ECO CANADA

Environmental Careers Organization

2005

Changing Climate: Canadian Meteorological Employment

ECO CANADA

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Individual members of the NSC contributed to many aspects of the Human Resource Study of the Canadian Meteorological Sector by providing advice, contacts for the study, participating in the survey and focus groups and communicating initiatives of the study to the practitioners and employers in the meteorological sector.

The NSC met twice over the course of the study. The first meeting was held on October 6, 2004 in Toronto, Ontario to officially launch the study. NSC members discussed the scope of meteorological practice, and identified recruitment, training, and retention issues expected from a growing private meteorological sector.

The second and final meeting was held on April 29, 2005 in Toronto, Ontario to signify the end of the study. NSC members discussed the key findings of the Human Resource Study of the Canadian Meteorological Sector and determined the next step in building a human resource strategy for the sector.

In a motion put forth by Ian Rutherford, Executive Director of the Canadian Meteorological and Oceanographic Society (CMOS), and seconded by Mory Hirt, World Weatherwatch, the National Steering Committee called for the development of National Occupational Standards as the next step in building a human resource strategy for the meteorological sector.

- Passed Unanimously, April 29, 2005 Toronto, ON

Executive Summary

With growing societal awareness of weather events, such as climate change and drought, and their impact on the population and economy, it is imperative that Canada understands the meteorological sector's human resource requirements in order to ensure its ongoing growth and prosperity. While most Canadians intuitively link the need for meteorological expertise to a traditional sector such as agriculture, meteorology also impacts industries as diverse as transportation, construction, and tourism. The provision of accurate and precise forecasts offer tremendous cost savings to the Canadian economy every year. The 2005 Changing Climate report is intended to provide its readers with a greater understanding of the Canadian meteorological sector by outlining common activities of meteorological employment, documenting the existing and forecasted labour market conditions and offering recommendations on steps that should be taken to support the sector.

In 2004, Environment Canada and the Canadian Meteorological and Oceanographic Society (CMOS) Private Sector Committee recommended that ECO Canada develop a human resource strategy that incorporated meteorological and weather occupations under its broader environmental employment umbrella. The ensuing report is a compilation of the data gained from 465 survey responses of meteorological organizations and meteorological practitioners from a sample of over 1,100 surveyed for a 95% confidence level. Supplementary data derived from eight expert interviews, five focus groups, and a review of existing literature on weather, risk, and economics provided further information. While the scope of study focused on the private sector, data on the public sector was also gathered and is presented in this report for comparison purposes. Recommendations are also presented, that indicate potential future direction for the Canadian private meteorological sector, as well as key players who will influence its development.

The Importance of Meteorological Services

A strong economic case exists for assessing the importance of meteorology to society as much greater than its current labour force size would suggest. Weather information provides benefits to both Canadian industries and individuals — benefits that carry economic implications as evidenced by $60 million in sales of weather forecasts by private sector firms in 2001 (CMOS, 2001). More importantly, there is consensus that meteorology has a multiplier value far exceeding its commercial sales, since timely and accurate weather forecasts may save hundreds of millions of dollars for industry and reduces the risk of loss of life and property. The issue of risk-management through the use of accurate meteorological information will become increasingly important in the future; for example, in the insurance industry, where actuarial rates have been difficult to establish due to the unpredictable effects of severe weather and climate change. The economic literature carries a wide range of implications regarding the substantial economic and human effects of weather events, but also the importance of cooperative and harmonized meteorological sectors and interfaces with users, to ensure effective results and benefits. Economic impacts are deemed to be more substantial in light of concerns regarding long-term climate change and an increasing incidence of severe weather events in recent years. (See Annex B for more information)

Today, Canada's meteorological sector spans both the private and public sectors and offers a wide variety of weather-related services to Canadian industries and individuals. It is estimated that approximately 100 private sector organizations operate within Canada's meteorological sector, providing traditional meteorological services, and that over 1,000 other organizations employ meteorological practitioners in various capacities (for example, weather observers, airline pilots, weather broadcasters, and utility planners) along with Canada's public weather service, Meteorological Service of Canada (MSC).

Key Findings

For the purposes of this study, ECO Canada defined the Canadian meteorological sector by those occupations that involve the observation, prediction or interpretation of atmospheric processes, and/or apply meteorological information or undertake numerous types/areas of meteorology related activities (see Section 1.3 for a listing of meteorology related activities as defined here). This study estimated that there are approximately 9,200 meteorological practitioners across Canada employed in nearly 1,100 private and public sector organizations.

Other key findings include:

The majority of Canada's traditional private sector meteorology organizations are small in size, employing fewer than 10 employees (56%), with most employing one or two meteorological practitioners. Large organizations are found to employ meteorological practitioners, particularly in the transportation industry.

Meteorological activities within the private sector vary and include instrumentation (44%), broadcasting weather information (39%), climatology (38%), observation (31%), air chemistry/quality (30%), operational meteorology (18%), meteorological services (16%), and others.

The projected future demand for trained practitioners in the private sector is high with an estimated 3,195 vacancies forecasted by 2010. A large portion of these positions require a post-graduate degree. Private sector employers pointed to shortages in the supply of trained meteorologists, which they indicated were exacerbated by low enrolments in related academic programs. This was reflected in a notable number of firms (18%) indicating they had attempted international recruitment.

Demographic data from the survey points towards increasing retirements in the public sector over the next five years, further exacerbating the shortages of trained meteorological practitioners. Retirements from MSC were estimated from the survey to be about 8% annually.

The survey results indicated that educational qualifications are a key requirement for trained meteorological practitioners. Eleven percent of meteorological practitioners in the private sector hold a Ph. D., while 25% have Master's degrees. Such demand for educational qualifications is predicted to remain strong since in 2008, it is anticipated that the majority of new job openings will require post-graduate degrees.

Gaps in meteorological training were suggested by the fact that most meteorological practitioners require job-related training following the completion of a degree before they can effectively begin work, and practitioners reported a wide range of continuing skill needs. Some 90% of employers reported that their practitioners required upgrading and additional training in technical areas (e.g. meteorological science, 29%), and many areas of general ability (e.g. communications, 23%).

Private sector employers and practitioners alike reported a high level of interest in, and expected benefits from the development of National Occupational Standards and Certification. Private sector organizations were virtually unanimous in seeing these types of programs as benefiting their organizations.

Views regarding the future directions for the sector are widely shared among all sub-sectors of meteorological employment (such as traditional meteorology, broadcasting and transportation) and by both private and public sector meteorological practitioners. As revealed through out this report, there are several human resource issues that are critical obstacles to the growth of the sector. These issues need to be addressed to ensure the sector can meet its full economic and employment potential.

Section 1: Background

1.1 ECO (Environmental Careers Organization) Canada

ECO (Environmental Careers Organization) Canada is a not-for-profit corporation that assists the Canadian environment sector in implementing sound human resource development policies. Since it was founded in 1992, ECO Canada has taken great strides toward developing a human resource strategy that is focused on the needs of environmental practitioners, employers, and educators.

ECO Canada is one of about 30 sector councils that were established with Government of Canada start-up funding to bring employers, workers, educators, and governments together to address human resource challenges facing the Canadian economy. The key objectives of ECO Canada are to:

- Develop and update national occupational standards for skills and training;
- Promote employment opportunities via a highly skilled workforce;
- Meet industry requirements for qualified new practitioners;
- Provide labour market projections and information on current and emerging trends in the environmental sector for employers, educators, youth, and governments;
- Improve dialogue between industry and the academic community; and
- Address labour market entry problems and school-to-work transition difficulties encountered by youth.

ECO Canada's mission is: "To ensure an adequate supply of people with the demonstrated skills and knowledge required to meet the environmental human resource needs of the public and private sectors."

ECO Canada's programs can be accessed by visiting www.eco.ca.

1.2 Study Objectives

Recognizing the importance of quality meteorological services and information for Canadian industries and individuals, ECO Canada designed this study to determine the current and future human resource needs of the meteorological sector in Canada. In addition to the traditional meteorological sector, the study explored a wide range of allied business sectors, including transportation, broadcasting, and other areas, which apply to meteorology. The study was designed to meet the following objectives:

- Provide the Canadian meteorological sector with a greater understanding of the sector's current and forecasted labour market requirements;

- Provide meteorological educators and trainers with a greater understanding of the industry's skills requirements and a competency foundation for program and course development and refinement; and
- Provide ECO Canada and funding organizations with sufficient information to determine if additional work, such as the development of national occupational standards and certification programs, would be of value.

1.3 Study Coverage

It is important to note that the study attempted to define an inclusive definition of meteorology-related industries and professions. This was determined initially through a broad definition of meteorological practitioners, as indicated (see Figure 1.3.1). This broad definition was not transparent or clear to all who were surveyed[1]. In fact, a lesson learned during the course of the survey was that the definition of a "meteorological practitioner" was extremely difficult to convey to persons outside of what might be termed as "traditional meteorology."

Figure 1.3.1
Definition of a Meteorological Practitioner as Presented in the Survey

Definition of a "meteorological practitioner": For the purpose of the study, a meteorological practitioner is defined as a person who observes, predicts or interprets atmospheric processes, and/or who applies meteorological information, or undertakes any of the following types/areas of meteorology-related activities*:

- Agrometeorology
- Air Chemistry
- Air Quality
- Biometeorology
- Boundary Layer
- Broadcasting Weather Information
- Climatology
- Forest Meteorology
- Forensic Meteorology
- Hydrometeorology
- Meteorological Instrumentation
- Meteorological Observation
- Marine Meteorology
- Meteorology Service Delivery
- Operational Meteorology
- Road Weather
- Solar Energy
- Meteorology Training
- Weather Modification
- Wind Energy
- Other Meteorological Applications

* Later in the study, it was noted that Aviation Meteorology was inadvertently omitted from this list.

The meteorological activities encompassed by this survey could be viewed as a core, supporting and other activities.

1 Also, as was noted during the course of the survey, at least one important area of activity was omitted from this formal definition— "aviation meteorology." This omission was remedied in the course of the survey through direct communications with aviation sector participants.

