

As indicated above, the role of the private sector is significantly more prominent in the United States than in Canada. The statistics summarized in Table 1 indicate that whereas private firms account for about 21 percent of domestic market activity, the private sector represents more than half the market in the United States. As shown in Section 3, this difference reflects a policy and legislative framework in the United States under which the National Weather Service (NWS) is not permitted to provide meteorological products and services that private firms either can or do supply. Environment Canada does not restrict MSC in this way.

## 2.4 The Economic Value of Meteorological Services in Canada

Meteorological services create value and economic benefits in two distinct ways:

- By improving productivity in many of the nation's key industrial sectors and thereby fostering growth in the Gross Domestic Product; and
- By facilitating fewer weather-related fatalities and injuries, less time stuck in traffic jams, less destruction of wildlife and habitat, and other prediction-related improvements. Society values such benefits but does not include their value in the accounting for Gross Domestic Product.

Benefits in the first category are called "private" benefits (because they arise principally in the private sector of the economy). This study finds that each one percent increase in the net value of the meteorological capital stock leads to a 0.5 percent increase in total factor productivity and a 1.8 percent increase in the nation's GDP. The precipitous decline in the value of the meteorological capital stock over the past 25 years has thus contributed to the nation's sluggish productivity growth and the disappointing growth in living standards. HLB estimates that annual GDP would have been \$15.02 billion greater had the value of the meteorological capital stock been maintained at its 1976 level.

Benefits in the second category are called "social" benefits because, despite having monetary value, that value typically is not reflected in private sector transactions. This study finds that each one-percent improvement in weather prediction accuracy yields at least \$1.02 billion dollars in social benefits over a 30-year period. Since the deterioration in the capital stock has almost certainly meant foregone opportunities to improve forecasting accuracy, social benefits will have inevitably been foregone accordingly.

The following two sub-sections present the detailed analysis of private and social benefits respectively.

### 2.4.1 Private Benefits

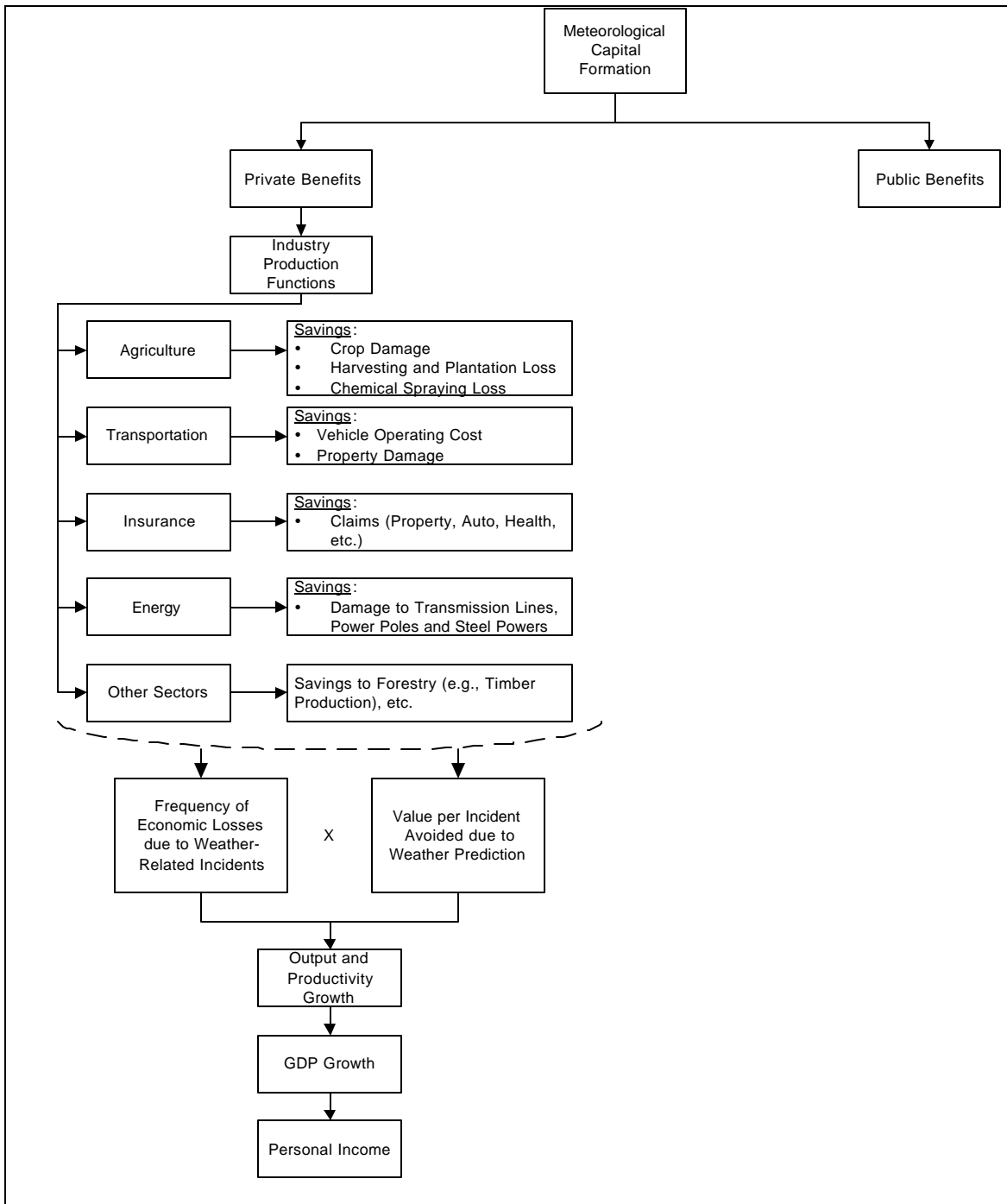
As shown in Figure 2, private sector benefits of weather and environmental forecasts arise in many different industry sectors and in many different forms. Agriculture is perhaps the most obvious beneficiary. Studies show the value of frost forecasts to fruit orchard managers to be worth between \$20.00 and \$41.00 per hectare per day in reduced bud damage and lost yields.<sup>7</sup> A 1995 study assessed the value of greater crop yields associated with improved accuracy in El Niño forecasts at \$96 million (in 1990 dollars).<sup>8</sup>

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<sup>7</sup> From studies summarized in, Richard W. Katz and Allan H. Murphy, *Economic Value of Weather and Climate Forecasts*, Cambridge University Press, 1997 (re-valued by HLB to year-2000 Canadian dollars).

<sup>8</sup> R.M. Adams and others, *Value of Improved Long-Range Weather Information*, Contemporary Economic Policy, XIII, 1995

**Figure 2: Private Benefits of Meteorological Services**



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In the transportation sector, a recent study concluded that trucking companies value reduced schedule delays due to the anticipation of ice and other road hazards at \$371.00 per hour. The adoption of just-in-time production and distribution logistics in most manufacturing sectors have led to a much-increased reliance on highly specialized weather forecasting products and services. In the lumber industry, forest products companies purchase specialized forecasts of lightning fires in order to plan harvest rotations so as to avert timber losses. As well, reduced actuarial risk in agriculture, transportation and other sectors diminishes costs in the insurance industry, with commensurate reductions in consumer premiums.

Although benefits like those described above have been quantified in a wide range of sector-specific studies, the range and diversity of effects make it difficult to roll-up the overall benefit of weather prediction throughout the economy on a sector by sector, benefit by benefit basis. Aggregate (economy-wide) modeling and measurement techniques are, however, available and viable. It is noteworthy in fact that such measurements have been applied to virtually all categories of public infrastructure (roads, water works and so on) except meteorological assets. Based upon such studies, a wide consensus emerged that public infrastructure makes a measurable and significant contribution to national productivity growth.<sup>9</sup>

Accordingly, HLB has employed the aggregate method to establish whether meteorological infrastructure investment gives rise to productivity growth in the national economy. We find that the effect is measurable, significant and comparable in magnitude to impact of other forms of public infrastructure.

Appendix A presents the detailed models and estimation procedure. The findings are summarized below.

## Measurement Framework

Real output (GDP) may be viewed as the product of the number of workers in the economy times the production per worker. GDP growth comes from more workers, greater productivity per worker, or both.<sup>10</sup> The size of the workforce is determined by net immigration rates and cyclical levels of unemployment. Productivity growth comes from education, capital investment, innovation and research and development.

Historically, it has been productivity growth that has been crucial to Canadian economic growth. It is well known that the productivity of labour, in addition to relying on the quality of labour, depends on the total quantity of capital per worker. The greater the capital intensity per worker, the more leverage the worker has on production. Less obvious, but of enormous economic importance, is that productivity growth, by enabling manufacturers to offer the same or higher quality products with smaller price

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<sup>9</sup> E. Garlic, *Infrastructure Investment: A Review Essay*, Journal of Economic Literature, September, 1994; See also, Wisner, Robert, *Infrastructure and Regional Economic Performance: Comment*, New England Economic Review, September/October 1991

<sup>10</sup> More precisely, growth comes from more hours worked, more output per hour worked, or both. See Appendix A. See also, David Lewis, *The Role of Public Infrastructure in the 21<sup>st</sup> Century*, Special Report 220, National Research Council, Washington D.C., 1988

increases, facilitates improved real wage rates and thus higher living standards. When in the 1990s automobile manufacturers invested in state-of-the-art robotic production lines, for example, the value of automobile output per worker increased, and economic growth increased with it. Canadian manufacturers thus became more competitive and real wage rates rose for the first time in many years.

Public infrastructure investment has been found to be productive in the same way. Studies demonstrate that improved highway capacity and pavement quality, by reducing congestion and delay, enables manufacturers to adopt highly productive just-in-time production methods, with commensurate gains in productivity. We can hypothesize, therefore, that when weather forecasts facilitate improved crop yields, reduced production delays and so on, the forecasts are actually facilitating the production of more economic output per hour, namely *productivity*.

### **Econometric Model**

To test the hypothesis -- to measure the effect of meteorological services on productivity and output growth, Appendix A establishes “production function” equations that test, for the period 1976 to 2000, the statistical significance of the hypothesized cause-and-effect relationship between GDP growth, and (1) the size of the labour force; (2) the change in the value of the stock of private capital due to new investment; and (3) the change in the value of the stock of public capital due to new investment.

Appendix A also establishes “productivity equations” that test for the same 1976 to 2000 period, the statistical significance of the hypothesized cause-and-effect relationship between productivity growth and (again) the size of the labour force, changes in the value of the stock of private capital due to new investment, and changes in the value of the stock of public capital due to due to new investment.

In the case of the public capital stock (highways, sewers, schools, government meteorological facilities and equipment), the meteorological capital assets have been separated out in order to determine whether their effect is distinct and statistically significant. The principal findings are as follows:

### **Results**

Based on the econometric model, we can conclude that public investment in meteorological facilities and equipment has a statistically significant effect on productivity and economic output. Specifically:

- Each ten percent change in the net value of the meteorological capital stock leads to a 0.5 percent change in productivity;
- Each ten percent change in the net value of the meteorological capital stock leads to a 1.8 percent change in the nation’s Gross Domestic Product.

These findings are significant at the 99 percent level of statistical confidence. These findings are similar in magnitude to those obtained by U.S. researchers in relation to the effect of other categories of public infrastructure.<sup>11</sup>

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<sup>11</sup> See M. Shaw Nadiri and Theodoris P. Ammonias, *Contributions of Highway Capital to Industry and National Productivity Growth*, Federal Highway Administration, September 1996



## Shrinkage in the Capital Stock of Meteorological Capital Assets has Diluted Canada's Productivity and Economic Growth

The relationships identified above hold for both increases and decreases in the capital stock. In other words, whereas *increasing* the value of the capital stock of meteorological infrastructure leads to increased productivity and output, *decreasing* the capital stock leads to reduced productivity and output. As shown earlier in Figure 1, reduced federal investment levels led to material shrinkage in the meteorological capital stock over the period 1976 to 2000. This in turn has meant less growth in national productivity and GDP and, in consequence, diminished personal income and household living standards. In short, the slow-down in government meteorological investment has diluted Canada's productivity and economic growth.

The implications of shrinkage in the capital stock are quantified in Table 2. The table shows that, based on the models developed in Appendix A, the average annual growth rate in productivity over the period 1976 to 2000 would have been 0.22 percent greater if the value of the meteorological capital stock had been maintained at the 1976 level. Seemingly small, the compounding effects of productivity growth are such that average annual GDP would have been \$15.02 billion greater than actually achieved over the 25-year period.

In short, the failure to sustain the value of the nation's meteorological assets contributed to Canada's sluggish performance in productivity growth, output growth and growth in living standards over the past two and half decades.

**Table 2: The Impact of Government Investment in Meteorological Services on Private Sector Productivity and Output: A Counterfactual Analysis (1976– 2000)**

	Average Annual Change in Productivity	Average Level Productivity	Average Annual Change in Private Sector Output	Average Level of Private Sector Output (Millions of 2000 Dollars)
<b>Under Actual Meteorological Investment Levels</b>	-0.26%	0.417	3.03%	521,339
<b>Had Investment Been Sufficient to Maintain the Capital Stock at the 1976 Level</b>	-0.09%	0.425	3.25%	536,592

HLB Decision Economics from econometric equations in Appendix A.