At the core, are traditional core meteorological activities such as forecasting, usually performed by persons who have university degrees in Atmospheric Science or a related discipline such as Engineering or Physics. They are found mainly in Meteorological Service of Canada (MSC), in private meteorology firms, and a scattering of industries throughout the economy.

Supporting meteorological activities are performed by technicians and other specialists, such as weather broadcasters, who generally hold college diplomas in meteorology or related fields, and are often located within the same organizations, providing supporting technical services in traditional meteorological activities such as forecasting.

Additionally, other meteorological activities are undertaken in a wide range of occupations and industries, where individuals may not have or need university degrees or college diplomas in meteorology for their work, but who may engage in meteorological activities full-time (such as weather observers), or use meteorological information in important aspects of their work. Examples would include airline pilots or marine officers, airport managers, forestry managers, and utility planners.[2]

Statistics Canada data was used along with data collected from the survey in order to calculate the size and scope of meteorological employment in Canada. (See Annex A: Methodology for more information).

The sectors that were identified for sampling were:

1. Private meteorological sector, which included:
   - Traditional meteorological business (comprised of firms whose primary function is to supply meteorological services and includes engineering and scientific services, environmental services, and conducting work in solar/wind energy);
   - Transportation industry (including NAVCANADA, airports, airlines, observation contractors, shipping, towing and others);
   - Communications industry (such as broadcasting corporations, networks and stations);
   - Utilities industries; and
   - Other Industries (such as resource and manufacturing industries, agriculture, fishing, forestry, mining, oil/gas, recreation, and retail).
2. Public meteorological sector which included:
   - Federal government (MSC);
   - Other government sectors (including other federal ministries such as Natural Resources Canada, and provincial government ministries); and
   - Educational institutions (colleges and universities).

2 Note that the distribution of these categories across industries may be highly varied. For example, while most professional meteorologists are employed by MSC and private meteorology firms, many can be found in sectors such as broadcasting and other industries.

Guidelines for Interpreting Survey Results:

All of the tables in the report (unless noted otherwise) are based on the survey responses of over 40 public sector employers and 100 private sector employers, of which about 50 private sector employers are located in the traditional meteorological business sector (including engineering and scientific services, environmental services, and other meteorological services), with the remainder divided up between transportation, broadcasting, utilities, and other industries. Practitioner statistics are based on a sample of over 400 practitioners, for which estimates are accurate ± 5% 95 times in 100. All tables display private sector data except where public sector comparison data is explicitly indicated.

1.4 Past Research and Issues Facing the Sector

Historically, meteorology in Canada has centred on the work of various Government of Canada agencies and is now conducted by the MSC. Generally, Canadians' have viewed the government as a "free" public service. This is similar to the opinions found in most countries around the world. This historical factor has hindered the development of private sector meteorology. The cyclical policies adopted by MSC and other strategic directions of the Federal government in general have affected the development of the Canadian meteorological sector. For example, the development of Canada's meteorological human resources from the 1970s to 1990s was strongly influenced in a positive manner by incentives for professional development created by MSC. In that period, to enhance the supply of meteorologists, MSC paid half-salaries to many students to study meteorology—especially for post-graduate studies. In the 1990s, a counter effect occurred with the onset of government-wide hiring freezes and cuts that impacted MSC disproportionately and sent a message to young people in that decade that a well-paying career in meteorology was not very likely. As a result, enrolment in university and related programs sharply declined, which has recently led to a decreased supply of trained meteorologists.

Dealing with the above issues is made more challenging by significant divisions of institutional efforts to train personnel in meteorology-related skills. University programs, as is noted within the body of this report, are generally seen as requiring operational training components for professional meteorologists before they are job-ready. Thus, a variety of training programs are operated, with MSC running its own training programs, and private firms providing their own on-the-job training. Additionally, other agencies, such as NAV CANADA operate their own training programs for their weather observers. This creates great challenges, as no common mechanism exists to address the training needs and share the wide range of expertise developed by each of these different entities.

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Findings from the research suggest that the importance of the meteorological sector is not fully recognized, and that work needs to be done to inform Canadians and Canadian industry more about the sector and the wide-ranging effects of the expertise of sector professionals and practitioners. Many survey respondents and all focus group participants agreed that there is a need to improve Canadian business' awareness of meteorology at the domestic level. One way of raising the profile of the sector, almost all agreed, would be through the implementation of National Occupational Standards and certification programs. Such initiatives were seen by both private sector organizations and practitioners and those in the public sector, as a way of promoting better academic and better workplace training programs, as well as providing the benefit of being able to pursue new business opportunities.

Labour-supply issues for the sector remain a concern, particularly as the research findings established that labour shortages exist within the meteorological sector and that these shortages are likely to persist in the future. Retirement and retention issues will be increasingly important for all meteorological organizations over the next several years, particularly as senior practitioners in both sectors prepare for retirement. As well, graduation data from atmospheric science programs at Canadian universities indicates that the supply of meteorological practitioners is small and unlikely to meet future demand. Recent Statistics Canada data shows that over the 10-year period 1992-2001, a total of about 300 students pursuing graduate-level training graduated from Canadian university meteorology programs.[4] In this vein, the study findings note that nearly all current and future vacancies within the sector will require college/university training, and strongly suggest the need for improved access to, and increased enrolment in, college and university training programs although university meteorology programs report difficulties attracting students.

4 Statistics Canada, *University graduates by field of study, program level, and sex*, 1992 to 2001. Custom data.

Section 2: Human Resource Profile of the Meteorological Sector

Canada's meteorological sector, although small, represents a significant contribution to the Canadian economy. The meteorological practitioners employed in Canada are highly educated and skilled and the services they provide have become increasingly critical to the workings of numerous Canadian industries. The following section presents a current profile of meteorological employment in Canada and the organizations employing meteorological practitioners. This section includes information on the:

- Scope of meteorological employment in Canada, including the number of organizations and meteorological practitioners involved in meteorological practice;
- Size of meteorological organizations; and
- Scope of meteorological operations.

2.1 Number of Meteorological Practitioners in Canada

Approximately 9,200 meteorological practitioners are employed in Canada. Table 2.1.1 and Figure 2.1.2 illustrates the distribution of meteorological practitioners by organization type. In general, the majority of meteorological practitioners were found in the private sector, with a large proportion in transportation, which was estimated to have over 5,300 meteorological practitioners engaged in other meteorological activities (for example, airline pilots, navigators, marine officers, and weather observers).

Of the total meteorological practitioner workforce, approximately 20% (over 1,800) are classified as meteorologists and meteorological technicians engaged in traditional and supporting meteorological activities, working primarily with the federal government (over 800) and private sector meteorological organizations (over 500).

This characterization of the meteorological labour force must be considered in light of the fact that training and related needs of these groups will vary greatly depending upon the extent to whether practice in meteorology is the primary or secondary skill/activity in their work (such as for pilots and marine officers).

Analysis of survey and 2001 census data from Statistics Canada indicated that meteorological employment is expected to grow by about 6% annually over the next five years.

Table 2.1.1
Distribution of Meteorological Practitioners by Organization Type (Private and Public) in 2005

	METEOROLOGISTS & TECHNICIANS[1]	TOTAL METEOROLOGICAL PRACTITIONERS[2]
PRIVATE SECTOR		
Traditional Meteorological Businesses	530	560
Transportation (Air and Marine)	200	5,380[4]
Communications	50	490
Utilities	40	510
Other Industries.	30	220
Sub-Total	850	7,160
PUBLIC SECTOR		
Federal Government (MSC)	810	1,470
Other Government	80	160
Education[3]	120	420
Sub-Total	1,010	2,050
TOTAL	**1,860**	**9,210**

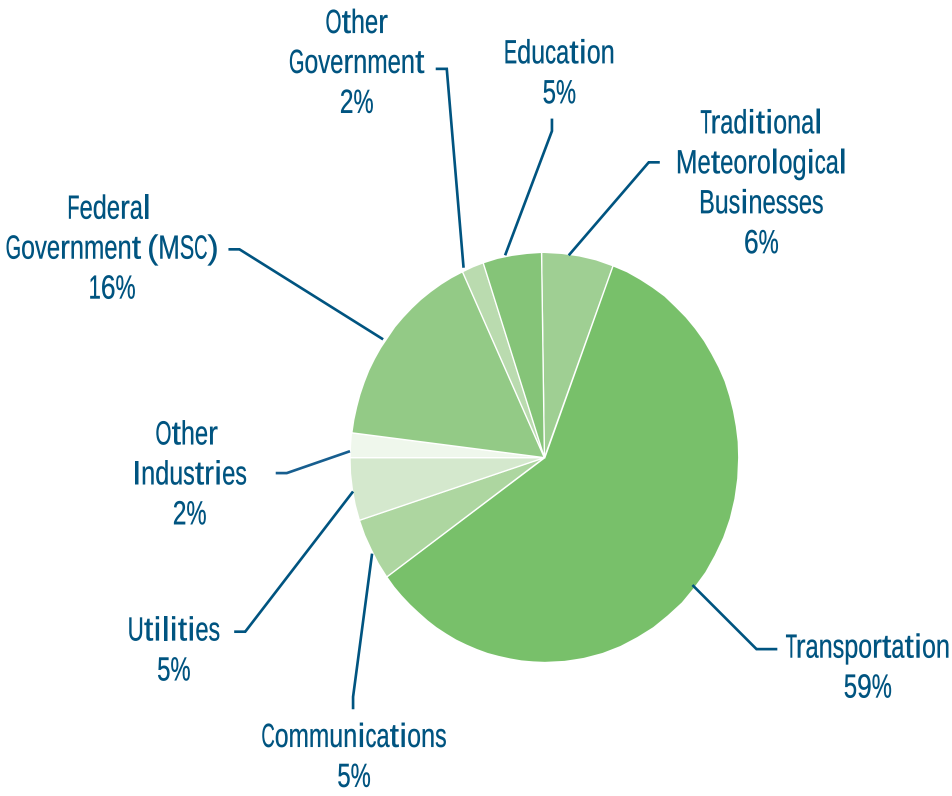
1 As defined by Statistics Canada and projected to the year 2005. Meteorologists "analyze and forecast weather, provide consultation on atmospheric phenomena, and conduct research into the processes and phenomena of weather, climate, and atmosphere." This group is the group largely engaged in what this study has termed " traditional meteorology."
Meteorological technicians "observe weather and atmospheric conditions, record and interpret meteorological data, transmit and report on recorded information, and provide meteorological information and advice to the general public, the transportation industry and the media." This group is the group largely engaged in what this study has termed "supporting meteorology."

2 As defined in Section 1.3 Study Coverage, above. Includes an estimated 788 solo-practitioners and contractors.

3 Estimated from data supplied by Canadian universities and colleges, 2005.

4 Includes meteorological practitioners engaged in "other meteorological activities" such as airline pilots, navigators, marine officers and weather observers).

Figure 2.1.2
Distribution of Meteorological Practitioners in 2005 by Organization Type



2.2 Number of Organizations Employing Meteorological Practitioners

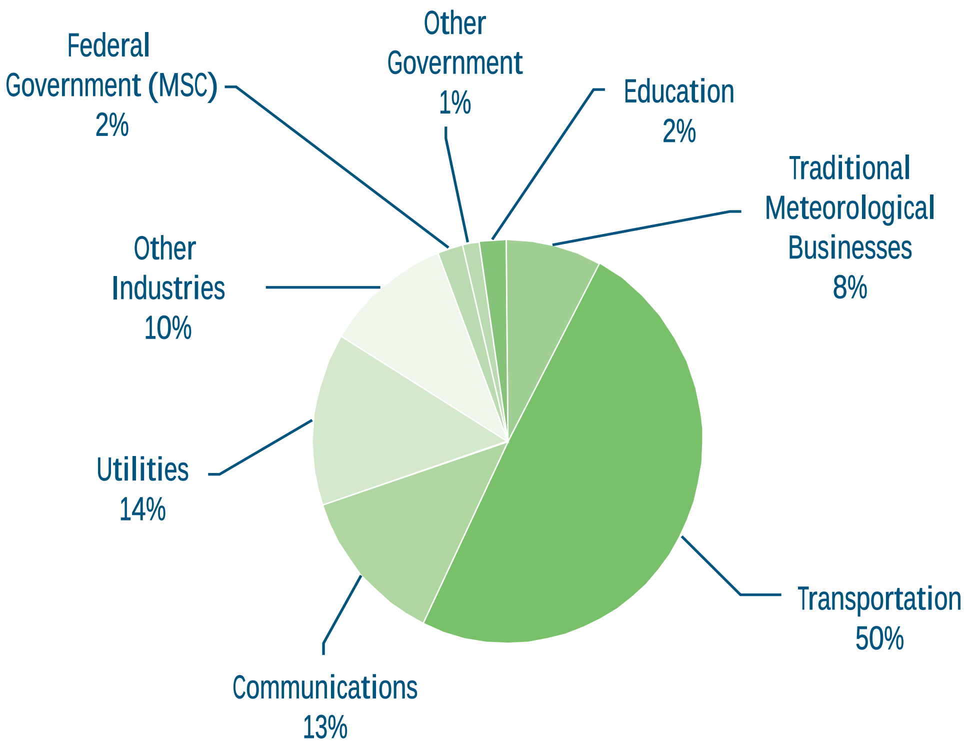
Approximately 1,090 organizations in Canada employ meteorological practitioners. Table 2.2.1 and Figure 2.2.2 presents the distribution of organizations by organization type. The majority of meteorological practitioners are employed by the private sector (94%), largely in transportation (48%). Public sector organizations provide 6% of the employment opportunities (with the federal government representing 2%, other government at 2% and education at 2%).

Table 2.2.1
Profile of Employers/Firms Employing Meteorological Practitioners in 2005[1]

	TOTAL	% SHARE
PRIVATE SECTOR		
Traditional Meteorological Businesses	90	8%
Transportation (Air and Marine)	520	48%
Communications	140	13%
Utilities	150	14%
Other Industries	120	11%
Sub-Total	1,020	94%
PUBLIC SECTOR		
Federal Government (MSC)[2]	20	2%
Other Government	20	2%
Education[3]	30	2%
Sub-Total	70	6%
TOTAL ORGANIZATIONS EMPLOYING METEOROLOGICAL PRACTITIONERS	1,090	100%

1 Percentages may not total 100% due to rounding. Excludes solo practitioners providing services on a part-time basis.
2 Estimated from regional MSC offices and special centres such as the Canadian Aviation Centre – West.
3 Estimated from data supplied by Canadian universities and colleges, 2005.

Figure 2.2.2
Distribution of Organizations Employing Meteorological Practitioners (By Organization Type) in 2005



2.3 Size of Organizations Employing Meteorological Practitioners

Table 2.3.1 provides data on the size of organizations employing meteorological practitioners. The private sector is comprised primarily of small businesses. Over three-quarters (76%) of private sector organizations are small with 50 employees or fewer and close to one-quarter (20%) reporting over 100 employees. In comparison, about 40% of public sector organizations are medium to large, reporting over 50 employees.

Table 2.3.1
Size of Organizations Employing Meteorological Practitioners in 2005

NUMBER OF EMPLOYEES	PUBLIC SECTOR	PRIVATE SECTOR
1–10	30%	56%
11–25	16%	9%
26–50	14%	11%
51–99	5%	4%
100+	35%	20%

Table 2.3.2 presents the proportion of meteorological practitioners employed by organizations. Over half of private sector organizations (57%) employ between one and two meteorological practitioners. In contrast, public sector employers were much less likely to employ small numbers of meteorological practitioners (30%) and were more likely to employ a large number of meteorological practitioners (37% of public sector organizations employ 11 or more meteorological practitioners).

Table 2.3.2
Proportion of Meteorological Practitioners Employed in 2005

NUMBER OF PRACTIONERS	PUBLIC SECTOR	PRIVATE SECTOR
1–2	31%	57%
3–5	17%	13%
6–10	14%	15%
11+	37%	15%

*Percentages may not total 100% due to rounding.

Table 2.3.3 provides data on the reported types of meteorological practitioners employed by organizations. The findings indicate that most organizations (72%) employ managers, over three-quarters (79%) employ senior meteorological practitioners with 16 years and more experience, and two-thirds (66%) employ intermediate practitioners with 10 to 15 years of experience. A significant number of private sector organizations (33%) also employ meteorological consultants. The distribution of occupational groups among public sector employers is similar to private sector meteorological employers, with a large number of organizations employing managers and senior practitioners.

Table 2.3.3

Reported Occupational Groups of Meteorological Practitioners Employed in 2005

OCCUPATIONAL GROUP	PUBLIC SECTOR	PRIVATE SECTOR
Organizations with Managers	81%	72%
Organizations with Intermediate Practitioners	94%	66%
Organizations with Senior Practitioners	100%	79%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

2.4 Scope of Meteorological Operations

Table 2.4.1 provides a breakdown of the geographic scope of organizations by sector. Private sector organizations tend to operate at all levels, representing the current capacity to serve geographic regions and international markets. Many private sector organizations operate locally (46%), provincially (39%), and internationally (39%).

Nearly half of private sector organizations report activity at the local level (46%). In comparison, more than half of public sector organizations report activity at the provincial level (63%).

Table 2.4.1
Geographical Scope of Operations of Organizations Employing Meteorological Practitioners in 2005

GEOGRAPHICAL SCOPE OF OPERATIONS	PUBLIC SECTOR	PRIVATE SECTOR
Local	28%	46%
Provincial	63%	39%
Regional	35%	32%
National	43%	37%
International	43%	39%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Table 2.4.2 presents the range of business sectors directly served by organizations in the public and private sector. As indicated, the range of business sectors served is large and varied, indicating the importance of meteorological information to Canada's economy. Over one-third of private sector organizations provide services to solar/wind energy (38%) and education (37%), while engineering-scientific service industries (36%) and forestry (34%) were noted nearly as often. "Other" sectors served by the private sector included air transportation, with clients including law firms, insurance companies, government, and the general Canadian public. It should be noted that this data identifies the percentage of organizations that serve a variety of businesses, many of which are in related technical areas, not volumes of business or economic impacts, which research suggests are greatest in areas such as construction and agriculture.

An interesting discussion of the value of meteorological services and information to different clients and sectors took place in several focus groups, with participants noting that many consumers in business sectors (such as agriculture) are unwilling to pay for information and services that they feel should be provided free of charge by the government.

Table 2.4.2

Scope of Business Sectors/Clients Directly Served by Organizations Employing Meteorological Practitioners in 2005

SECTOR/CLIENT SERVED	% OF PUBLIC SECTOR	% OF PRIVATE SECTOR
Solar/Wind Energy	34%	38%
Education	26%	37%
Engineering and Scienti c Services	34%	36%
Forestry	40%	34%
Mining	21%	33%
Transportation	26%	30%
Utilities	16%	23%
Agriculture	18%	22%
Meteorological Services	5%	22%
Oil/Gas	18%	21%
Fishing	24%	20%
Broadcasting/Media	32%	17%
Environmental Services	11%	16%
Recreation	3%	13%
Retail	16%	12%
Other	3%	5%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Table 2.4.3 sets out the proportion of organizations engaged in different meteorological employment activities. Over one-third of private sector organizations employ practitioners for work related to broadcasting weather information (39%), while meteorological instrumentation and climatology are also well covered by private sector organizations (44% and 38% respectively). Organizations in the public sector employ meteorological practitioners for work related to broadcasting weather information (46%), meteorological service delivery (41%), and meteorological training (41%). Other activities, as indicated by private sector organizations employing meteorological practitioners, include aviation and related areas, and research and development. Weather forecasting, avalanche forecasting, and risk and disaster management were also noted as important activities.

Table 2.4.3

Activities Undertaken by Organizations Employing Meteorological Practitioners in 2005

ACTIVITY UNDERTAKEN BY ORGANIZATION	PUBLIC SECTOR	PRIVATE SECTOR
Meteorological Instrumentation[1]	39%	44%
Broadcasting Weather Information	46%	39%
Climatology	36%	38%
Meteorological Training	41%	31%
Meteorological Observation	36%	31%
Air Chemistry and Air Quality	18%	30%
Operational Meteorology	15%	18%
Meteorological Service Delivery	41%	16%
Other	3%	2%

1 Most respondents indicating meteorological instrumentation as an activity were practitioners, rather than manufacturers of instruments.