### 2.4.2 Social Benefits of Meteorological Services

As shown in Figure 3, the social value of weather and climate prediction arises in many sectors of the economy. Market analyses demonstrate that, as an expression of such value, firms and households are

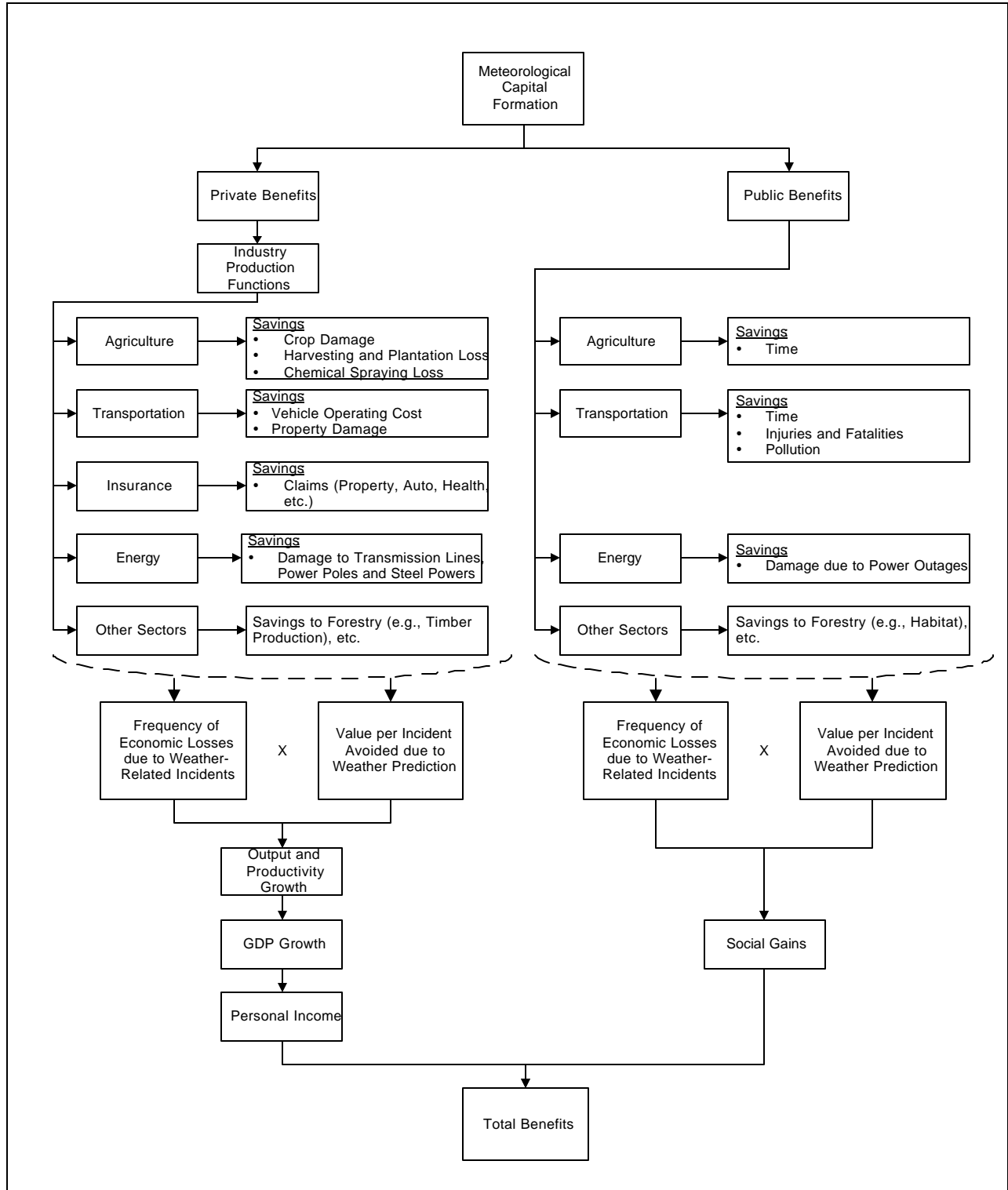
willing to pay for weather and climate predictions that reduce the risk of fatalities and injuries, the chances of being stuck in commuter traffic jams, the destruction of habitat and wildlife and so on.<sup>12</sup> In economic analysis, the amount people are willing to pay in order to obtain the benefits of a service is a direct measure of how much value they assign to the service. Since social values are, by definition, not accounted for in GDP, such values are additive to the economic benefits discussed in the section 2.4.1.

This study finds that each one-percent improvement in weather prediction accuracy yields at least 1.02 billion in social benefits over a 30-year period. Since the deterioration in the capital stock has almost certainly meant foregone opportunities to improve forecasting accuracy, social benefits will have inevitably been foregone accordingly.

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<sup>12</sup> Private firms in Canada sell specialized weather forecasts and related products to industrial and household consumers worth \$60 million annually. See also, Richard W. Katz, et al. al. (op. cit.)

**Figure 3: Public Benefits of Meteorological Services**



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## Measurement Framework

Economic analysis and probability theory provide the measurement framework within which the quantitative significance of social benefits can be examined. Presented in detail in Appendix B, the framework is essentially a three factor equation, as follows:

***Social Value =***

**the frequency of adverse incidents of type i, times**

**the reduction in adverse incidents of type i due to weather prediction, times**

**the economic value (based on peoples' willingness to pay) of mitigated adverse effects of incidents of type i.**

The first two factors are probabilities. Consider "floods." Floods occur within an uncertain but quantifiable probability range. The frequency with which weather prediction will facilitate mitigating behaviour and the avoidance of social loss depends upon the accuracy of the forecast and the nature of loss (lives, injuries) and is also quantifiable within a probability range. Finally, the economic value of mitigated social loss is measurable from *willingness to pay* studies. Such studies employ a variety of techniques, including behavioural research, stated preference surveys, hedonic price models and market research.

## Findings

Appendix B presents HLB's application of the social value equation over a range of sectors. Although we do not consider the analysis comprehensive, it does provide an indicative, if conservative, expression of the quantitative significance of social benefits. The results are summarized in Table 3 and a selected bibliography of relevant industry-level analysis is given at the end of the report. The findings reflect event probabilities over a 30-year period and unit values of life, injury and other social factors in general use by federal Departments and approved by the Treasury Board.

As reported in Table 3, the analysis indicates that each one-percent improvement in the accuracy of weather prediction yields an estimated \$1.02 billion in social benefits over a 30-year period. Since the number of sectors and social benefit categories covered in Appendix B is limited, there is an estimated 75 percent probability that actual social benefits are greater than those reported Table 3.

## **Shrinkage in the Capital Stock of Meteorological Capital Assets has Meant Fewer Social Benefits from Improved Weather Prediction**

Deterioration in the capital stock has almost certainly meant foregone opportunities to improve forecasting accuracy. As shown later in the report, the Meteorological Service of Canada (MSC) estimates that its proposed new investment plan will reduce the rate of system failures and will likely to improve short-term (next-day) forecasting accuracy by about 2.5 percent. Assuming, conservatively, that dilution in the capital stock since 1976 led to missed opportunities for improved accuracy of the same amount (2.5 percent), social benefits of an estimated \$2.6 billion will have been forgone over the period (\$1.02 billion per one-percent improvement in accuracy *times* a 2.5 percentage point improvement yields \$2.6 billion).

**Table 3: Probability Analysis of the Social Benefits of Meteorological Services in Canada**

Sectors	Savings over 30 Years due to a 10% Weather Prediction Improvement (2000 Dollars)	Savings over 30 Years for Each 1% Weather Prediction Improvement (2000 Dollars)
<b>Agriculture</b>		
Crop Damage		
Harvesting Loss		
Plantation Loss		
Chemical Spraying Loss		
Other Losses		
Total Loss/Gain	\$2,250,000,000	\$225,000,000
<b>Transportation</b>		
Air		
Time Savings (Flight Diversion and Cancellation, Delayed Decision)	\$317,550,000	\$31,755,000
Reduced Injuries & Fatalities	\$17,826,480	\$1,782,648
Road (Car and Bus)		
Time Savings	\$7,137,314,286	\$713,731,429
Reduced Injuries & Fatalities	\$400,671,360	\$40,067,136
Rail		
Time Savings	\$45,364,286	\$4,536,429
Reduced Injuries & Fatalities	\$2,546,640	\$254,664
Marine		
Time Savings	\$30,242,857	\$3,024,286
Reduced Injuries & Fatalities	\$1,697,760	\$169,776
Other Modes		
Time Savings	\$30,242,857	\$3,024,286
Reduced Injuries & Fatalities	\$1,697,760	\$169,776
Total Loss/Gain	\$7,985,154,286	\$798,515,429
<b>Energy</b>		
Damage due to Power Outages	N/A	N/A
<b>Other Sectors</b>		
Forestry: Reduced Fire Intensity	\$5,177,779	\$517,778
<b>GRAND TOTAL</b>	<b>\$10,240,332,065</b>	<b>\$1,024,033,206</b>

HLB Decision Economics Inc. (Appendix B)

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### 3 OPTIMAL PUBLIC AND PRIVATE ROLES IN THE PROVISION OF METEOROLOGICAL SERVICES

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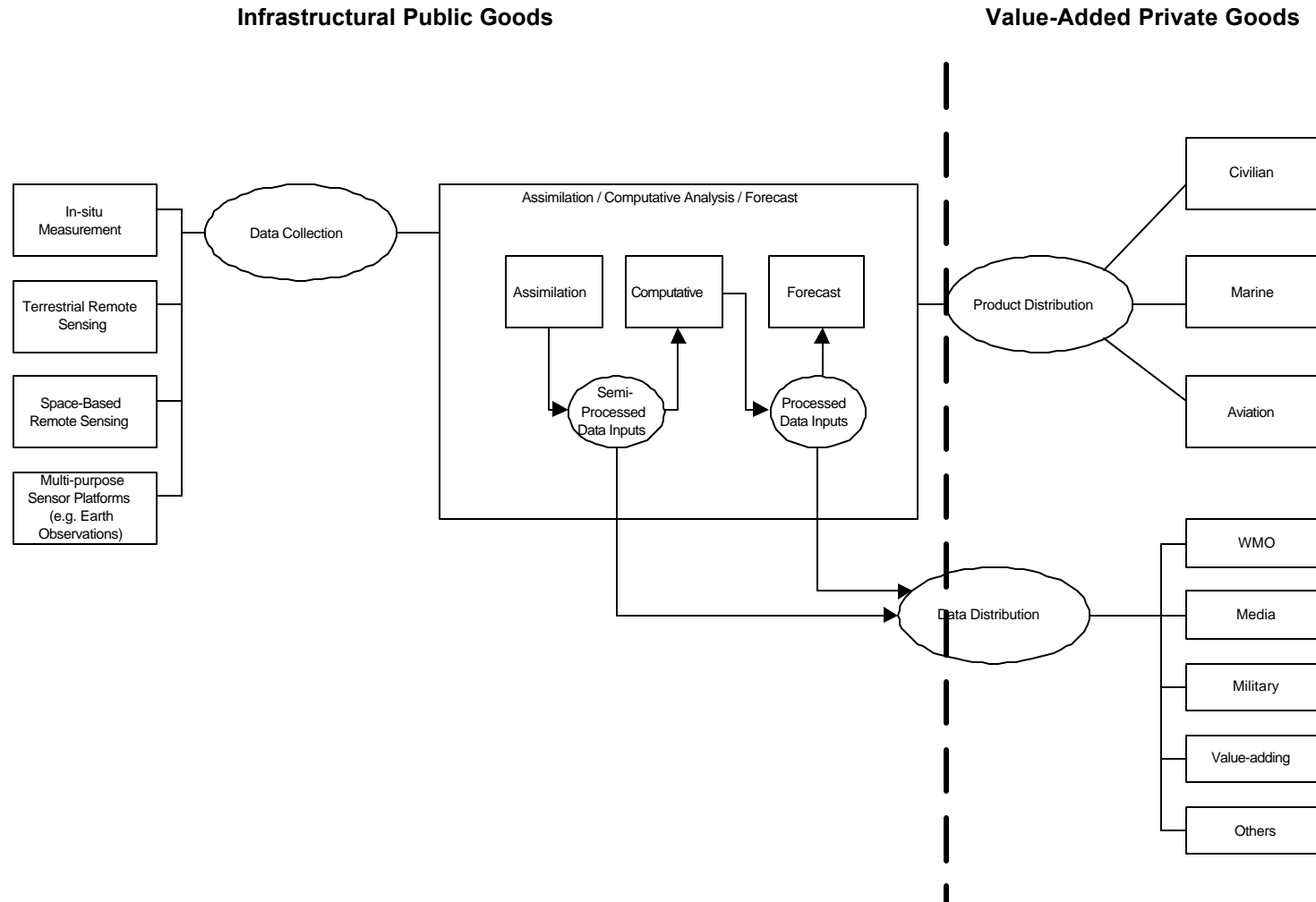
It is clear from the evidence in Section 2 that Canada has under-invested in meteorological infrastructure over the past 25 years. Before addressing the question of how much to invest going forward, however, it is necessary to tackle the broader matter of “who should do what.” Should the federal government invest in meteorological infrastructure, or should such investments be left to private meteorological firms? Who should develop and sell specialized forecasting and analysis services, the government, private firms, or some combination of the two?. In short, how should the market for meteorological services be organized. Unless the market is organized appropriately, the provision of investments, the conduct of research and the delivery of specialized services will inevitably be inefficient – neither the economy nor society at-large will reap the highest-possible economic and social rewards of weather and climate analysis and prediction.