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Section 3: Demographic and Work Profiles of Meteorological Practitioners

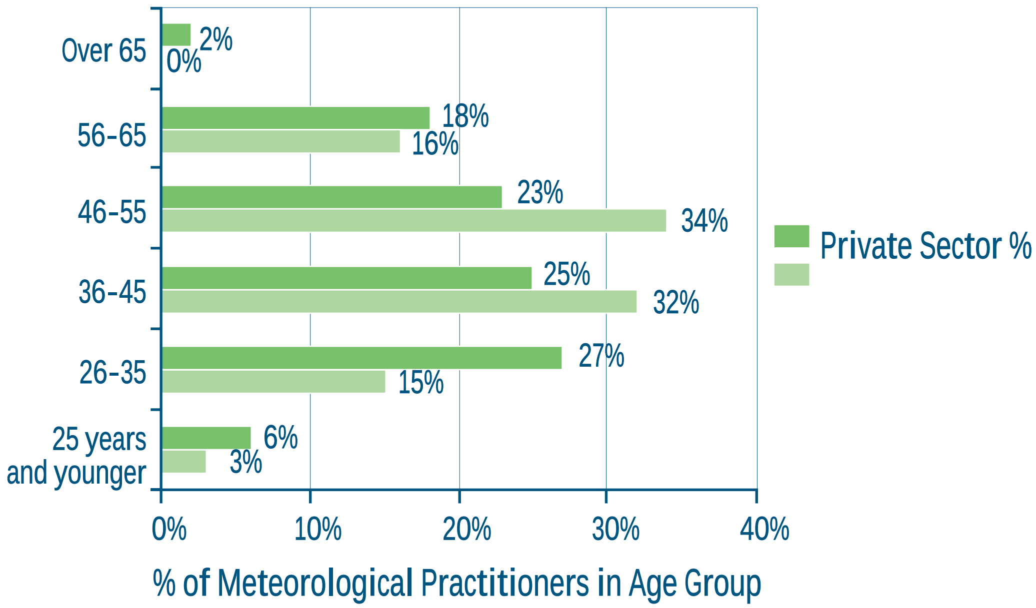
Meteorological practitioners working in the public and private sector in Canada represent a range of age groups and work experience levels. However, there is a potential labour supply issue present as younger practitioners are underrepresented and more senior practitioners prepare for retirement over the next five years. A high rate of job turnover indicates potential employee retention issues. An analysis of skill transferability between private and public sectors indicates that public sector retirees may represent a potential labour supply pool for private sector meteorological employment (particularly in the area of private consulting). The following section discusses demographic and work profile information of meteorological practitioners, specifically:

- Demographic characteristics including age cohorts and gender profile of meteorological practitioners;
- The activities undertaken by meteorological practitioners;
- Length of career and number of hours worked per week by meteorological practitioners; and
- The transferability of skills between public and private sectors.

3.1 Demographic Characteristics

Figure 3.1.1 illustrates the age of meteorological practitioners working in the private and public sectors. Public sector employees are older than those who work in the private sector, although, the majority of meteorological practitioners in both sectors fall within the age range of 36-55 (66% in the public sector and 48% in the private sector). Fewer practitioners in the public sector than in the private sector are within the age range of less than 25-35 (18% and 33% respectively). This suggests that there may be a supply issue, namely that more entry-level meteorological practitioners will be needed to fill the gap left by senior practitioners as they retire over the next 10 years. In addition, the data suggests the possibility of "poaching" practitioners from other firms as retirements in the public sector increase.

Figure 3.1.1
Distribution of Meteorological Practitioners by Age Group in 2005



As illustrated in Table 3.1.2, women currently account for approximately 21% of the total number of meteorological practitioners in the private sector and 20% in the public sector. Employment equity issues may need to be addressed, along with broader recruitment activities into the sector (for example, in high school science programs and at career fairs), to encourage a higher proportion of female and Aboriginal persons (currently 2% of practitioners) to consider careers in Canada's meteorological sector.

Table 3.1.2
Gender Profile of Meteorological Practitioners in 2005

GENDER	PUBLIC SECTOR	PRIVATE SECTOR
Female	20%	21%
Male	80%	79%

3.2 Activities Undertaken by Meteorological Practitioners

As indicated in Table 3.2.1, meteorological practitioners work in a wide range of areas. In the private sector, 42% of meteorological practitioners are engaged in meteorological instrumentation and 37% in air chemistry/air quality activities; however, activities undertaken by meteorological practitioners in the private sector are relatively evenly distributed. In comparison, over one-third of practitioners working in the public sector (36%) are engaged in meteorological training, with an otherwise similar distribution of as meteorological activities as practitioners in the private sector. Other activities meteorological practitioners are engaged in vary from vessel response to avalanche forecasting. About one-quarter of practitioners in the private sector indicated that they work in other activities such as meteorological or atmospheric research, while hydrometeorology was also noted as an activity undertaken by practitioners.

Table 3.2.1
Activities Undertaken by Meteorological Practitioners in 2005

ACTIVITY UNDERTAKEN BY PRACTITIONER	PUBLIC SECTOR	PRIVATE SECTOR
Meteorological Instrumentation	19%	42%
Air Chemistry/Air Quality	7%	37%
Meteorological Training	36%	31%
Broadcasting Weather Information	35%	29%
Other	19%	26%
Climatology	17%	25%
Meteorological Observation	19%	22%
Operational Meteorology	22%	14%
Meteorological Service Delivery	26%	10%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

3.3 Length of Career and Hours Worked

Figure 3.3.1 provides information regarding the number of years meteorological practitioners working in the private sector have been engaged in meteorological practice. While private sector meteorological practitioners tend to have been engaged in meteorological practice for shorter periods of time —10 years and less (46%) — a significant proportion have over 10 years of experience (54%). The number of years engaged in meteorological practice is more evenly spread across time for public sector practitioners with 32% spending 10 years and less and 68% having over 10 years of experience.

Figure 3.3.1
Number of Years Engaged in Meteorological Practice by Practitioners in the Private Sector

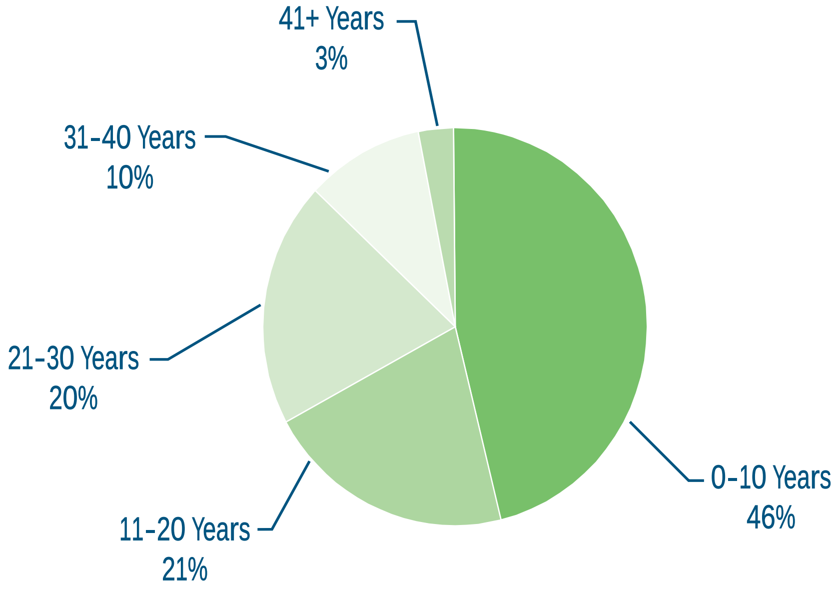
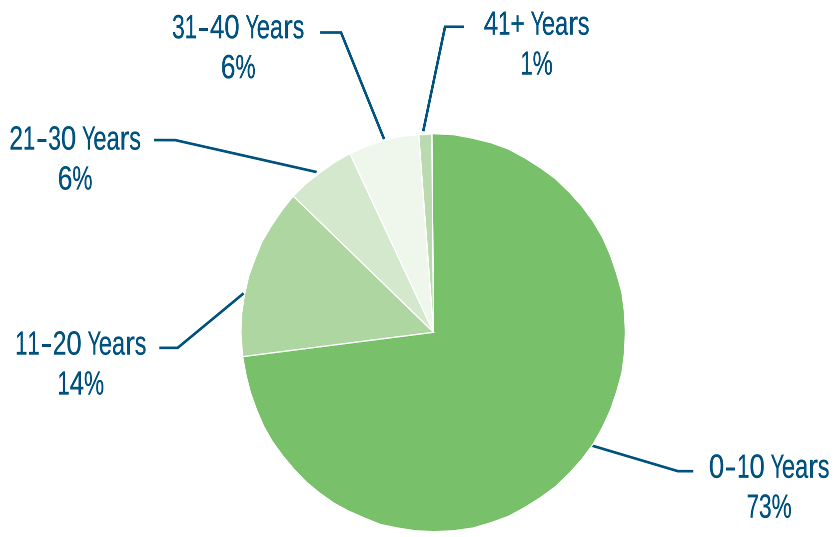


Figure 3.3.3 displays the number of years meteorological practitioners in the private sector have been working in their current employment position. While nearly three-quarters of all practitioners in the private sector have worked in their current position for up to 10 years (73%), the same is true for public sector practitioners (73%). Considering the proportion of meteorological practitioners who have been engaged in meteorological practice over the longer-term, it is interesting that 73% of respondents have only spent 0-10 years in their current position. This finding may reflect the general tendency for people to change jobs frequently today, or possibly to retention issues.

Figure 3.3.3

Number of Years Spent in Current Employment Position by Meteorological Practitioners in the Private Sector



As presented in Figure 3.3.5, over half (52%)of meteorological practitioners working in the private sector work between 31 and 40 hours per week, while others report a longer 41-60 plus hour work week (29%). As presented in Figure 3.3.6, public sector results are generally similar, with more practitioners indicating a 31-40 hour work week (67%).

Figure 3.3.5
Number of Hours of Work Per Week by Meteorological Practitioners in the Private Sector

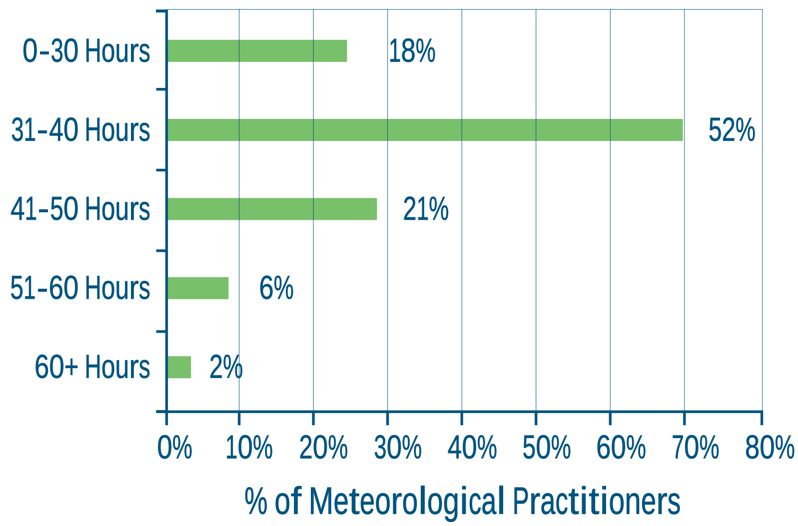
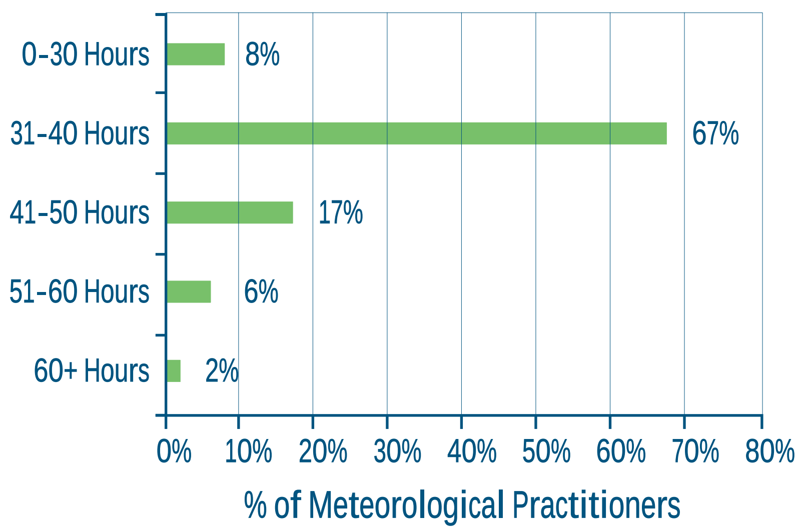


Figure 3.3.6
Number of Hours of Work Per Week by Meteorological Practitioners in the Public Sector



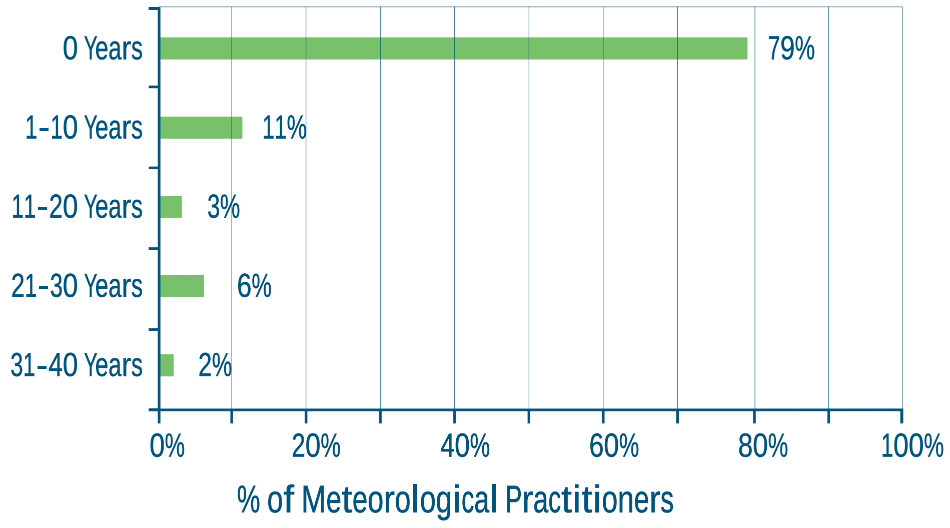
3.4 Transferability of Skills Between Public and Private Sectors

The transferability of skills between public, private, and consulting work is discussed in this section. The analysis focuses on the number of meteorological practitioners who have worked in both the public and private sectors or have carried out consulting work for either sector. An analysis of data collected from practitioners who previously worked for MSC may indicate the importance of MSC as a labour pool for private meteorological employment.

Another indication of the transferability of skills can be derived from the number of practitioners in both sectors who engage in freelance or consulting work outside of their usual jobs. Nearly equal numbers of private and public sector practitioners indicate their involvement in this type of work (13% and 12% respectively).

Figure 3.4.1 displays the number of years meteorological practitioners in the private sector have previously worked for MSC. While most private sector practitioners indicated that they have never previously worked for MSC, about one in five meteorological practitioners (22%), have worked for MSC at some time in their careers and 11% worked at MSC for up to 10 years before moving to private sector work.

Figure 3.4.1
Number of Years Private Sector Meteorological Practitioners Previously Worked for MSC



Section 4: Overview of Labour Market Needs and Recruitment

The increasing demand for accurate meteorological information in Canada, along with the importance of this information to all Canadian industry sectors and individuals, indicates the need for a healthy labour market in the meteorological sector. Current and projected labour supply issues are of concern for the sector, particularly as senior practitioners in the private and public sectors begin to retire over the next few years. Low enrolment and graduation rates from college and university meteorology programs will affect the stability of the meteorological labour supply in the coming years. This section details aspects of labour market needs and recruitment, including:

- Current and projected vacancies, including the number of vacancies due to retirement and those requiring college/university training;
- Organizations' retirement and hiring projections over the next five years;
- The potential for meteorological practitioners' workforce re-entry after retirement;
- Preferred recruitment methods of employers and practitioners, including international recruitment;
- Level of work contracted from the public sector to the private sector over the next five years; and
- Current and projected labour supply over the next five years.

4.1 Current Vacancies and Retirement Issues

Table 4.1.1 below represents the estimated numbers of additional and replacement meteorological practitioners hired in 2004. These figures indicate substantial employment activity across the sector, with new positions exceeding replacements, suggesting an expansion in the area of meteorological employment in general. In 2004, an estimated 960 meteorological practitioners were hired in the public and private meteorological sector. Employment activity in the public sector in 2004 was less substantial than in the private sector, with an estimated 130 total positions hired in 2004. Analysis of private sector data indicates that the majority of employment activity is across the broad private meteorological sector (includes industries outside the traditional meteorological sector such as communications, and much larger sectors such as transportation). Overall the private sector accounts for 86% of the total positions hired in 2004 and indicates a hiring rate of 15.4%.[5]

5 The reader is reminded that the traditional meteorological sector (such as forecasting and modelling) represents less than 10% of the sector-wide total of practitioners, with the largest group of meteorological practitioners defined for the study estimated to be in the transportation sector. The larger population of meteorological practitioners is estimated to be over 7,000, of which about two thirds are in the transportation sector (such as pilots and marine officers).

Table 4.1.1
Estimated Number of Meteorological Practitioners Hired by Organizations in 2004

TYPE OF POSITION	PRIVATE SECTOR	PUBLIC SECTOR	ALL ORGANIZATIONS
New Positions	490	80	570
Replacement Positions	340	50	390
TOTAL HIRED	**830**	**130**	**960**

*Population estimates derived from Statistics Canada data.

Figure 4.1.2 presents the percentage of new positions versus replacement positions hired in the private sector (public sector not shown here). In the private sector 59% of positions hired in 2004 were new positions. The public sector is comparable to that of the private sector with 62% of positions hired as new positions.

Figure 4.1.2
Percentage of Meteorological Practitioners Hired by Private Sector Organizations in 2004 as New and Replacement Positions

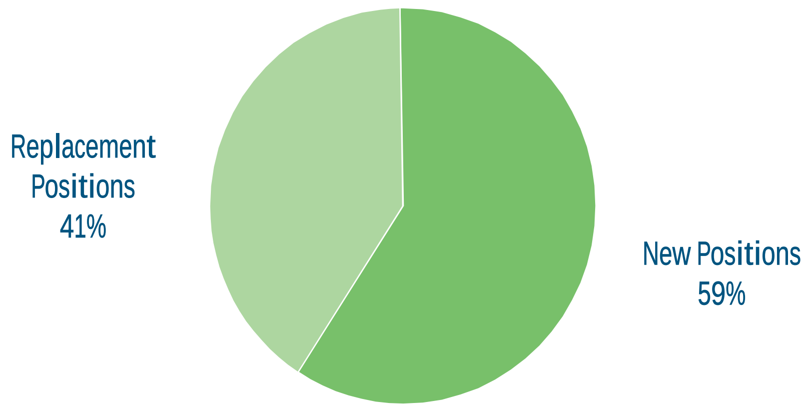


Table 4.1.3 provides a breakdown of environmental practitioner vacancies by sector. Of the estimated 170 vacancies in Canada, 38% are in the private sector (65 positions). In the public sector, 15 of the current vacancies are due to retirements and 59 of the vacant positions require college or university training. In the private sector, 10 of the vacant positions are due to retirements while 60 require college or university training. This data suggests, as noted elsewhere, the importance of university and college education to hiring in meteorology, as most positions require college or university training, and the lesser importance of retirements.