#### 3.1 The Economics of Optimal Market Organization

As shown in Figure 4, the development of weather forecasts and other meteorological services proceeds through a supply chain that begins with major capital facilities and equipment (satellite stations, terrestrial remote sensing equipment and super computers), which in turn facilitate complex data analysis and modelling and, ultimately, the production of specialized forecasts for various end-users. The supply chain is highly capital intensive at the front-end and more labour intensive at the other. A recent popular science article describes the supply chain anecdotally, but helpfully. To paraphrase:

*To decide whether to take an umbrella to work, people tune in to the TV or radio or check a newspaper or website. In turn, these media buy their forecasts from commercial meteorologists or the federal government. The private forecasters purchase the weather data they use to make predictions from either the federal government or from commercial data vendors who have contracts to obtain and process the raw data, radar and satellite readings from the federal government. Investment in the satellite stations, radars and other data collection equipment is financed by the federal government. In addition to supplying the basic data, the federal government also makes its own specialized forecasts. (Jeffrey Rosenfeld, Scientific American Presents, pp28-31, April 1999).*

**Figure 4: Supply-Chain Architecture of Weather Forecasting**



HLB Decision Economics, Inc. adapted from "Overview of Meteorological Technology Trends, Environment Canada (by Cooper Lybrand), March 1998



The question we pose here is, which of the various activities in the supply chain should be the purview of the federal government and which should be the domain of private firms? Economic theory provides the answer: The government should undertake those activities that address a market failure. Private firms should do the rest.

### 3.1.1 Attributes of Market Failure

“Market failure” occurs when the cost structure and technology attributes of a service are such that private firms operating in a competitive market environment cannot supply the optimal quantity, quality and price. Optimal here means the quantity, quality and price that maximize efficiency, innovation and value to the consumer. Most goods and services do not exhibit such characteristics. Accordingly, competitive supply in a free market leads in most situations to more or less the optimal outcome.

Market failure does arise, however, in the private provision of goods and services that exhibit “increasing returns to scale,” also known as economies of scale. As shown in Figure 5 (first panel), the cost of such services declines sharply as the volume of output increases. An important characteristic of this class of goods and services is that the unit marginal cost of supplying them lies *beneath* their average unit cost. Since the allocation of economic resources is optimized by charging *marginal*, not average cost,<sup>13</sup> private firms would automatically charge too much. This is because private firms must charge average cost in order to break even and earn a normal profit. In charging too much, firms supplying such goods and services would lead consumers to reduce the quantity of service they choose to purchase to a level beneath that required for maximum economic and social benefits. Governments, on the other hand, do not need to break even in order to survive and are thus better able to optimize output levels and prices.

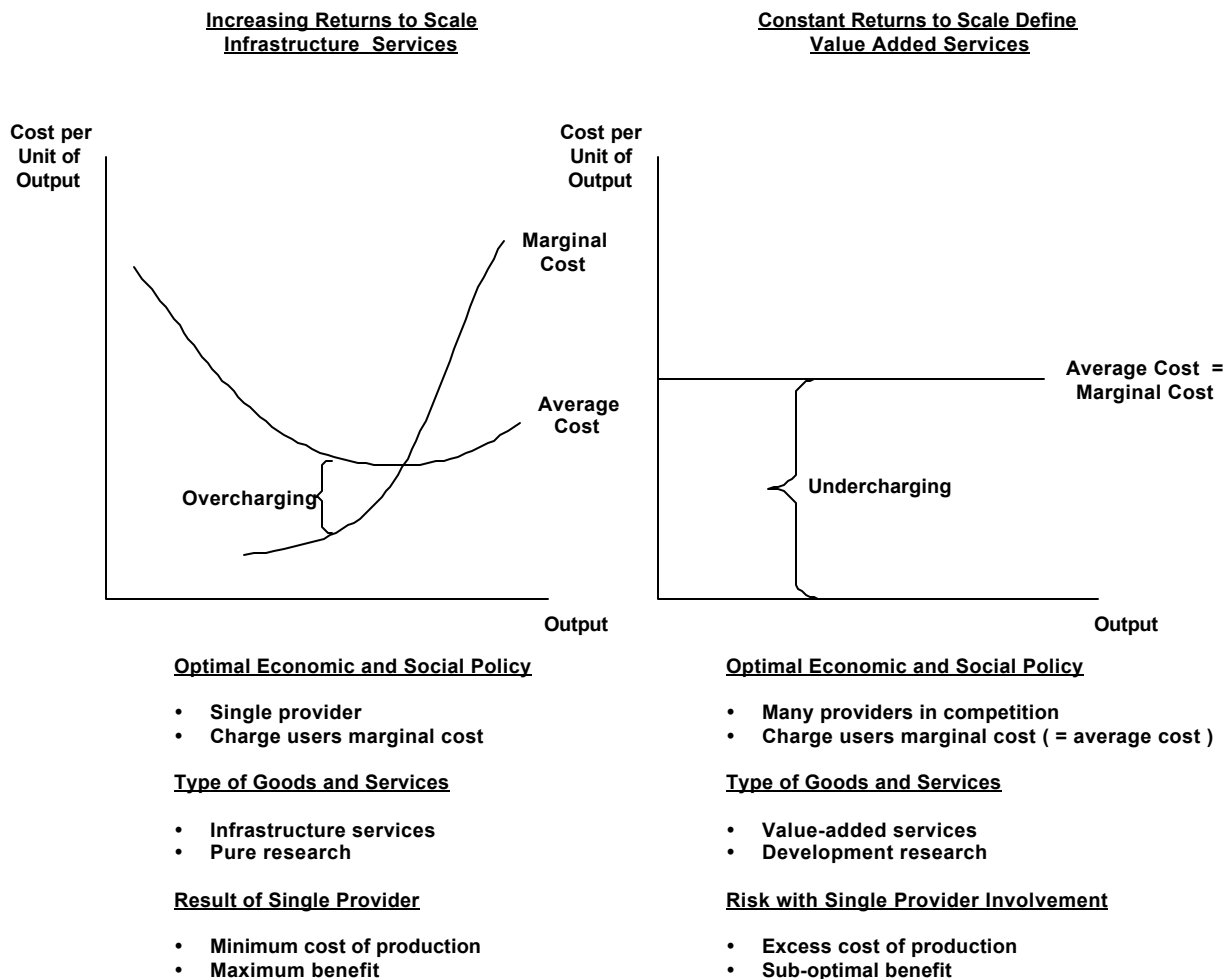
As shown in the left-hand panel of Figure 5, average and marginal costs are equal in the supply of goods and services that exhibit constant returns to scale (as the majority of goods and services in the economy do). This means that private, competitive provision yields optimum quantities and prices because, in setting prices at average unit cost (including normal profit), firms automatically set prices at marginal unit cost as well.

Market failure also occurs in the private provision of services that exhibit the characteristics of so-called “public goods.” Public goods are defined by an attribute called “non-excludability.” Non-excludability means that two or more consumers can simultaneously use the same unit of service and it is not, in general, possible to prevent certain groups or individuals from doing so. Firms seeking to maximize profits in this environment inevitably set prices too high, and produce too little service accordingly, because they fail to account for the value of “external” benefits in their pricing and production decisions.

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<sup>13</sup> This is a fundamental and widely held tenet of market economics. For a foundational discussion, see Paul A. Samuels, *Foundations of Economic Analysis*, MIT Press, 1948

**Figure 5: Definition of Optimal Public/Private Balance of Provision: Increasing and Constant Returns to Scale**



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### 3.2 The Current Situation in Relation to Optimal Conditions

In light of the discussion above, the chief criterion for government involvement in the provision of meteorological goods and services is whether they address a market failure, either because they exhibit economies of scale or non-excludability (i.e., they are public goods). Meteorological goods and services that exhibit either (or both) of these characteristics are typically termed “infrastructure services” whereas all other goods and services are termed “value-added” goods and services (see Figure 5). The rule of economic optimization states that infrastructure services should be provided by the federal government and sold at prices equal to their unit marginal cost.

### 3.2.1 Current Division of Responsibilities Between MSC and the Private Sector

Table 4 divides the existing range of activities and outputs supplied by Meteorological Services of Canada (MSC) into those which are likely to exhibit the characteristics of infrastructure goods and services and those which are likely to display the characteristics of value-added goods and services. The assignment of outputs and activities to each category was conducted on the basis of the principles and criteria outlined above and with cost and output data supplied by MSC, Environment Canada. The analysis is presented in Appendix C and summarized in the box below.

#### ***How HLB Established the Division of Activities in Table 4***

*Economic criteria were used to assign WEP activities to the infrastructure category (the group of services appropriate for public provision) and the value-added category. These are:*

- *The activity is likely to exhibit “increasing returns to scale.” This indicates a risk of sub-optimal provision if supplied by private firms in a competitive environment;*
- *The activity is likely to exhibit the characteristics of a public good, with special reference to “excludability.” “Excludability” denotes a situation in which the supply of a service cannot be restricted to those who are willing to pay. (National defense is an obvious example). Private provision is obviously not viable under such circumstances.*

*HLB did not have access to the detailed data on unit costs and volumes (outputs) needed to apply the criteria on the basis of a detailed modeling and accounting framework. Indeed, the analysis needed in order to draw definitive conclusions on an activity by activity basis is extensive. Instead, we obtained, from MSC, a detailed spreadsheet of WEP activities (see Appendix C). With the guidance of MSC staff,<sup>14</sup> we inspected the technological characteristics and production attributes of each activity in relation to conventional economic wisdom about the attributes of goods and services that display increasing returns or the features of public goods. Activities were assigned to the infrastructure category accordingly; all other activities were assigned to the value-added category. The overlay of non-economic criteria could, of course, shift the assignments obtained in the way described here.*

The results are given in Table 4. Of the \$225.5 million in MSC outlays in fiscal year 2000-01, a total of \$159 million (71 percent) are found to support infrastructure activities; the balance, \$66.6 million (29.5 percent) are found to support the production of value-added outputs. This means that just under three-quarters of the MSC fiscal year 2000-01 budget involved activities in which a government role is economically justified. Just under a third of MSC expenditures are in support of activities that would be

<sup>14</sup> HLB consulted with FMA-MSC and MSC’s Special Clients and Partners Directorate. Final allocations are the responsibility of HLB alone.

supplied more efficiently by private firms. Analysis reported in Section 5 below indicates that private firms in Canada are already supplying some of the same products and services as those listed in the right-hand panel of Table 4.

### 3.2.2 Current MSC Pricing

We examined MSC costing and pricing policies and practices in order to determine:

- Whether infrastructure goods and services are being priced at marginal cost; and
- Whether value-added goods and services are being priced at average cost (including an imputed allowance for normal profit and commercial risk).

Although HLB was not supplied with specific cost and revenue data for the various outputs listed in Table 4, we were given access to the costing principles employed in the establishment of prices.<sup>15</sup>

In the case of infrastructure services, we find that the principles of “full cost allocation” in use today lead to prices that lie close to average unit cost and, accordingly, lie substantially above the unit marginal cost. In the case of value-added services, we find that prices lie close to average unit costs, but do not, by design, include an allowance for normal profit and risk.

As explained above, charging more than unit marginal cost for infrastructure services creates a sub-optimal demand for meteorological goods and services. Conversely, charging less than average unit cost for value-added services places private firms at a competitive disadvantage. Growth in the number of private firms is inhibited accordingly, as is private research, development and innovation in the provision of weather and climate forecasting products and services.

## 3.3 Conclusion

Five conclusions stem from the analysis in this section:

1. Just under three-quarters of the expenditures of Environment Canada’s Meteorological Services of Canada (\$159 million in fiscal year 2000-01) involve infrastructure activities and outputs that address a market failure.
2. The federal government has permitted the value of the capital stock of meteorological infrastructure to erode over the past 25 years. This has contributed to the nation’s sluggish rate of growth in productivity, Gross Domestic Product and real personal income;

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<sup>15</sup> Atmospheric Environment Service, Commercial Services: *Full Costing Model and Revenue Distribution Guidelines* (undated) and Environment Canada, Commercialization and Management Practices Branch, *Policy on Revenue and Collaborative Arrangements: Financial and Administrative Framework for User Charging, Collaborative Arrangements and Intellectual Property Licensing*, December 4, 2000 (unpublished)

3. MSC charges more than the optimal price for infrastructure services, thereby preventing the maximization of the economic and social benefits of weather prediction;
4. An estimated 30 percent of the expenditures of Environment Canada's Meteorological Services of Canada, \$66.5 million in fiscal year 2000-01, are for the production of value-added services that would be more efficiently provided by private firms; and
5. MSC does not impute normal and risk into the prices it levies for value-added products and services. This places private providers at a competitive disadvantage that limits their growth and inhibits innovation in the private sector supply of such products and services.

Regarding conclusion 3, this study has not determined the magnitude of the difference between optimal infrastructure user fees and actual fees charged. This is because HLB did not have access to the specific cost and revenue data needed to make a service-by-service determination of optimal versus actual charges. However, in light of the significant economies of scale associated with satellite-based technology, remote sensing and other meteorological infrastructure, the policy of charging average cost will inevitably yield significant gaps between marginal cost-based prices and actual prices. On the other hand, the high level of taxpayer subsidy implied in the textbook prescription of marginal cost pricing creates economic and practical problems of its own. The Box Essay (after Table 4 below) addresses possible solutions.