Table 4.1.3
Estimated Number of Meteorological Practitioner Vacancies in 2004

SECTOR	VACANCIES
Public Sector	105
Private Sector	65
TOTAL VACANCIES	170

*Population estimates derived from Statistics Canada data.

4.2 Future Demand and Retirement Issues

Analysis of the study data suggest that the demand for meteorological practitioners in the broader private sector (industries outside of traditional meteorological business) will be very high over the next five years, with expected demands for training also being high. As indicated in table 4.2.1, by 2010, private sector employers estimate that they will hire over 3,100 meteorological practitioners, of which 2,350 new positions (mostly in transportation) will be created, and close to 900 will be replacement positions.

Private sector employers predict 370 retirements by 2010. However, of the total retirements forecasted by employers, only 290 positions will be hired as replacements, suggesting a change in skill requirements.

Table 4.2.1

Projected Demand for Meteorological Practitioners by Private Sector Organizations in 2010
(Including New Positions and Replacement Positions)

TYPE OF POSITION	PROJECTED EMPLOYMENT IN 2010
Number of New Positions	2,350
Number of Replacements Positions	845
TOTAL METEOROLOGICAL PRACTITIONERS	**3,195**

Table 4.2.2 indicates that by 2010, public sector employers estimate that they will hire over 400 meteorological practitioners, of which 50 will be new positions and an estimated 370 will be replacement positions. Of the total replacement positions, approximately 300 will be due to retirements, indicating a significant labour supply issue approaching the public sector in the next five years.

Table 4.2.2

Projected Demand for Meteorological Practitioners by Public Sector Organizations in 2010
(Including New Positions and Replacement Positions)

TYPE OF POSITION	PROJECTED EMPLOYMENT IN 2010
Number of New Positions	50
Number of Replacements Positions	370
TOTAL METEOROLOGICAL PRACTITIONERS	**420**

While retirements are not a particular issue for the private meteorological sector, public sector retirements will be increasingly important for private meteorological organizations over the next several years, as more MSC employees reach retirement. Hiring within the public sector to replace retirements will affect the ability of private meteorological sector employers to recruit and retain meteorological practitioners for traditional meteorological employment activities (such as forecasting). This issue is discussed more closely below in relation to the supply of meteorological practitioners engaged in traditional meteorological employment activities.

4.3 Potential for Workforce Re-Entry

Close to half of all private sector practitioners stated that they would re-enter the workforce after retirement in order to pursue consulting work (45%). Over one-third of public sector practitioners indicated their plans to re-enter the workforce (37%) (Table 4.3.1). Of the respondents noting what type of work they would undertake if they were to pursue freelance or consulting opportunities, nearly one-third indicated that they would consider casual, part-time contract work with the government, and many indicated that they would engage in some part-time consulting work and part-time weather broadcasting work. This data indicates a potential pool of labour for the private sector. An important line of enquiry based on this finding would be to determine the impact of workforce re-entry on the current supply of trained meteorological practitioners within the private meteorological sector.

Table 4.3.1

Practitioners with Plans to Pursue Meteorological Consulting Work after Retirement

PLAN TO PURSUE CONSULTING WORK	PUBLIC SECTOR	PRIVATE SECTOR
Yes	37%	45%
No	29%	28%
Unsure	34%	27%

As indicated in table 4.3.2, in the next five years (by 2010), employers in private sector organizations are most likely to hire meteorological practitioners to engage in activities such as broadcasting weather information (77%) and meteorological training (55%). Hiring in the public sector is most likely to occur in meteorological instrumentation (83%) and climatology (67%).

Table 4.3.2

Meteorological Activities in which Employers/Managers Are Most Likely to Hire Within the Next Five Years (by 2010)

	PROJECTED DEMAND IN 2010	
	PUBLIC SECTOR	PRIVATE SECTOR
Broadcasting Weather Information	60%	77%
Meteorological Training	8%	55%
Air Chemistry/Air Quality	33%	53%
Meteorological Observation	40%	47%
Operational Meteorology	59%	44%
Meteorological Instrumentation	83%	33%
Climatology	67%	25%
Meteorological Service Delivery	36%	20%

4.4 Recruitment Methods (Employers and Practitioners)

The most frequently cited recruitment method among private sector organizations and practitioners is to keep an applicant's resume on file (64%). Internet recruitment is also popular among private sector organizations (60%). A majority of public sector organizations and practitioners prefer to either keep resumes on file (64%) or to use newspapers and trade journals (49%) for recruiting. Interestingly, co-op programs are not well-used for recruitment in either sector, although focus group participants spoke enthusiastically about the benefits of co-op programs. Respondents indicating "other" noted a number of different potential options, including increased recruitment-related activities through ECO Canada's job board and CMOS.

Table 4.4.1
Recruitment Methods Preferred by Practitioners and Organizations

RECRUITMENT METHOD	PUBLIC SECTOR	PRIVATE SECTOR
Resumes on File	64%	64%
Electronic Bulletin and Job Banks and Internet	45%	60%
Internal Company Searches	44%	31%
HRSDC (Human Resource Centres)	17%	26%
Newspapers or Trade Journals	49%	26%
On Campus Recruitment	15%	23%
Professional Recruitment Agencies	21%	22%
Personal Contacts	12%	16%
Co-op Programs	3%	4%
Other	2%	1%

Preferred methods of recruitment reported by employers/managers and meteorological practitioners reveal that most favour traditional methods, with 64% reporting that they keep resumes on file as an effective way to recruit practitioners. Other preferred methods included job banks, internet postings (60%), and internal company searches (31%).

4.5 International Recruitment

International recruitment is an issue, which has been prominent in past studies, and in interviews conducted with key informants. If the current shortage of meteorological practitioners in Canada continues, private sector organizations may turn to international recruitment as a potential solution. Interestingly, more organizations in the public sector (23%) than in the private sector (18%) have attempted international recruitment to find meteorological practitioners.

4.6 Contracting of Meteorological Work by the Public Sector

A variety of differences and divisions between meteorological employment in the private and public sectors exist. This division may change substantially in the future, affecting the size of the meteorological practitioner labour market. Most public sector organizations indicate that they currently contract meteorology work to the private sector. The same number of public sector organizations noted that they will either remain at the same level of contracting or that they don't know how the level of contracting to the private sector will change over the next five years. Based on a sample of between three and five government employers, operational meteorology (100%) and air chemistry/air quality (100%) are the most likely areas in which contracts will be granted to the private sector over the next five years.

Table 4.6.1
Whether Government Organizations Contract Meteorology Work to the Private Sector

CONTRACT WORK TO THE PRIVATE SECTOR	PUBLIC SECTOR
Yes	44%
No	39%
Don't know	17%

* Based on a sample of 28 government employers.

Table 4.6.2
Level of Work Expected to Be Contracted to the Private Sector by Government Organizations by 2010

LEVEL OF CONTRACTING EXPECTED IN 2010	PUBLIC SECTOR
Stay at the same level of contracting	39%
Contract more meteorology work to private sector	18%
Contract less meteorology work to the private sector	4%
Don't know	39%

* Based on a sample of 28 government employers.

Increased public/private sector interaction will play an important role in the continued development of the private meteorological sector in Canada. Forty-four percent of public sector employers in government indicated that their organization currently contracts work to the private sector. As well, operational meteorology and air chemistry/air quality seem to be the meteorological activity on which contracts are most likely to be based. Findings on whether contracting levels will shift over the next five years indicate that the majority of government organizations will either remain at the same level (39%) or are unsure of how the level of contracting may change (39%).

4.7 Supply of University Trained Meteorological Practitioners

Data suggests an increase of about 6% in new positions for meteorological practitioners per year. This projection is also consistent for meteorological firms engaged in traditional meteorology, for which university degrees are generally required. This therefore indicates that the forecasted demand for trained practitioners will also increase in these firms. At the same time, MSC survey respondents projected the need to replace retirement positions (and to add a very small number of new positions) to account for about 8% in new hires per year—again usually with a university degree. Together, this public and private sector demand would total about 75 new practitioners with university degrees each year.

Existing data suggests that universities will not meet this demand. Statistics Canada data collected over the 10-year period from 1992 to 2001 indicated a total of only 305 graduates in meteorology and atmospheric science, or an annual average of about 30 graduates, with declining enrolments reported in many institutions offering meteorological/atmospheric science-type programs.

These patterns were also reaffirmed by university graduation data collected directly from Canadian universities, where graduation rates were consistent or moved up and down over a six-year period in meteorology and atmospheric science programs.[6]

Focus group participants reaffirmed that there would be a significant shortfall in the supply of university graduates. Participants emphasized the current shortfall of university graduates, the difficulties universities currently face in operating their programs, and the importance of remedying this situation. The significance of this specific gap in the current supply of meteorological practitioners is heightened when considering that university-trained meteorological practitioners are not only the drivers of traditional meteorological activities such as forecasting, but also of significant aspects in the training of other meteorological practitioners who engage in meteorological activities for only a part of their work.

6 Statistics Canada, *University graduates by field of study, program level, and sex, 1992 to 2001*. Custom data.

Section 5: Education Levels and Training Requirements of Meteorological Practitioners

The provision of meteorological information is complex in nature and requires individuals that are highly educated and skilled. As meteorological information continues to play a critical role in the decision-making process of industries and people in Canada, the skills and training required of meteorological practitioners is expanding to meet the various demands of its users. This section explores various training issues with respect to meteorological practitioners including:

- Level of education and background of study of meteorological practitioners in the private sector;
- Organizations' perceptions about training needs and skill requirements of meteorological practitioners;
- Use and interest in various training formats;
- Skills required by meteorological practitioners for their current work; and
- Interest in national occupational standards and certification programs.

5.1 Educational Attainment Levels

Table 5.1.1 describes the educational attainment levels of private sector meteorological practitioners and includes data on the number of practitioners currently employed at various educational levels. There is a relatively high level of education among meteorological practitioners in the private sector as approximately 36% hold a postgraduate degree, (25% hold a master's degree, and 11% hold a PhD). While almost the same percentage of public sector practitioners hold master's degrees (26%) as private sector practitioners, less than half as many private sector practitioners hold a Ph.D. than in the public sector (31% of public sector practitioners hold a Ph.D.) As well, practitioners with college or CEGEP degrees are more than four times more likely to work in the private sector than in the public sector.