Regarding conclusion 5, the difference between optimal and actual fees for MSC value-added services is quantitatively less significant than the price gap in the case of infrastructure services. Again, HLB did not have access to cost and revenue data for specific products. The costing principles in use, however, indicate that the only components missing from the optimal economic price are imputed profit and risk. While these factors are not insignificant, they are likely to create a smaller divergence between optimal and actual prices than in the case of infrastructure services.

The next Section identifies the range of policy options with which these conclusions can be addressed. Section 5 then evaluates the options and Section 6 presents the study's overall conclusions.

**Table 4: Environment Canada Infrastructure and Value Added Services Expenditures <sup>16</sup>, FY 2000-2001.**

	Infrastructure Activities - Expenditures (Millions of Current Dollars)			Value Added Activities - Expenditures (Millions of Current Dollars)			Total
	Net Budgetary Expenditure	Vote Net Revenue (excl. EBP)	Gross Budgetary Expenditures	Net Budgetary Expenditure	Vote Net Revenue (excl. EBP)	Gross Budgetary Expenditures	
<b>Research &amp; Development</b>	23.6	2.2	25.8	8.3	1.4	9.7	<b>35.5</b>
<b>Production</b>	42.8	0.0	42.8	21.4	33.6	55.0	<b>97.8</b>
<b>Monitoring Infrastructure</b>	47.3	22.3	69.6	0.0	0.0	0.0	<b>69.6</b>
<b>Service Delivery</b>	1.3	3.7	5.0	1.3	0.5	1.8	<b>6.8</b>
<b>National Support Systems</b>	14.7	1.1	15.8	0.0	0.0	0.0	<b>15.8</b>
<b>Total</b>	<b>129.7</b>	<b>29.3</b>	<b>159.0</b>	<b>31.0</b>	<b>35.5</b>	<b>66.5</b>	<b>225.5</b>

Source: Appendix C

<sup>16</sup> All budget figures from Planning Database, Pivot Table Version – January 5, 2001.

**BOX ESSAY: THE ECONOMICS OF PRICING PUBLIC GOODS -- AN OVERVIEW**

The term “public good” is used in two different, albeit overlapping senses in the economics literature. One has to do with “non-excludability.” The other concerns “absence of rivalry in consumption.” Early on in the literature, a broadcast from a radio or television tower was a commonly used example of public goods in both senses of the term. On non-excludability, the literature observed that once a station’s signal is transmitted from its tower, any of its neighbours could receive it; no mechanism existed with which to provide it only to those who were willing to pay for it. Regarding absence of rivalry in consumption, the time one neighbour spent being entertained by the signal was observed to have no effect on the quality of the signal any other neighbor received.

Technology has altered this state of affairs in the last decade or so. DirecTV uses a satellite over the Gulf of Mexico to beam a signal toward Canada and the United States. The reception of that signal by one person neither increases DirecTV’s costs nor reduces the quality of the signal anyone else receives. But these signals *are* subject to excludability. Any household can authorize someone answering a phone at DirecTV to charge its credit card and, in return, instantly receive access to a fraction of the signal that is “striking” its home. If the household pays an additional amount, it receives a bit more of the total signal. The cost of billing the household is DirecTV’s total cost of serving it; if DirecTV provided the service free, serving the additional household would cost DirecTV nothing.

For a large and growing fraction of what is produced these days, the marginal cost of an extra unit of output is trivial in comparison to its average total cost. The copy of the paperback novel that sells for \$3.95 at the supermarket checkout counter costs on the order of 20 cents to produce. Computer programs that cost millions of dollars to develop are distributed on compact disks that cost 25 cents or so. Knowledge collected by MSC that costs it many thousands of dollars to produce can be sent to an additional radio station or newspaper or producer of highly specialized weather reports for a tiny fraction of many thousands of dollars. Suppose that MSC were to employ a DirecTV-type technology to provide weather knowledge only to those willing to pay a price that, when added over all paying customers, would cover its costs of producing and distributing this knowledge. Such a procedure would exclude—possibly very many—customers whose benefits from this knowledge fall short of this average-cost price but who would happily pay the marginal-costs of serving them.

Micro-economics textbooks invariably point out that, when the price of a commodity exceeds the incremental or marginal cost of producing it, additional output would generate additional consumer benefits that would exceed the additional costs of producing this additional output. This being the case, the textbook prescription is, “Set price equal to marginal cost.” This prescription is costly when, as in the cases presently at hand, the revenue from marginal-cost prices would fall short of total costs. Under such circumstances, price could always equal marginal cost only if someone or some entity willingly always subsidizes the resulting deficits. In textbook discussions, governments are almost always assumed to be the subsidizing entities.

**BOX ESSAY: THE ECONOMICS OF PRICING PUBLIC GOODS -- AN OVERVIEW ...  
con't**

Governmental subsidies to equate price and marginal cost have at least two problems: First, subsidies require tax revenues. Taxes imposed on goods and services inevitably result in buyers paying more for them than their sellers receive. Even in markets where prices would otherwise equal marginal costs, taxes introduce the sorts of gaps between consumer value and supplier cost that subsidies designed to equate prices and marginal costs in other markets are aimed at eliminating. Conclusion: At a maximum, the subsidy required to reduce the gap between price and marginal cost in one market should yield benefits in that market no greater than the costs the necessary taxes impose in other markets.

The second problem with governmental subsidies to individual markets: Their costs are borne by taxpayers in general; their benefits go in considerable measure to those most actively involved in the subsidized markets. Almost all of us benefit from the general weather reports we read in newspapers, hear on the radio, or see in TV. Were these the only benefits that MSC provides, its optimal level of output would probably be considerably lower than it is presently. But it provides many other beneficial services. For example, frost alerts from MSC or independent entrepreneurs who use MSC data give fruit farmers time to set up sprinklers, smudge spots, or other equipment to repel frost. The primary beneficiaries from such reports are those who produce them, those who use them to reduce crop damage and, perhaps, fruit consumers. Taxpayers in general are not likely to be enthusiastic about such income transfers.

Because of such problems, subsidies designed to reduce gaps between prices and marginal costs in markets are unlikely to eliminate these gaps substantially even when they are very large. Fortunately, sophisticated pricing techniques have been developed in the economic literature that promise to reduce gaps between prices and marginal costs in many types of market. Two techniques are particularly prominent in this literature – “bundling” and “two-part tariffs.” Bundling: if consumers differ in the values they attach to individual products in a related group of commodities, charging a single price for each of a group of carefully designed bundles can increase both revenues and buyer benefits from the group. Two-part tariffs: Charge an up-front fee that is independent of total purchases in a market together with a unit price per unit that is closer to marginal cost than an average-cost price. The up-front fee could, alternatively, be associated with a group successively lower per-unit fees.



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## 4 ALTERNATIVE DIRECTIONS FOR FEDERAL POLICY

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What policies and investment levels would maximize the net economic benefits of meteorological infrastructure investment and promote the most efficient market structure? This section identifies the options and the criteria for their assessment. The assessment itself is reported in Section 5.

### 4.1 Strategic Policy Options

The base case policy framework is presented next, followed by an elaboration of alternative policy directions.

#### 4.1.1 The Base Case

The going-forward policy and investment framework is given in Environment Canada's *Weather and Environmental Predictions: Business Line Plan 2000/01-2003* dated January 26, 2000. As shown in Table 5, The Business Plan (and subsequent amendments) calls for \$124.6 million in new capital investment, plus an estimated \$85.6 million in associated operating and maintenance expenditures (in current dollars). Although this level of capital investment would help close the infrastructure investment gap identified earlier, we find in the next Section that more investment would be needed to maximize economic and social returns.

The Business Plan does not anticipate any structural change in the mix of infrastructure and value-added activities performed by Environment Canada.

#### 4.1.2 Strategic Policy Options for Shifting Toward Optimal Provision of Meteorological Services

The strategic policy options available here are fundamentally three:

1. Adjust the level of MSC capital investment in meteorological infrastructure to a level that maximizes economic returns;
2. Withdraw from the provision of value-added products and services that would be more efficiently supplied by private firms; and
3. Implement pricing policies that (i) reduce user fees charged for infrastructure services so as to equate them with their marginal cost; and (ii) increase user fees charged for federally-produced value-added services to include imputed profit and risk.

**Table 5: Canadian Public Sector Meteorological Infrastructure– MSC Capital Investment Plan, FY 2001 – 2004.**

		<b>2000/2001 (Millions of Current Dollars)</b>	<b>2001/2002 (Millions of Current Dollars)</b>	<b>2002/2003 (Millions of Current Dollars)</b>	<b>2003/2004 (Millions of Current Dollars)</b>	<b>Total</b>
<b>Monitor the Atmosphere</b>	Incremental Capital	21.8	18.3	16.6	14.8	71.5
	Incremental O&M	2.6	2.4	2.7	3.3	11
<b>Warn Canadians of Hazardous Meteorological Events</b>	Incremental Capital	2.5	6.5	5.5	8.1	22.6
	Incremental O&M	12.6	13.1	13.7	14.6	54
<b>Information on Past and Present Climate</b>	Incremental Capital	1	0.7	0.5	0.5	2.7
	Incremental O&M	0.6	0.6	0.6	0.7	2.5
<b>Information on Past &amp; Present Water Quantity</b>	Incremental Capital	5.1	4.1	4.1	4.0	17.3
	Incremental O&M	1.9	2.0	1.9	2.1	7.9
<b>Warn Canadians of Hazardous Lake and Sea Ice</b>	Incremental Capital	1.5	0.0	2.6	2.3	6.4
	Incremental O&M	1.0	1.3	1.3	1.3	4.9
<b>Warn Canadians of Hazardous Air Quality Levels</b>	Incremental Capital	1.4	0.7	0.0	0.0	2.1
	Incremental O&M	0.0	0.0	0.0	0.0	0.0
<b>Science Advice on Climate Change</b>	Incremental Capital	0.7	0.7	0.0	0.0	1.4
	Incremental O&M	0.5	0.6	0.7	0.8	2.6
<b>Science Advice on Air Quality</b>	Incremental Capital	0.5	0.1	0.0	0.0	0.6
	Incremental O&M	0.3	0.4	0.5	0.6	1.8
<b>Total<sup>17</sup></b>	Incremental Capital	34.5	31.2	29.2	29.7	<b>124.6</b>
	Incremental O&M	19.6	20.7	21.7	23.6	<b>85.6</b>

<sup>17</sup> Totals based on tabular values may exhibit rounding errors.

**Notes to Table 5.**

“Environment Canada: Atmospheric Environment Program (Millions) Capital and Operating Requirements”, Environment Canada, undated. Note that the program outlined above reflects a one-time submission by MSC to the Treasury Board Program Integrity 1 exercise on July 24, 1999. Out of the total \$216 million in incremental capital and associated operating and maintenance dollars requested over five years, MSC has received \$20 million (over five years) to address critical occupational and health safety issues. It should also be noted that the proposed investment plan referenced above does not reflect the most current MSC investment planning assumptions. Use of the Program Integrity 1 plan are used here to analyze optimal capital sums required and associated benefits, incremental to the reference levels in 2000/01.

In principle, the optimal infrastructure investment level is that which achieves the maximum economic return on investment. In practice, government departments are limited by the fiscal framework and cannot necessarily receive Cabinet approval for optimal investment amounts. Section 5 assesses the return on investment likely to be forthcoming from the base case investment plan (shown above in Table 5) and examines the case for yet higher levels of investment.

A withdrawal from the provision of value-added services is commensurate with a policy framework in which federal government involvement is guided by the test of market failure. There are different ways in which such a policy framework could be implemented. In the United States, for example, federal policy states that the National Weather Service shall not provide a product or service that the private sector either does, or could provide. An appeals office exists to examine private claims of violation. Alternatively, Environment Canada could examine the detailed cost structure of each of its activities so as to determine whether or not they exhibit economies of scale, non-excludability or other evidence of market failure. The adjustment of user fees to reflect imputed profit and risk represents a third approach. By “levelling-the-playing field” between government and private provision of value-added services, the market would help determine whether a product or service is best provided in the public sector, the private sector or both. Of course, a combination of these three implementation strategies could also be developed.

A policy of federal withdrawal from the provision of value-added services would need to be implemented with due regard for the time required by private firms to step in. Withdrawing too abruptly would create the risk of U.S. firms stepping in to certain sectors of the Canadian marketplace before domestic firms can establish serious competitive beachheads. On the other hand, once such beachheads were in place, the United States offers a well developed export market. Alternative withdrawal strategies for balancing these risks and rewards are not considered in this study.

## 4.2 Evaluation Criteria

The study evaluates the major strategic alternatives outlined above in relation to two principal criteria:

1. Economic efficiency (maximum net economic and social benefits); and
2. Promotion of the most efficiently-sized private sector in meteorological infrastructure services.

The evaluation is presented next.

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## 5 EVALUATION OF ALTERNATIVE FEDERAL POLICY DIRECTIONS

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Section 5.1 looks first at the business case for Environment Canada's investment plan (as summarized in Table 5 above). We find the expected return on investment to be high, in order of 69.4 percent. One reason for the high rate of return is the large backlog of capital requirements. Delay means that potential benefits have cumulated over the years and are being released through capital investment now.

Section 5.2 asks whether higher levels of capital investment would liberate greater benefits still and whether their incremental economic value would justify the incremental economic costs.

Finally, Section 5.3 assesses the prospective effects of strategic options under which the federal government would withdraw from the provision services that do not exhibit evidence of market failure.