Table 5.1.1
Highest Level of Education Reported by Meteorological Practitioners (by Sector)

TYPE OF DEGREE/DIPLOMA	PUBLIC SECTOR	PRIVATE SECTOR
Ph.D.	31%	11%
Master's degree	26%	25%
Bachelor's degree	29%	27%
Meteorology diploma	5%	7%
College/CEGEP diploma or equivalent	5%	21%
Other	4%	9%

The majority of practitioners working within the transportation industry have College/CEGEP diplomas or higher educational attainment. Practitioners also commented on a range of other educational qualifications, including various training certifications from associations (such as the Canadian Avalanche Association) and government training programs. The completion of training programs offered by universities in the United States was also noted by some respondents. High levels of post-graduate qualifications within a broad range of disciplines suggest that educational institutions need to place a strong emphasis on math and science in order to encourage an interest in meteorology that will meet future demands for qualified practitioners in this area.

The importance of practical training, however, was raised in a discussion of the responsibility of university programs in the Vancouver focus group, with a number of participants noting that universities only instil theoretical knowledge, which creates a disadvantage for students in important fields such as operational meteorology (since additional college training is often required after university).

As represented in Table 5.1.2, the majority of practitioners in the private and public sector hold degrees in a wide-range of academic areas that include physics, mathematics, statistics, geography, fine arts, and fisheries (these areas are indicated in the category "other"). A significant percentage of practitioners hold diplomas or degrees in engineering with 46% in the private sector and 33% in the public sector, while a smaller number hold diplomas or degrees in meteorological and atmospheric science.

Table 5.1.2
Academic Area of Diploma or Degree Held by Meteorological Practitioners (by Sector)

ACADEMIC AREA OF DEGREE/DIPLOMA	PUBLIC SECTOR	PRIVATE SECTOR
Other	37%	57%
Engineering	33%	46%
Meteorological and Atmospheric Science	10%	8%
Climatology	9%	5%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Public sector practitioners are more likely than those in the private sector to hold a diploma or degree in meteorological and atmospheric science or climatology but are less likely to hold engineering or other qualifications. The focus group discussion held in Montreal explored issues around university program availability in both physics and meteorology, noting that the Université du Québec à Montréal (UQAM) has discontinued its baccalaureate meteorology program, decreasing the accessibility of meteorological training.

Table 5.1.3 provides information regarding the levels of educational attainment of meteorological practitioners as reported by private sector employers in 2001 and 2004 and projections for employment/educational levels for 2008. Educational attainment of private sector meteorological practitioners for the period from 2001 to 2004 appears to have increased incrementally, with much higher demand projected at all levels of attainment (with the exception of "other") for 2008. The opposite seems to be true in the public sector, where educational demands of practitioners are projected to be lower in comparison to the private sector (possibly due to hiring freezes).[7]

Approximately one-quarter of respondents indicating "other" noted their highest level of educational attainment as post-graduate MSC or other government training courses (including Department of National Defence training). Some respondents also indicated CMOS accreditation and weather observer training or certificates.

Table 5.1.3
Educational Attainment Levels of Meteorological Practitioners
As Reported by Organizations in 2001, 2004, and Projected for 2008 (Private Sector Only)

LEVEL OF EDUCATIONAL ATTAINMENT	2001	2004	2008
Employees with University or College Degrees or Diplomas	19%	19%	47%
Employees with Bachelor's Degree	29%	34%	76%
Employees with Meteorology Diploma	12%	18%	70%
Employees with Master's Degree	22%	31%	71%
Employees with Ph.D.	13%	16%	57%
Other (such as post-graduate MSC)	39%	50%	41%

7 Data is not presented for the public sector due to the small number of respondents to this question (n<10).

Survey results show that the majority of meteorological practitioners employed by organizations have attained either a Bachelor's or Master's degree, underlining the link between higher education and job requirements. Of those holding diplomas or degrees, 8% indicated that their diplomas/degrees were in the area of Meteorological and Atmospheric Science, while 69% indicated that they had an Engineering or other diploma or degree.

5.2 Training Needs and Skill Requirements

This section outlines the training needs and skill requirements from both an employer and practitioner perspective. The following tables highlight areas in which employers feel additional training may be necessary for meteorological practitioners, along with information about how training needs are currently being met (such as through in-house training programs, conferences, and external training).

The following information emphasizes the importance of everything from college/university education to more practical meteorological training and highlights the issue of curriculum development at the college/university level in order to aid training processes. Most meteorologists require additional training following the completion of a degree before they can actually begin work, and research findings suggest that future skill demands may be even greater. As the training of meteorological practitioners directly impacts the quality of meteorological services, inadequate training presents risks and costs to Canadian business and society in general.

Table 5.2.1 presents employers' perceptions about the specific areas in which meteorological practitioners need training or upgrading. Private sector employers indicate that many of their meteorological practitioners require training or upgrading in the numerous transferable skills (also called essential skills) such as analytical skills (47%) and statistical analysis skills (33%). Planning and organizational skills (32%) and technology skills (29%) were also noted as being important areas where improved training and upgrading were desired by one-third of private sector employers. Public sector results were similar to the private sector with about half of public employers indicating analytical skills as an area where improved training is needed (43%).

Other skills requiring training or upgrading varied, although employers reported that English-language skills were important.

Table 5.2.1
Percentage of Organizations in 2005 that Reported Training/Upgrading is Required

TYPES OF SKILLS	PUBLIC SECTOR	PRIVATE SECTOR
Analytical Skills	43%	47%
Statistical Analysis Skills	14%	33%
Planning and Organizational Skills	34%	32%
Technology Skills	40%	29%
Meteorological Science and Knowledge	34%	29%
Customer Service Skills	31%	26%
Research Skills	34%	26%
Leadership Skills	23%	26%
General Communication Skills	17%	23%
Critical Thinking and Judgement	26%	15%
Presentation Skills	23%	19%
No Upgrading or Training Needed	9%	11%
Other	2%	1%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

A discussion regarding training needs took place at the Vancouver focus group, with participants noting that cutbacks in MSC training budgets have been damaging for the public sector and have also limited the potential for beneficial public/private training partnerships.

Table 5.2.2 presents data on the anticipated future use of training formats by employers while Table 5.2.3 presents data on the training methods practitioners would like to use in the future. Employers and practitioners in both the private and public sectors favour personal reading and research (82% in the private sector and 85% in the public sector) and conferences and workshops (78% in the private sector and 83% in the public sector) for training and professional development. Participants in the Edmonton focus group discussed the merits of textbook learning versus hands-on learning and recommended a move toward more active training methods.

In-house and company-sponsored training methods are much more common among public sector employers, with private sector employees displaying a greater interest in these training methods than their employers.

Table 5.2.2

Training Methods Employers Would Like to Use in the Future

TRAINING METHOD	PUBLIC SECTOR	PRIVATE SECTOR
Company-Sponsored Training	49%	23%
Conferences and Workshops	83%	78%
Exchange Programs	36%	32%
Expert Visitors	59%	42%
External Face-to-Face Training	60%	42%
On-the-Job Training	76%	69%
Online Training	59%	54%
In-House Training	65%	40%
Personal Reading and Research	85%	82%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Table 5.2.3

Training Methods Meteorological Practitioners
Would Like to Use in the Future

TRAINING METHOD	PUBLIC SECTOR	PRIVATE SECTOR
Company-Sponsored Training	72%	77%
Conferences and Workshops	93%	86%
Exchange Programs	71%	55%
Expert Visitors	81%	73%
External Face-to-Face Training	70%	59%
On-the-Job Training	69%	60%
Online Training	66%	65%
In-House Training	68%	62%
Personal Reading and Research	84%	78%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Table 5.2.4 presents meteorological practitioners' assessments of the skills required for their current work. Private sector meteorological practitioners indicate that providing consultation services is the most important skill required for their current work (69%). Other private sector skills required include developing, testing and using mathematical or computer models (62%), and producing weather forecasts (46%). Public sector responses are similar, and include providing consultation services (80%) and producing weather forecasts (66%) as important skills. As well, MSC employees in attendance at the Montreal focus group discussed the importance of decision-making skills, critical thinking, and teamwork ability in the recruitment of practitioners to MSC.

When asked what other meteorological-related skills/competencies are required for their current work, meteorological practitioners provided a range of answers from marketing skills to the ability to supervise graduate students, along with a number of technical competencies. Some respondents indicated that mentorship and training skills, graphic design skills, and communication skills were needed for their work, particularly to make presentations to clients and the general public.

Table 5.2.4

Meteorological Practitioners' Assessment of Skills Required for Current Work

TYPE OF SKILLS	PUBLIC SECTOR	PRIVATE SECTOR
Provide Consultation Services	80%	69%
Develop, Test, and Use Mathematical or Computer Models	60%	62%
Produce Weather Forecasts	66%	46%
Analyze and Interpret Meteorological Data	40%	45%
Conduct Research on Meteorological Processes	54%	41%
Make Presentations and Publish Reports or Articles	17%	17%
Design and Develop New Equipment Procedures	13%	16%
Develop New Service Delivery Technologies	2%	5%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Organizational and practitioner views on training appear to be relatively similar. In both cases, the most popular training methods are conferences or workshops in the private sector (86% of practitioners and 78% of employers/managers would like to use this training method in the future). This finding may indicate the need for networking opportunities among practitioners and employers in the meteorological sector. While a majority of private sector employers/managers reported that training/upgrading is needed in all areas (only 11% indicated that no training/upgrading was needed), analytical skills, planning and organizational skills, and technology skills appear to take priority.

5.3 National Occupational Standards/Certification Programs

Occupational standards describe the skills, knowledge and attributes required to perform competently in the workplace. In particular, National Occupational Standards (NOS) are statements of performance that describe what competent people in particular occupations are expected to be able to do on a national basis. The standards serve as the foundation of certification and assist educators in the development of curricula that is in harmonization with industry needs. NOS are typically used for recruitment, job design, evaluation, training, continued education, curriculum development, career guidance and certification.