### 5.1 The Business Case for MSC's Proposed Infrastructure Investment Plan

The infrastructure investment plan shown in Table 5 can be expected to yield both private and social economic benefits. As discussed in previous sections, private benefits arise in the form of enhanced national productivity and Gross Domestic Product. Social benefits arise in the form of values that are not reflected in the national GDP accounts. These include the value of lives saved, injuries avoided, time savings, habitat preserved and so on.

#### 5.1.1 Private Economic Benefits

Based on the econometric model presented in Appendix B, the estimated present-day value of increased productivity and economic output due to the Environment Canada investment plan is \$4.5 billion. This assumes a ten-year economic life for new facilities and equipment, a potentially conservative number but one that reflects the risk technological obsolescence as well as normal wear and tear.

#### 5.1.2 Social Benefits

Under the measurement framework presented earlier, the magnitude of social benefits turns on the extent to which new investment is likely to improve the accuracy of weather predictions. Based on an estimated 2.5 percent improvement (see Figure 6) and the earlier estimate of "social benefits per percentage point improvement in forecast accuracy", the present value of the investment plan's projected social benefits is \$88.4 million, as shown in Table 6.

#### 5.1.3 Net Economic Benefits

Given the projected benefits outlined above, and expected costs of \$280.9 million (present value, in constant 2000 dollars), the investment plan *net present value* is an estimated \$4.6 billion. This equates to an internal rate of return of 69.4 percent. Although a return of this magnitude might seem

unexpectedly high for a public investment, it is in fact characteristic of returns on public infrastructure projects (such as roads and water facilities) that redress many years of delayed modernization and upkeep. In studies for the U.S. Federal Highway Administration, Nadiri<sup>18</sup> found the return on highway investment in the United States to be 35 percent during the 1970s when the United States was catching up with many years of relative neglect. Returns fell to “normal” levels – about 10 percent – thereafter.

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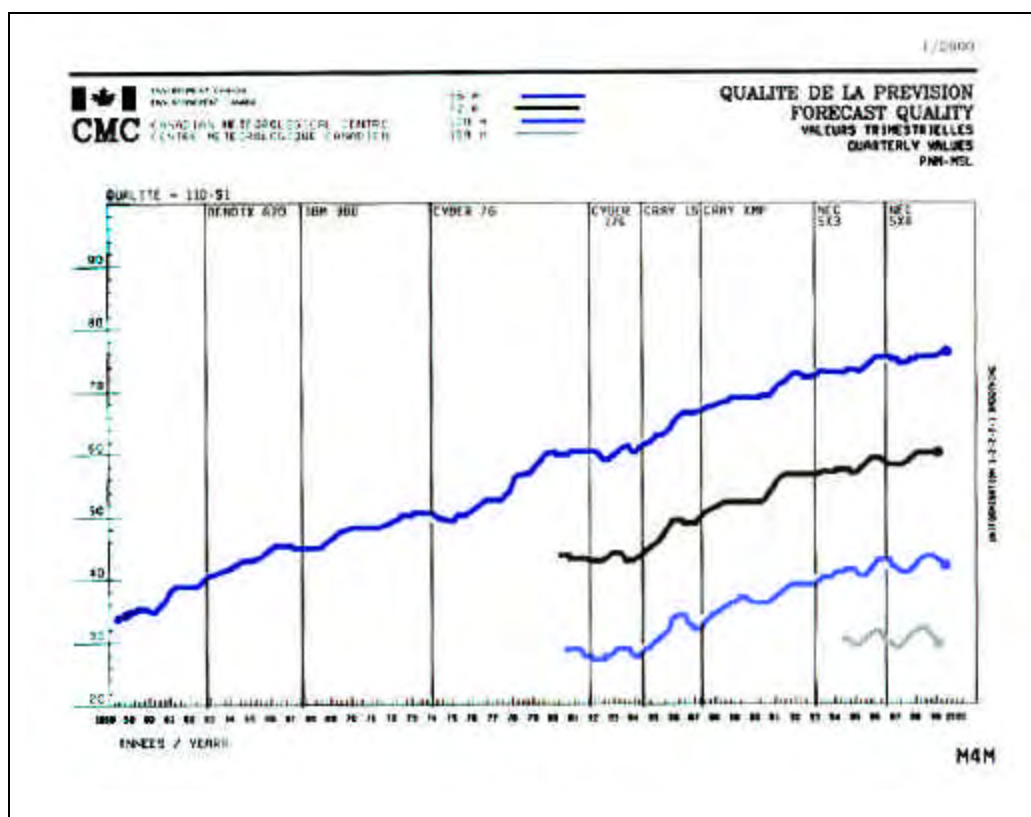
<sup>18</sup> Nadiri, op. cit 1996

**Table 6: Business Case Assessment of MSC Proposed Capital Investment Plan, FY 2001 – 2010 (in constant 2000 dollars).**

	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	Present Value (10 % Discount Rate)
<b>Costs<sup>19</sup></b>											
Capital Spending (Millions of 2000 Dollars)	34.5	28.4	24.1	22.3	20.3	0	0	0	0	0	<b>129.6</b>
Incremental O&M (Millions of 2000 Dollars)	19.6	18.8	17.9	17.7	16.1	14.7	13.3	12.1	11.0	10.0	<b>151.3</b>
Total Cost (Millions of 2000 Dollars)	54.1	47.2	42	40	36.4	14.7	13.3	12.1	11.0	10.0	<b>280.9</b>
<b>Benefit</b>											
Output (Millions of 2000 Dollars)	0.0	0.0	0.0	0.0	0.0	1,017.7	955.4	896.6	841.0	788.5	<b>4,499.2</b>
Social (Millions of 2000 Dollars)	0.0	0.0	0.0	0.0	0.0	21.2	19.3	17.5	15.9	14.5	<b>88.4</b>
Total Benefit (Millions of 2000 Dollars)	0.0	0.0	0.0	0.0	0.0	1038.9	974.7	914.1	856.9	803.0	<b>4587.6</b>
<b>Net Present Value (Total Benefit – Total Cost) (Millions of 2000 Dollars)</b>											<b>4,306.7</b>

**Note:** The program outlined above reflects a one-time submission by MSC to the Treasury Board Program Integrity 1 exercise on July 24, 1999. Out of the total \$216 million in incremental capital and associated operating and maintenance dollars requested over five years, MSC has received \$20 million (over five years) to address critical occupational and health safety issues. It should also be noted that the proposed investment plan referenced above does not reflect the most current MSC investment planning assumptions. Use of the Program Integrity 1 plan are used here to analyze optimal capital sums required and associated benefits, incremental to the reference levels in 2000/01.

<sup>19</sup> Environment Canada: Atmospheric Environment Program Capital and Operating Requirements Include Inflation Factors. Note: Assumes a nominal Incremental Capital cost in 2004/2005 of 29.7.

**Figure 6: Canadian Meteorological Centre Forecast Quality, 1958– 2000.**

*Weather and Environmental Predictions – Business Line Plan, 2000/2001 – 2002/2003, Environment Canada, January 26, 2000.*

## 5.2 The Business Case for Higher Levels of Infrastructure Investment

Although this report does not seek to quantify the theoretically optimal level of meteorological capital investment, simulations with the econometric model presented in Appendix B indicate that the optimal level is greater than that reflected in the Environment Canada investment plan. In other words, up to a certain point, higher levels of capital investment would yield economic benefits in the form of productivity of national output that exceed the incremental capital and operating costs. While more analysis would be needed to provide a detailed estimate, initial simulations indicate that the currently planned level of investment would need to be approximately doubled to achieve maximum efficiency. One means of financing such additional investment would be through the diversion of budgetary outlays presently dedicated to the provision of value-added products and services.



### **5.3 The Economic Effects of Federal Withdrawal from the Provision of Value-Added Products and Services**

The primary effect of Environment Canada's withdrawal from the market for value-added commercial products and services would be:

- A larger number of private firms and privately generated products and services;
- Greater private sector investment and innovation in value-added commercial forecasting products and services; and
- Lower consumer prices for value-added commercial products and services.

#### **5.3.1 Impact on Market Size**

Although the timing of market effects would depend upon the rate at which the federal government transitioned out of the provision of value-added commercial services, the long run implications for market size are significant. As shown in the market analysis presented in Table 7 (the underlying technical basis of which is given in Text Box 1), the private sector in meteorological products and services would expand for its current level of about \$60 million in total annual revenues to between \$186.2 million and \$159.6 million annually. If average revenues per firm remain at the current level (of about \$2 million a year), the number firms in the Canadian market would expand from about 30 today to more than 110.

#### **5.3.2 Impact on Innovation and Consumer Prices**

At the upper end of the range given in Table 7, the value of total private sector meteorological products and services would grow to exceed the total value of such services provided today by the federal government and the private sector combined. The latter figure is \$169 million, comprised of \$109 million in federally provided products and services (see Table 5) plus the \$60 million in privately supplied products and services. As shown in Table 7, the private sector could grow to \$186.2 million annually, some 10 percent more than the combined value of federal and private services today. This increase would likely represent a combination of factors, including better prices and thus more demand, but also greater innovation spurred by the additional competition for private business.

**Table 7 The Potential Canadian Market for Meteorological Services, by Service and Value (Millions of 2001 Dollars)**

Types Of Services	Value-Added Services	Value of Services Supplied by Private Firms under Current Market Structure	Estimated Value of Services Supplied by Private Firms under Optimal Market Structure	
			Low	High
<b>Services Provided by Public &amp; Private Sectors</b>	<ul style="list-style-type: none"> <li>• Specific R&amp;D</li> <li>• Software Development</li> <li>• Numerical Modeling</li> <li>• Weather Data Analysis</li> <li>• Data Processing &amp; Quality Control</li> <li>• Weather Forecasting</li> <li>• Hydrological Data &amp; Forecasts</li> <li>• Air Pollution</li> <li>• Media</li> <li>• Consultation Services</li> </ul>	\$55–65	\$152.2	\$177.5
<b>Public/Private Partnerships</b>	<ul style="list-style-type: none"> <li>• Aviation Weather Forecasts</li> <li>• Lightning Detection &amp; Forest Fire Prevention</li> </ul>			
<b>Services Provided by Private Sector Alone</b>	<ul style="list-style-type: none"> <li>• Training &amp; Continuous Education</li> <li>• Forensic Meteorology</li> <li>• Micro Climate</li> </ul>			
<b>Services Provided by Public Sector Alone</b>	<ul style="list-style-type: none"> <li>• Weather Data Gathering and Archiving</li> <li>• Weather Warnings (Information)</li> <li>• General Weather Services in Sparsely Populated Areas</li> <li>• R&amp;D</li> </ul>	–	\$7.4	\$8.7
<b>Services Provided by U.S. Private Sector &amp; Not Duplicated by Canadian Private Sector</b>	Though Canadian and U.S. firms tend to specialize in different services, overall the array of services is similar in both countries.		N/A	
<b>Services Provided by U.S. Public Sector Alone</b>	N/A		N/A	
<b>Total Services</b>		<b>\$55–65</b>	<b>\$159.6</b>	<b>\$186.2</b>

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**Notes to Table 7: The Potential Canadian Market for Meteorological Services**Value of Services Supplied under Current Market Structure

The annual revenues of Canadian meteorological firms are currently estimated at \$55-65 million. The array of services provided in Canada is very similar to the U.S. and we could not identify specific services provided in the U.S. only. Though it is suspected that such additional services exist, they account for a very small share of the market. Therefore, under the current market structure the value of the private Canadian market is **\$55-65 million**.

Value of Services Supplied under Optimal Market Structure

To assess the value of the potential Canadian market under an optimal market structure, we need to know the value of services solely provided by the MSC:

- Weather data gathering and archiving: Weather data gathering and archiving are not considered as true value added services. Their value added can be estimated at \$2 million approximately.
- Weather warnings (including marine warnings): \$3 million (a tenth of weather warnings, forecasts and information). On average, the MSC releases 14,000 severe weather warnings and half a million weather forecasts annually.
- General weather services in sparsely populated areas: Their value is not known. These services account for a very thin share of the potential market, thus their value is negligible.
- Research and development (excluding marine weather R&D): \$8.3 million

As a result, the services solely provided by the MSC have a total value of **\$13.3 million**.

These estimates need to be adjusted to account for the potential size of the private sector based on the U.S. experience. Annual revenues of the private sector are estimated by HLB at \$1,855–2,616 million. Therefore, the market share of the US private sector lies between **50.9%** and **59.4%**. In Canada, private companies account for only 21% of the market. Furthermore, we can reasonably assume that the Canadian market will expand by about 10% (**\$28.5 million**) as a result of the entry of new firms on the market.

The total value of the market for meteorological services is currently estimated at **\$285 million**. Thus the adjusted total value of the potential Canadian private market is:

- $\$285 \text{ million} * (1+10\%) * 50.9\% = \$159.6 \text{ million}$  (low estimate)
- $\$285 \text{ million} * (1+10\%) * 59.4\% = \$186.2 \text{ million}$  (high estimate)

The share of additional services to the private sector (i.e., services provided by the MSC alone under the current market structure) is:

- $\$13.3 \text{ million} * (1+10\%) * 50.9\% = \$7.4 \text{ million}$  (low estimate)
- $\$13.3 \text{ million} * (1+10\%) * 59.4\% = \$8.7 \text{ million}$  (high estimate)

The share of services currently supplied by the public and private sectors is:

- $\$159.6 \text{ million} - \$7.4 \text{ million} = \$152.2 \text{ million}$  (low estimate)
- $\$186.2 \text{ million} - \$8.7 \text{ million} = \$177.5 \text{ million}$  (high estimate)

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## 6 CONCLUSION

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This study yields four principal conclusions, as follows:

1. Just under three-quarters of the expenditures of Environment Canada's Meteorological Services of Canada (\$159 million in fiscal year 2000-01) involve meteorological infrastructure activities and outputs that address a market failure and thus belong in the federal domain. The remaining expenditures, \$66.5 million in fiscal year 2000-01, are for the production of value-added services that would be more efficiently provided by private firms.
2. The federal government has permitted the value of the capital stock of meteorological infrastructure to erode over the past 25 years. This erosion has contributed measurably to the nation's sluggish rate of growth in productivity and Gross Domestic Product. Although Environment Canada's proposed \$280 million five-year capital investment plan would yield net benefits of \$4.6 billion over ten years (a 69 percent rate of return), even higher levels of federal infrastructure investment would be economically justified.
3. MSC charges more than the optimal price (more than marginal cost) for meteorological infrastructure services, thereby preventing the maximization of the economic and social benefits of weather prediction; and
4. MSC does not impute an allowance for normal profit and risk into the prices it levies for its value-added products and services. This places private providers at a competitive disadvantage that limits their growth and inhibits innovation in the private sector supply of such products and services. If the federal government were to withdraw from the provision of products and services in which no evidence of market failure is apparent, the value of private sector output and employment in the production of meteorological services would more than double.

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## APPENDIX A. HLB ESTIMATION OF THE OUTPUT AND PRODUCTIVITY BENEFITS OF METEOROLOGICAL SERVICES

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### 1. Framework

Consider the production function:

$$Y_t = A_t * f ( K_t , L_t , G_t )$$

Where:

- Y = real aggregate output of the private sector;  
 A = a measure of productivity;  
 K = aggregate stock of non-residential private capital;  
 L = aggregate employment of labour services by the private sector; and  
 G = non-military public capital stock, or public expenditures.

Here, we replace G by either a measure of the public stock of capital used in the production of weather services (weather forecasting equipment and the like) or a measure of public spending on weather services (e.g., annual budget of the Meteorological Service of Canada).

A simple estimating equation can be written as:

$$\log(Y_t) = \beta_0 + \beta_1 \cdot \log(K_t) + \beta_2 \cdot \log(L_t) + \beta_3 \cdot \log(G_t) + \varepsilon_t$$

$$\text{or } y_t = \beta_0 + \beta_1 \cdot k_t + \beta_2 \cdot l_t + \beta_3 \cdot g_t + \varepsilon_t$$

We may also consider additional explanatory variables, including:

T = a time trend; and

CU = the capacity utilization rate in the private sector (or manufacturing/industrial sector only), to control for the influence of the business cycle.

$$y_t = \beta_0 + \beta_1 \cdot k_t + \beta_2 \cdot l_t + \beta_3 \cdot g_t + \beta_4 \cdot t + \beta_5 \cdot cu_t + \varepsilon_t \text{ (See Figure A-1)}$$

Following Aschauer, we also estimate a productivity equation, relating output per unit of capital (y - k) to the labour to capital ratio (l - k) and the public capital to private capital (g - k) ratio:

$$y_t - k_t = \beta_0 + \beta_1 \cdot (l_t - k_t) + \beta_2 \cdot (g_t - k_t) + \beta_3 \cdot t + \beta_4 \cdot u_t + \varepsilon_t \text{ (See Figure A-2)}$$

## 2. Data Requirement and Data Sources

### Data Requirements:

Annual data for Y, K, L, G and CU, for at least 20 years, preferably 30;

All variables are either end-year or mid-year values, we convert end-year to mid-year if needed;

All "money" variables (Y, K, and G) are expressed in constant dollars;

Capital stock data (K and G) are net of depreciation;

The public capital stock (G) is inclusive of federal, state, and local equipment and structures;

L, the aggregate employment of labour services by the private sector, is measured in hours.

### Suggested Data Sources:

Most data are found on Statistics Canada website, at <http://www.statcan.ca/english/CANSIM>.

<b>Variables</b>	<b>Data Sources</b>
Y	Statistics Canada, CANSIM II, Table 379-0004: Gross domestic product at factor cost in 1992 constant dollars, by Standard Industrial Classification (1961-2000)
K	Statistics Canada, CANSIM II, Table 031-0002: Flows and stocks of fixed non-residential capital, by North American Industry Classification System (NAICS) (1955-2000)
L	Statistics Canada, CANSIM II, Table 279-0020: Labour force survey estimates, employment (actual hours worked) by North American Industry Classification System (NAICS) (1976-2000)
CU	Statistics Canada, CANSIM II, Table 028-0001: Industrial capacity utilization rates, by Standard Industrial Classification (1962-2001)
G	Statistics Canada, CANSIM II, Table 031-0002: Flows and stocks of fixed non-residential capital, by North American Industry Classification System (NAICS) (1955-2000)
	Statistics Canada, CANSIM II, Table 379-0004: Gross domestic product at factor cost in 1992 constant dollars, by Standard Industrial Classification (1961-2000)
	Measure of the public stock of capital used in the production of weather services.
	Budget of the Meteorological Service of Canada.

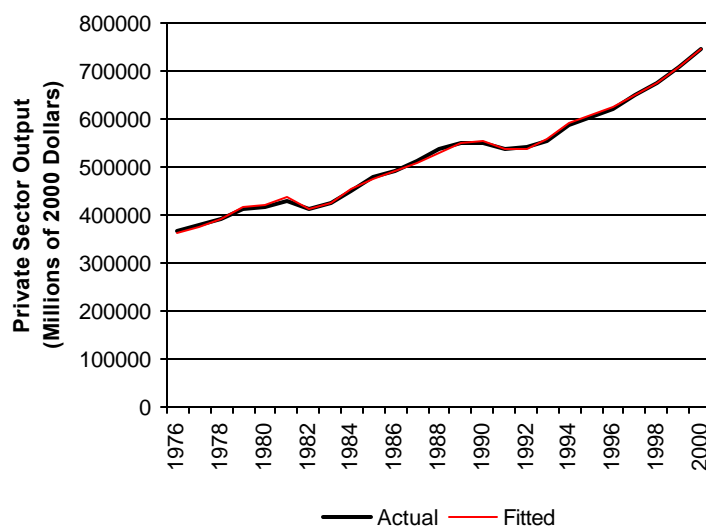
### 3. Estimation

Overview:

- 1) We begin by estimating an Aschauer-like equation (output and productivity equations), where  $G$  is the total non-military public stock of capital. This allows an assessment of data quality.
- 2) We replace  $G$  in 1) by total non-military public expenditures. Figures A-1 and A-2 present the regression output for output and productivity estimations, while Box A-1 describes the data used in these estimations.

**Figure A-1: Estimation of the Impact of Meteorological Infrastructure Capital Stock on Private Sector Output, 1976 – 2000.**

<b>Dependent Variable: Log of Private Sector GDP at Factor Cost, 1976 - 2000</b>	
<b>Variable</b>	<b>Coefficient (t-Ratio)</b>
Constant	-6.570967 (-1.483427)
Log of Private Capital Stock	0.907837 (2.670732)
Log of Hours Worked	0.446077 (5.129345)
Log of Meteorological Infrastructure Capital Stock	0.179366 (1.964462)
Time Trend (1976 – 1992)	-0.006027 (-0.811807)
Time Trend (1992 – 2000)	0.003848 (0.755341)
Capacity Utilization	0.004523 (4.736274)
<b>Regression Statistics</b>	
R-Squared	0.998576
F-Statistic	2103.083
Durbin-Watson	1.240603

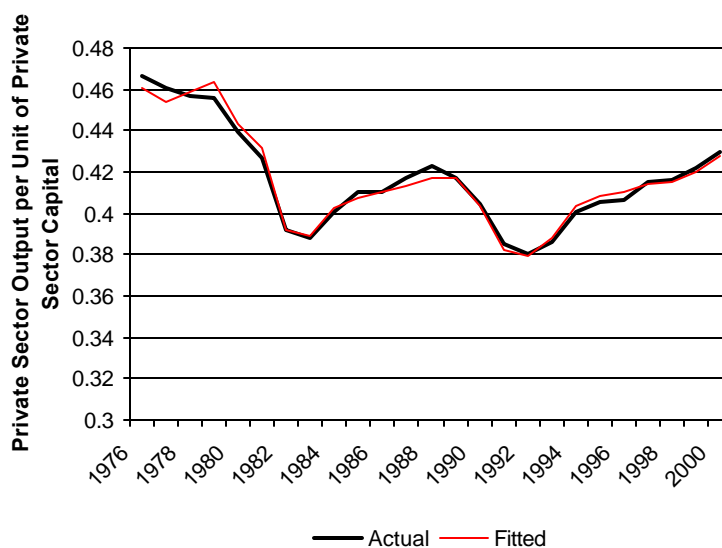


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**Figure A-2: Estimation of the Impact of Meteorological Infrastructure Capital Stock on Private Sector Output per Unit of Private Sector Capital, 1976– 2000.**

Dependent Variable: Log of Private Sector GDP at Factor Cost <i>less</i> Log of Private Capital Stock, 1976 – 2000	
Variable	Coefficient (t-Ratio)
Constant	-0.041931 (-0.291178)
Log of Hours Worked <i>less</i> Log of Private Capital Stock	0.538751 (10.81978)
Log of Meteorological Infrastructure Capital Stock <i>less</i> Log of Private Capital Stock	0.047109 (2.464922)
Time Trend (1976 – 1992)	0.004667 (3.860399)
Time Trend (1992 – 2000)	0.011192 (11.75748)
Capacity Utilization	0.003466 (7.803807)
Regression Statistics	
R-Squared	0.980139
F-Statistic	187.5323
Durbin-Watson	0.963874



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**Box A-1: Variable Definitions, Estimation of Private Sector Output and Productivity Impacts**

Variable	Description and Source
<b>GDP at Factor Cost</b>	Private sector Gross Domestic Product at factor cost, millions of constant dollars, end-year. Statistics Canada, CANSIM II, Table 379-0004
<b>Private Capital Stock</b>	<p>End-year gross capital stock – Canada, Private Sector. Calculated by subtracting Public Capital Stock<sup>1</sup> from Total Capital Stock<sup>2</sup>. Non-residential, millions of constant dollars.</p> <p>1. End-year gross capital stock – Canada, Public Sector, non-residential, millions of constant dollars. Statistics Canada, CANSIM II, Table 031-0002.</p> <p>2. End-year gross capital stock – Canada, non-residential, millions of constant dollars. Statistics Canada, CANSIM II, Table 031-0002</p>
<b>Private Sector Hours Worked</b>	Actual hours worked - Canada, private employees, all jobs, annual averages, in thousands. Statistics Canada, Labour Force Survey, Program A21187
<b>Meteorological Infrastructure Capital Stock</b>	<p>Gross Capital Stock, Weather services business lines, Environment Canada. Calculated using depreciation rate of 10%<sup>3</sup>, reference capital stock of \$333,405M in 1998<sup>4</sup>, and annual capital expenditures<sup>5</sup>. End-year, millions of constant dollars.</p> <p>3. <u>Weather and Environmental Predictions Business Line Plan 2000/2001 – 2002/2003</u>, Environment Canada, January 26, 2000.</p> <p>4. “Estimated Value of AEP Assets by Functional Usage”, Environment Canada, June 21, 1998.</p> <p>5. <u>Public Accounts of Canada, 1976 – 2000</u>.</p>
<b>Capacity Utilization</b>	Industrial capacity utilization rates for manufacturing industries, percent, as an annual average. Statistics Canada, CANSIM II, Table 028-0001
<b>Constant</b>	Equal to 1 in each period.
<b>Time Trend</b>	Equal to 1 in 1976, incrementing by 1 each year.

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## Derivation of Business Case Private Benefits Estimates

The estimates of output benefits provided in Section 5 are derived as follows. The results depend upon the theoretical foundation and associated regression results provided above.

1. Forecast independent variables from the productivity regression model for the period 2001 – 2010 (The right-hand side of the equation below, which corresponds to the productivity equation above).

$$Y_t = \mathbf{b}_0 C + \mathbf{b}_1 L_t + \mathbf{b}_2 G_t + \mathbf{b}_3 T_{1t} + \mathbf{b}_4 T_{2t} + \mathbf{b}_5 CU_t$$

2. Use regression results and forecasted independent variables to create a forecast of the dependent variable (the left-hand side of the equation above) under different assumptions (see 3 below) regarding the coefficient on the log of meteorological stock / Capital stock variable ( $\mathbf{b}_2$  in the equation above).
3. Three estimates are calculated:
  - Regression estimate ( $\mathbf{b}_2 = 0.047109$ )
  - Low estimate = 95% probability that the true coefficient exceeds this estimate ( $\mathbf{b}_2 = 0.00964948$ )
  - Risk-adjusted estimate = 25% of low estimate ( $\mathbf{b}_2 = 0.00241237$ )
4. For each estimate,
  - Calculate the forecast output values under a “no-investment” scenario
  - Calculate the forecast output values under the assumed capital investment stream
5. Benefits from the capital investment are assumed to begin in 2005/06, following the completion of the investment stream. The difference between the two forecasts calculated in 4 is discounted to 2000 dollars (using a discount rate of 10%). The results are detailed in the Table below.

**Appendix Table: Estimates of Output Benefit Stream under Three Alternatives**

<b>Coefficient Estimate Used</b>	<b>05/06</b>	<b>06/07</b>	<b>07/08</b>	<b>08/09</b>	<b>09/10</b>	<b>Present Value (10% Discount Rate)</b>
<b>Regression Estimate</b>	13,284.8	12,401.7	11,572.4	10,794.1	10,064.3	58,117.2
<b>Low Estimate</b>	3,813.8	3,577.1	3,353.7	3,142.9	2,944.2	16,831.8
<b>Risk-Adjusted Estimate</b>	1,017.7	955.4	896.6	841.0	788.5	4,499.2

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**APPENDIX B. HLB ESTIMATION OF SOCIAL BENEFITS**

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Social Benefits and Externalities	Valuation Unit	Total Events per Year	Total Value of Loss (Valuation Unit * Total Events)	Weather Prediction Improvement Ratio	Loss Reduction/Year due to Weather Improvement	Benefits Over 30 Years	Source and Comments
<b>Weather Related Gains to Insurance Industry</b>							Report from Small Business Group on Weather and Insurance Industry.
Property and Casualty Claims	\$ value of claim	Number of claims					
Crops Damage Claims	\$ value of claim	Number of claims					
Life Loss Claims	\$ value of claim	Number of claims					
Auto Claims	\$ value of claim	Number of claims					
<b>Total Loss/Gain</b>			\$4,000,000,000	10.00%	\$400,000,000	\$12,000,000,000	
<b>Weather Related Gains to Agriculture Sector</b>							P.G. Aber, "Social and Economic Benefits of Weather Services, Assessment Methods, Results and Applications".
Crop Damage	\$ value of per hectare damage	Number of hectares damaged					
Harvesting Loss	\$ value of per hectare harvesting loss	Number of hectares not harvested					
Plantation Loss	\$ value of per hectare plantation	Number of hectares not planted					
Chemical Spraying Loss	\$ value of per hectare loss of chemical spray	Number of hectares affected					
Other Losses	\$ value of per hectare damage	Number of hectares damaged					
<b>Total Loss/Gain</b>				10.00%	\$750,000,000	\$22,500,000,000	

Social Benefits and Externalities	Valuation Unit	Total Events per Year	Total Value of Loss (Valuation Unit * Total Events)	Weather Prediction Improvement Ratio	Loss Reduction/Year due to Weather Improvement	Benefits Over 30 Years	Source and Comments
<b>Weather Related Gains to Energy Sector</b>							Report from Small Business Group on Weather and Insurance Industry.
Transmission Lines Damage	\$ value of transmission line	Average number of transmission lines destroyed					
Power Poles Damage	\$ value of pole	Average number of poles destroyed					
Steel Towers Damage	\$ value of tower	Average number of towers destroyed					
<b>Total Loss/Gain</b>				10.00%	<b>\$200,000</b>	<b>\$6,000,000</b>	
<b>Weather Related Safety Gains</b>							
Life Savings	Average \$ value of life (\$3 million)	Number of lives (3.86 lives)	\$11,580,000	10.00%	\$1,158,000		In 1987, flood caused 2 people to die in Montreal and tornadoes caused 27 to die in Edmonton. In 1996, flood caused 25 people to die in Canada. Thus over 14 years there were 3 prominent events, or 3/14=0.21 event per year. On average each event caused 18 deaths, or 3.86 deaths per year. Since the price of life is \$3 million, the total life loss is \$11,580,000 per year. (Small Business Group)
Reduced Accidents	Average \$ value of each accident	Number of accidents	\$409,508,000	10.00%	\$40,950,800		
Injuries	\$50,000	2,598	\$129,900,000				
Property Loss	\$4,000	69,902	\$279,608,000				
<b>Total Loss/Gain</b>					<b>\$42,108,800</b>	<b>\$1,263,264,000</b>	

Social Benefits and Externalities	Valuation Unit	Total Events per Year	Total Value of Loss (Valuation Unit * Total Events)	Weather Prediction Improvement Ratio	Loss Reduction/Year due to Weather Improvement	Benefits Over 30 Years	Source and Comments
<b>Weather Related Gains to Forestry</b>							
Reduced Fire Intensity	Cost of each Fire Load Sustained Action (\$90)	Average number of FLSA due to lightning (58,112)	\$5,230,080	10.00%	\$523,008		
<b>Total Loss/Gain</b>					<b>\$523,008</b>	<b>\$15,690,240</b>	
<b>Weather Related Gains to Time</b>							
Loss of Flight Diversion	\$ value of each flight diversion	Average number of flight diversions	\$14,600,000	10.00%	\$1,460,000		Assuming 365 flight diversions per year. Each flight diversion costs \$40,000. (Small Business Group)
Loss of Flight Cancellation	\$ value of each flight cancellation	Average number of flight cancellations	\$54,750,000	10.00%	\$5,475,000		Assuming 365 flight cancellations per year. Each flight cancellation costs \$150,000. (Small Business Group)
Loss of Delayed Decision	\$ value of each delayed decision	Average number of delays	\$36,500,000	10.00%	\$3,650,000		Assuming 1 delayed decision every day means 365 delays per year. Each delay decision costs \$100,000. (Small Business Group)
<b>Total Loss/Gain</b>					<b>\$10,585,000</b>	<b>\$317,550,000</b>	
<b>GRAND TOTAL</b>					<b>1,203,416,808</b>	<b>\$36,102,504,240</b>	

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## **APPENDIX C. ENVIRONMENT CANADA OUTPUTS CLASSIFIED BY INFRASTRUCTURE AND VALUE-ADDED PRODUCTS AND SERVICES**

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**Grand total, all activities (Net Budgetary Expenditures): \$160.7 M**

**Grand total, all activities (Vote Net Revenue): \$64.8 M**

**Grand total, all activities: \$225.5 M**

Infrastructure Activities	Expenditures			Value Added Activities	Expenditures		
	(Millions of Current Dollars)				(Millions of Current Dollars)		
	Net Budgetary Expenditure	Vote Net Revenue (excl. EBP)	Gross Budgetary Expenditures		Net Budgetary Expenditure	Vote Net Revenue (excl. EBP)	Gross Budgetary Expenditures
<b>Total</b>	<b>129.7</b>	<b>29.3</b>	<b>159.0</b>	<b>Total</b>	<b>31.0</b>	<b>35.5</b>	<b>66.5</b>
<b>Research &amp; Development</b>	23.6	2.2	25.8	<b>Research &amp; Development</b>	8.3	1.4	9.7
Cloud and precipitation physic	1.9	0.7	2.6	Numerical Weather Prediction	2.3	0.6	2.9
Severe Weather	0.45	0.15	0.6	Data assimilation and satellite	1.7	0.05	1.8
Climate modeling & Analysis	5.2	0.0	5.2	Marine weather research	0.0	0.2	0.2
Climate processes	4.0	0.2	4.2	Climate trends & data analyses	4.3	0.5	4.8
Ice research	0.0	0.4	0.4	<b>Production</b>	21.4	33.6	55.0
Hydrologic modeling & application development	0.8	0.01	0.8	Weather warnings, forecasts and information	10.1	28.2	38.3
Stratospheric studies	2.6	0.2	2.8	Marine warnings, forecast and information	0.3	0.1	0.4
Atmospheric science based assessment	0.9	0.1	1.0	Climate applications, forecast and information	0.6	1.3	1.9
Atmospheric change adaption	1.5	0.0	1.5	Ice warnings, forecast and information	0.7	2.2	2.9
Atmospheric change impacts	0.5	0.08	0.6	Hydrological forecasts and information	0.4	0.1	0.5
Rais on	0.3	0.08	0.4	UV forecasts and information	0.0	0.0	0.0
Management & admin support	3.1	0.0	3.1	Nuclear and volcanic modeling	0.2	0.0	0.2
Scientific support to R&D	2.3	0.3	2.6	Electronic data processing AES	4.6	1.0	5.6

Infrastructure Activities	Expenditures			Value Added Activities	Expenditures		
	(Millions of Current Dollars)				(Millions of Current Dollars)		
	Net Budgetary Expend-iture	Vote Net Revenue (excl. EBP)	Gross Budgetary Expend-itures		Net Budgetary Expend-iture	Vote Net Revenue (excl. EBP)	Gross Budgetary Expend-itures
<b>Monitoring Infrastructure</b>	<b>47.3</b>	<b>22.3</b>	<b>69.6</b>	Electronic data processing regions	1.4	0.1	1.5
Land-based surface networks	3.2	2.6	5.8	support to the warning production system	0.2	0.1	0.3
Aerological network	7.0	0.03	7.0	product development	0.2	0.1	0.2
Radar network	6.4	0.2	6.6	Management & admin support	1.6	0.5	2.1
Satellite network	0.0	0.0	0.0	Other support	1.0	0.0	1.0
Lightning network	0.1	1.2	1.3	<b>Service Delivery</b>	<b>1.3</b>	<b>0.5</b>	<b>1.8</b>
Marine network	0.8	0.0	0.8	Client consultation and feedback	1.2	0.5	1.7
Other data	0.0	0.0	0.0	Environment assessment	0.1	0.0	0.1
Inspection & maintenance	8.3	2.7	11.0				
Engineering & technical support	3.0	1.0	4.0				
Network planning	2.1	0.01	2.1				
Climate network	0.5	0.0	0.5				
Ice reconnaissance data	0.9	3.1	4.0				
Inspection & maintenance (ice)	0.001	0.0	0.001				
Engineering & technical support (ice)	0.6	4.7	5.3				
Network planning (ice)	0.0	0.0	0.0				
Water quality & quantity network	8.2	5.4	13.6				
Inspection & maintenance (water)	1.5	1.1	2.6				
Engineering & technical support (water)	1.19	0.012	1.2				
Network planning (water)	0.8	0.0	0.8				
Stratospheric Ozone/UV network	0.0	0.0	0.0				
Archive & quality control	1.2	0.06	1.3				
Management & Admin Support	1.5	0.2	1.7				

Infrastructure Activities	Expenditures			Value Added Activities	Expenditures		
	(Millions of Current Dollars)				(Millions of Current Dollars)		
	Net Budgetary Expend-iture	Vote Net Revenue (excl. EBP)	Gross Budgetary Expend-itures		Net Budgetary Expend-iture	Vote Net Revenue (excl. EBP)	Gross Budgetary Expend-itures
<b>Production</b>	42.8	0.0	42.8				
Weather warnings, forecasts and information	20.1	0.0	20.1				
Marine warnings, forecast and information	0.6	0.0	0.6				
Climate applications, forecast and information	1.2	0.0	1.2				
Ice warnings, forecast and information	1.5	0.0	1.5				
Hydrological forecasts and information	0.8	0.0	0.8				
UV forecasts and information	0.1	0.0	0.1				
Nuclear and volcanic modeling	0.3	0.0	0.3				
Electronic data processing AES	9.1	0.0	9.1				
Electronic data processing regions	2.7	0.0	2.7				
Support to the warning production system	0.5	0.0	0.5				
Product development	0.4	0.0	0.4				
Management & admin support	3.2	0.0	3.2				
Other support	2.0	0.0	2.0				
<b>Service Delivery</b>	21.4	33.6	55.0				
Dissemination and special delivery system	0.9	3.3	4.2				
Dissemination system design	0.0	0.4	0.4				
Public out reach and education	0.1	0.002	0.1				
Management and admin support	0.3	0.004	0.3				

Infrastructure Activities	Expenditures			Value Added Activities	Expenditures		
	(Millions of Current Dollars)				(Millions of Current Dollars)		
	Net Budgetary Expend-iture	Vote Net Revenue (excl. EBP)	Gross Budgetary Expend- itures		Net Budgetary Expend-iture	Vote Net Revenue (excl. EBP)	Gross Budgetary Expend- itures
<b>National Support Systems</b>	21.4	33.6	55.0				
Telecommunication general	3.2	0.3	3.5				
Telecommunication water	0.0	0.0	0.0				
Business planning	0.3	0.0	0.3				
Evaluation and performance measurements	0.4	0.0	0.4				
Policy, liaison & international affairs	0.0	0.8	0.8				
WMO assessment	0.2	0.0	0.2				
Communication support to WEP	0.2	0.0	0.2				
Training and development	1.1	0.0	1.1				
Management and admin support	0.6	0.0	0.6				
WEP senior management	2.7	0.0	2.7				
Management support to senior WEP management	6.0	0.0	6.0				

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## Appendix D: Presentation on A Meteorological Industry Strategy for Canada

# A METEOROLOGICAL INDUSTRY STRATEGY FOR CANADA INITIAL THOUGHTS FOR DISCUSSION

Presentation by R. Ambury Stuart, Ph.D.  
On behalf of the CMOS Private Sector Task Force  
May 29, 2001

I want to say first of all that it is an honour to follow Dr. Everell in this session of the Canadian Meteorological and Oceanographic Society, and to recognize and affirm the new directions that he is urging for Canadian meteorology. Unlike the other sessions of this Congress where we will be looking at highly specialized academic studies, this session is trying to look at the BIG picture, the overall policies and ideas that will shape Canadian meteorology for the next ten years. In a moment I will try to respond to Dr. Everell's vision of this future, and I will do so from my limited perspective as a member of the private sector community of meteorologists.

First though, I think we need to understand again how we all participate in the BIG picture. I have participated in conversations among government, university and private sector scientists long enough to know that whenever we approach these discussions we all make sure that we have our government, university or private sector hats firmly attached to our brains. Often these hats become football helmets as we bash into one another. I would like to suggest another approach. We all work for a single corporation which I will call Corporation Earth. Those of us in this room work for two different branches of Corporation Earth which are the Atmosphere Branch and the Oceans Branch. We live and work in a geographical area called Canada, but you don't have to work in either the Atmosphere Branch or the Oceans Branch for very long before you realize how secondary and irrelevant these human divisions into nation states really are. The atmosphere and the ocean don't give a fig for national boundaries. It is the most natural thing in the world for us to think hemispherically or globally when we do our work. Does it make any sense for example to have a Canadian global climate model or a Canadian global weather prediction model? Maybe a made in Canada meteorology or oceanography is just as unrealistic and finally unworkable as made in Canada oil prices that the government tried to achieve with the National Energy Program in the 80's. Anyone who has been to a gas station recently will know that that program failed. Surely the flow of atmospheric and oceanic currents across national boundaries is just as disrespectful of these boundaries as the economic forces of the global energy market for oil and gas. Why don't we stop trying to kid ourselves and join forces with our counterparts in the United States?

For most of us in this room these ideas are a kind of heresy that we reject right away. "Things are different here in Canada", we argue with varying degrees of conviction. "We might just as well become the 51st state and be done with it". This society - The CANADIAN Meteorological and Oceanographic Society - exists to promote the advancement of meteorology and oceanography in Canada. These dangerous and crazy ideas would suggest that this society become a branch of the American Meteorology Society - just as we started out as a branch of the Royal Meteorology Society over 50 years ago.

Let me say right now that I too reject these heresies. I, like most of you sense a value of being part of our profession in this country, but I think that we must admit that our position is becoming harder and harder to defend. The world is becoming smaller, national economies are being merged as large trading blocks in Europe and North America are being formed. If we are going to maintain our separateness as Canadian meteorologists and oceanographers, then we need to work harder at doing this than we ever have before.

I think we must begin by learning to work together more effectively. If we don't hang together, then we'll hang separately! Those of us who work in the private sector believe independent companies have strategic and tactical advantages over government organizations and universities in the application of private capital investment to meteorology. We would like to exploit these advantages and grow our companies, but over the past five years or so it has been almost impossible to do this for reasons that most people understand very well. Some companies have closed their doors, others have given up on Canada, and still others have given up on meteorology. However, now it seems the wind has changed. There seems to be a new interest in MSC to revisit the idea of partnerships in more meaningful ways. And we in the private sector welcome that change - first with scepticism and now with optimism.

Today I am going to report to you on a unique new attempt to build a Meteorological Industrial Strategy for Canada. Notice that this strategy still believes in a distinctively Canadian approach to this issue and for this reason alone it has value, not only to the private sector but also to everyone who wants to maintain a unique Canadian profession.

The purpose of this talk is to present initial thinking on an industrial strategy for the "weather" commercial sector, where weather includes meteorology, climatology, air quality and hydrology. You need to know that this strategy has been developed by a Task Force made up mostly of members of the CMOS Private Sector Committee, and while we are grateful to MSC for helping us with the funding to do this study, we need to emphasize that none of the views to be presented here necessarily reflect the views of Environment Canada. We are here to seek your feedback both in this session and the panel discussion after the coffee break, and to move forward to take advantage of opportunities.

We all know why weather is important from a commercial sector perspective - most of our industries in Canada are affected by the weather, either directly or through transportation and energy costs. As our technological capacity improves, we need to know weather information will become more and more important.

Climate as well - especially climate change and variability - has important commercial sector implications, especially in long-range planning and infrastructure decisions.

Despite its importance, the commercial weather sector today is quite small - \$65 Million - which includes MSC commercial activities outside intergovernmental "sales" like the large contracts with Nav Canada, Defence, Coast Guard and the provinces. Together, the private sector and MSC generate more than \$130 Million in revenue. In the U.S., commercial services have a value of \$1 Billion. There are about 100 firms in commercial services in Canada including traditional weather services, environmental science and policy and instrumentation and software. Most are small with

the exception of the Weather Network which accounts for about half of the non-MSO revenues in the commercial weather sector.

These details don't matter very much. There are two players in the commercial weather sector today - Pelmorex and MSO who together have about 70 per cent of the market and who have been responsible for virtually all of the growth in the past decade.

Times are changing though. Government spending constraints have reduced contracts to private companies for research and services forcing those companies to look elsewhere for revenues. Some of the survivors and newer companies as well are moving into value-added weather and climate services to non-government clients. The Weather Network has become the prime Canadian source of weather information through the mass media including the Internet. The MSO is refocusing on its core services most of which are in the public sector as opposed to the commercial sector. Finally, the communications revolution is having its impact on commercial weather services in a variety of ways. The availability of information of all kinds has stimulated increased demands for weather information so that is a plus. However, the ease of access of Internet communications has also increased the number of providers of this information and greatly increased the competition. Like Corporation Earth, the Internet also has no respect for national boundaries.

MSO has announced that it needs more money for key infrastructure improvements, but it will have to compete with all the other demands for government money, including for example the demand for reduced taxes so that doctors, nurses, scientists, engineers and mobile high-tech industries don't leave the country for more after-tax dollars in other jurisdictions. Without new revenues, MSO services will deteriorate which will in turn make them vulnerable to suggestions that everything except the raw observations be done south of the border. If the new infrastructure investment can be secured however, public good needs will be better met, and we have a chance to develop a commercial sector industry that returns strong economic benefits to industries that operate in Canada and who have to deal with Canada's weather. With growing international competition, these weather sensitive companies will need all the help they can get, and governments at all levels will value the expertise that provides this help.

So our vision for the future is the development of a uniquely Canadian public-private partnership so that all citizens and organizations have instant access to critical weather and climate information they need, when they need it and wherever they need it, from Canadian suppliers so that the Canadian economy knows about and adapts to the weather-related risks and opportunities better than any other country in the world. This as I see it is our response to homogenizing effect of globalization that would submerge our Canadian ship into a global sea. We are different up here because our weather and its related risks and benefits are different. Also, it is not just a matter of dollars and cents. If we plan our commercial and recreational activities with more attention to the weather then we will expend less energy and pollute less. If we use less pesticides on a field because we better understand the winds then less pesticides will end up in the ground water. We have unique weather challenges in Canada that would not be a priority in a U.S. led initiative either in the private or public sector.

What are the outcomes of such a vision?

- Canadian weather sensitive organizations will be more efficient economically and they will pollute less.
- Canadians will have access to information that is specifically tailored to Canadian conditions.
- The Canadian financial sector will discover the weather derivatives market and will open up even more opportunities for weather expertise.
- Public services will also be improved - things like improved highway weather forecasting will be better.

In addition to advantages to Canadians and Canadian business, the commercial weather itself will become a valuable part of Canada's high-tech sector.

- It will lever Canada's advantages in research, technology, communications and resources.
- It will develop leading edge content for Canada's Internet agenda.
- It will provide growth opportunities in the information, high tech and science sectors and the career opportunities that go with that.
- It will grow very rapidly as new high tech initiatives often do from about \$70 Million now to \$500 Million in 2011 which is about half the size of the current U.S. industry.

So how do we do this?

From government we need a collaborative weather network that collects timely, high-quality weather information, forecasts and weather services, both for public good and as input for private sector commercial products. By "collaborative", we mean a weather network where many players assist Environment Canada in gathering the core information from which all participants benefit.

From universities we need training of the required professionals and cutting edge research that serves both government and industry requirements.

From the private sector we need a weather industry that is recognized around the world as innovative and competitive.

And now we get to the tricky part. We don't have an adequate commercial services sector now and if we are going to get one then things have to change. Change is always difficult and difficult to negotiate. In order to begin this process, the Task Force has planted some seeds in the form of questions to begin discussion.

We need a new partnership model if we are going to be successful.

What could be a redefined role for MSC? Is it possible for them to focus on core infrastructure collecting and analyzing activities that only they can do in gathering and analyzing weather and climate information? Is it possible that they could provide data outputs at little or no cost to stimulate new products and services?

How might the academic sector provide more qualified people and more targeted research products? Is it possible that the private sector might become more actively involved in the allocation of government R&D grants to universities?

How might the commercial sector outside MSC quickly expand its capacity for value-added services? Is it possible or realistic to envision the private sector taking on more/most commercial weather activities?

We need to expand the private sector.

What are the barriers? Is growth being blocked by small Market size? Do we lack Investment Capital? Are we short of talented People?

What commercial services should be targeted first?

How should the commercial services people in Environment Canada respond to the need to expand the private sector?

Are there better ways to distribute data?

What other government agencies outside Environment Canada might be helpful?

Should the weather industry be better organized? How would we do this?

We need rapid transfer of data and the results of relevant research

How can we encourage this?

What are the barriers? Is it Investment capital? Organizational issues?

What other areas of science and technology need to be brought into play? Where is the expertise for that?

Who in the government/university/industry mix does what?

How do we deal with legal issues around intellectual property?

We need qualified and energetic people.

Can future demands be met with current educational institutions?

Can we coordinate with Environment Canada's hiring needs better?

Should there be an accreditation standard for meteorologists?

Should there be a sector council to oversee growth? How can we tap expertise in Human Resources agencies in federal and provincial governments?

Finally there are marketing issues

What are the market opportunities?

What kinds of products and services are needed?

How do we get the word out?

Would an industry-wide web site be useful? Who would run it?

Where do we go from here?

Following our discussions today, we intend to hone our thinking and carry out appropriate economic research in Canada and elsewhere before completing our report in the fall.

The Task Force is grateful to MSC for support for this work. We have presented a private sector perspective on what the future of our industry should look like if it is to become an effective player in the Canadian economy. We believe that with more effective use of weather information, improved efficiencies will also result in less waste and environmental degradation. This is truly a win/win situation which will enhance the environment and will at the same time ensure that those of us who consider the environment to be so important that we have dedicated our working lives to it to be able to continue our work in Canada, whether it be as a public servant, an academic or an entrepreneur.

Thank you.

Note:

Dr. Stuart's talk was accompanied by a slide presentation. If you would like further information on this presentation or would like to provide feedback to the Private Sector Task Force, please contact one of the co-chairs of the Task Force, Susan Woodbury [swoodbury@seimac.com](mailto:swoodbury@seimac.com) or Ian Rutherford [ian@houlerutherford.com](mailto:ian@houlerutherford.com)

## **Appendix E: E-mail Survey Questionnaire for Faculty Heads and Students of Canadian Meteorology Universities**

### **Context**

A private sector weather strategy task force of Canadian Meteorological and Oceanographic Society (CMOS) is developing a meteorological sector strategy, for consideration by the federal government this fall. As part of its work, the task group is seeking the views of students and professors in the academic sector as input for the task force as it develops the overall strategy and specific recommendations for action under the strategy. The sector strategy would address roles, responsibilities and strategies of the public sector, the private sector and the academic sector.

We would request that you support our work by responding to the questions, below, by e-mail by August 1, 2001.

### **Questions for students**

1. What, in your view, are the challenges facing students pursuing a career in meteorology?
2. When you think of your future job prospects, do you think of working in Canada or elsewhere (if in the U.S., specify)? Why?
3. Would you expect to work for the private sector or for the public sector (government, national or international); in an operational role, research, teaching, consulting or in another occupation where your meteorological training would be useful? Why? Are you thinking of employment outside of meteorology and, if so, where? Why?
4. How would you describe your view of the prospects of working in the public sector, in the private sector or in academia? Consider opportunities for entry-level jobs and advancement, salary levels, interest-level/challenge factor?
5. What could be done to improve prospects for working in the private sector? In what ways can the current meteorology programs (at universities) be altered to better prepare students for employment?
6. One issue identified in the task force's work to date is the need to smooth-out the hiring from year to year, especially by large players like the Meteorological Service of Canada (MSC) and Pelmorex/The Weather Network? Is this something you feel needs to be done and, if so, have you any thoughts about how this could be accomplished?
7. Should accreditation be standardized for meteorologists and, if so, how? Should there be a standard defining an accredited meteorologist and, if so, what?

8. Is it worth establishing a way to accredit meteorologists?
9. What are your salary expectations for the your first job; in 5 years; in 10 years?

### **Questions for academics**

1. What, in your view, are the challenges facing the academic sector in meteorology: from a teaching point of view; from a research point of view?
2. How could the academic sector help to fill the needs for more professionally-qualified meteorologists? What in your view is needed to enhance meteorological research in your institution? in Canada?
3. What is the training capacity of your institution? Can future demands be met by existing Canadian post-secondary training capacity?
4. What should the appropriate roles be for academia, governments and the private sector in carrying out meteorological R&D? What is your view about the current level of funding by the private sector of R&D? What could be done to encourage more R&D in the private sector?
5. How could the private sector work with government and the academic sector in providing input on the allocation of government R&D funds? Are there examples where this is already happening that the task force should examine?
6. What can be done to encourage/enable increased technology transfer between universities/research establishments & the private sector? What are the appropriate roles for each?
7. What are the barriers to commercializing new science and technology developed in universities and other R&D institutions? Are there special tax incentives or institutions that would help?
8. What are the critical areas of Science and Technology that could be applied to weather & climate?
9. Is there a need for a new policy on licensing and intellectual property rights in connection with the results of academic research?
10. What are your major deterrents in setting up, organizing or pursuing meteorological research programs in Canada?