As noted in Table 5.3.1, over one-third (35%) of private sector organizations document standards for meteorological practitioners and public sector organizations were more likely to document standards for meteorological practitioners than their private sector counterparts (41%). One-quarter (25%) of private sector organizations used standards developed by other associations or agencies. About one-third (32%) of private sector organizations indicated that they do not document standards of any kind and 39% of public sector organizations indicated that they do not document standards.

Table 5.3.1
Whether Organizations Document Occupational Standards forMeteorological Practitioners

DOCUMENT OCCUPATIONAL STANDARDS	PUBLIC SECTOR	PRIVATE SECTOR
Yes	41%	35%
No	39%	32%
Used Standards Developed by Associations or Similar Agencies	8%	25%
Unsure	12%	8%

Table 5.3.2 displays information regarding the benefits for private and public sector employers of developing National Occupational Standards (NOS). According to private sector employers/managers, the development of NOS is likely to aid virtually all meteorological sector organizations in a variety of ways (93% reported "some advantage"). Private sector organizations indicated that recruiting better-trained practitioners was the most important potential benefit of NOS development (37%). On the topic of other ways in which NOS would aid organizations, employers indicated a range of responses, most significantly, that NOS would provide recognition to meteorological practitioners in the general public, courts, and provincial public service commissions as well as aid private sector firms to obtain liability insurance.

Public sector organizations noted the ability to recruit better-trained practitioners as being a benefit (47%). Interestingly, public sector organizations were more likely to indicate the ability to pursue new business opportunities as a perceived benefit of NOS than their private sector counterparts (36% and 31% respectively). Forty-five percent of educators reported that educational organizations would be aided by NOS through curriculum update and development, and 60% of employers/managers indicated using some occupational standards. These findings may indicate a gap, especially since many employers/managers noted various ways in which occupational standards could aid their organization.

Table 5.3.2
Organizational Benefits of Developing National Occupational Standards

BENEFIT	PUBLIC SECTOR	PRIVATE SECTOR
Recruiting Better Trained Practitioners	47%	37%
Evaluating Practitioner Performance	44%	31%
Developing Technical Training Plans	17%	37%
Reducing Professional Risks of Errors or Omissions	36%	24%
Pursuing New Business Opportunities	36%	31%
Developing Certifications	6%	31%
Planning Professional Development	42%	20%
Other	0%	5%

Most private sector employers (94%) indicated that the development of a certification program would aid their organizations in numerous areas. Table 5.3.3 displays data on the importance of certification to private sector and public sector organizations. Nearly all organizations indicated that certification would be advantageous with 52% of employers/managers in the private sector and 45% in the public sector stating that professional certification is important to their organization, which indicates the potential for the development of a national certification program.

Table 5.3.3
Importance of Certification to Organization

IMPORTANCE OF CERTIFICATION	PUBLIC SECTOR	PRIVATE SECTOR
Important	45%	52%
Neither Important nor Unimportant	18%	24%
Not Applicable	17%	11%
Not Important	15%	8%
Don't Know	5%	5%

Table 5.3.4 presents data on the perceived benefits of certification programs to private sector and public sector employers. The benefits of certification programs include reducing the professional risks of errors or omissions (37%), aiding in the pursuit of new business opportunities (35%), developing technical training programs (35%), and recruiting better-trained practitioners (34%) in the private sector. Public sector organizations would be aided in the area of evaluating practitioner performance (37%) and professional development (34%), although pursuing new business opportunities was seen to be most beneficial (49%), even more so than in the private sector.

Table 5.3.4
Organizational Benefits of National Certification Programs

BENEFIT	PUBLIC SECTOR	PRIVATE SECTOR
Reducing Professional Risks of Errors or Omissions	9%	37%
Pursuing New Business Opportunities[1]	49%	35%
Developing Technical Training	17%	35%
Recruiting Better Trained Practitioners	23%	34%
Evaluating Practitioner Performance	37%	32%
Professional Development	34%	29%
None of the Above Could Aid Organization	6%	5%
Other	7%	1%

1 The 49% of public sector respondents indicating "pursuing new business opportunities" as a benefit for national certification programs were largely comprised of educational bodies (such as universities), which were found to be relatively entrepreneurial and sensitive to the business needs of those they serve.
*Totals exceed 100% due to respondents' ability to respond to more than one category.

Discussion groups also touched on the topic of the difficulty faced by private sector firms in obtaining liability insurance to protect against errors and omissions. It was suggested that certification programs might aid organizations in overcoming this challenge since certification guarantees a level of knowledge and performance for private sector practitioners.

As indicated in Table 5.3.5, better workplace training programs were noted most often as an effect of certification programs (50% in the private sector and 52% in the public sector). Private sector organizations and practitioners cited better academic training programs as another likely outcome, with similar results reported from the public sector (43% and 34% respectively). Employer/manager and practitioner views differ as to why certification programs are needed and what their effects may be. For example, employer/managers noted that reducing professional risks of errors or omissions would be the most beneficial aspect of national certification programs (37%).

Other effects of national certification programs, as indicated by survey respondents, varied greatly. Many indicated that certification would benefit organizations and practitioners by establishing a standard of professionalism for the sector through increased coordination and better training, while some employers noted that certification would facilitate the hiring of qualified practitioners. Several respondents commented that certification would result in higher consulting fees; however, most agreed that the standard of work would also improve.

Table 5.3.5
Assessed Effects of National Certification Programs

EFFECT OF CERTIFICATION	PUBLIC SECTOR	PRIVATE SECTOR
Better Workplace Training Programs	52%	50%
Better Academic Training Programs	34%	43%
Difficult to Find Employment	31%	33%
Difficult to Find Qualified Staff	34%	29%
Would Have No Effect	29%	23%
Other	7%	5%
Easier to Find Employment	5%	5%
Mobility of Practitioners	4%	5%
Finding Qualified Staff	4%	2%

*Totals exceed 100% due to respondents' ability to respond to more than one category.

Section 6: Future Directions

6.1 Educational-Training-Informational Initiatives

A number of issues in education and training were examined in the survey for both private and public sector employers. Data provided below presents the importance rankings for various initiatives that have been suggested to shape the future of the meteorological sector, both public and private. Importance is represented by a mean rating, and indicates that virtually all initiatives were rated as important to the sector.

Table 6.1.1
Employer Ranking of Importance of Educational-Training-Informational Initiatives

INITIATIVE	PUBLIC SECTOR	PRIVATE SECTOR
	Mean %	Mean %
Access to Training and Upgrading	72%	70%
Info about Meteorology Job Opportunities	70%	70%
Access to and Awareness of College and University Programs	72%	68%
Understanding of Careers in Meteorology	73%	67%
Training Academic and Business Community Partnerships	64%	67%
Co-Op and Internship Opportunities	73%	67%
Better MSC Private Sector Training Partnerships	59%	65%
Develop National Occupational Standards	58%	64%
Develop New Certification Programs	61%	64%
College and University Meteorology Program Enrolment	65%	60%
Flow of Employment Equity Groups into College and University	41%	44%

* Percentage importance indicated for future directions, where 0% = not important at all, and 100% = very important.

6.2 Labour-Supply-Business Development

Findings from the surveys and focus groups suggest that the importance of the meteorological sector is not fully recognized, and that more needs to be done to inform Canadians of the wide-ranging advantages and need for this type of expertise. Equally, the standing of the Canadian private meteorological sector (focus group participants emphasized) is not high internationally, suggesting a role for Industry Canada (whose mandate with the Department of Foreign Affairs and International Trade (DFAIT) encompasses the export of services). Many study respondents noted that there is a need to improve Canadian business' awareness of meteorology at the domestic level, and researchers noted that one possible way to raise the profile of the sector is by instituting certification programs. Study participants viewed such programs as a way of promoting better academic and better workplace training programs, as well as providing the opportunity to pursue new business opportunities.

Labour shortages exist within the meteorological sector and are likely to persist in the future. Retirement and retention issues may become increasingly important for all meteorological organizations over the next several years, as more and more public sector employees prepare for retirement. As well, universities indicate that the supply of meteorological practitioners is small and may not meet future demand.

Statistics reported in Table 6.2.1 below rate the importance of key initiatives in labour supply and business development as seen by employers in both the private and public sectors.

Table 6.2.1
Mean Ranking of Importance of Labour-Supply-Business Development Initiatives

INITIATIVE	PUBLIC SECTOR	PRIVATE SECTOR
	Mean %	Mean %
Improving Canadian Business Awareness of Meteorology	76%	74%
Increasing the Supply of Qualifed Entry-Level Staff	63%	62%
Providing More Assistance to Private Sector Meteorology	43%	59%
Reviewing Environment Canada Private Sector Policies	42%	57%
Reviewing Government Policies to Aid Private Sector	45%	54%
Increasing the Supply of Mid-Senior Level Practitioners	46%	49%
Reducing Competition for Staff with the MSC	34%	46%

* Percentage importance indicated for future directions, where 0% = not important at all, and 100% = very important.

When asked what meteorological services, if any, will experience the most growth over the next five years, a variety of responses were provided, including online training and seminars, broadcast meteorology, commercial and value-added services, as well as automated weather observation systems. Respondents noted client consulting services and private sector services generally as two of the most likely areas to experience growth. Air quality and climate services were also indicated numerous times, with some respondents indicating that growth would be stifled by the large number of imminent retirements, which will result in a huge loss of experience for the sector.

It is significant that many directions were rated as important by over two-thirds of those surveyed, indicating a wide range of needs in the sector for both human resources and business development. The researchers interpreted this as being reflective of a diverse sector much in need of revitalization—a view that was widely confirmed in focus groups.

Section 7: Conclusions and Recommendations

This report attempts to provide the reader with a greater understanding of the Canadian meteorological sector's current labour market profile and anticipated human resources requirements. As noted throughout this document, this sector is growing in terms of employment and importance to the Canadian economy while undergoing a transformation as government services are offloaded to the private sector. As the sector matures, it is imperative that all relevant stakeholders, employers, practitioners, academics and government, have a shared understanding of the skills, knowledge and competence required by the industry to meet its full economic potential. The following section outlines a number of recommendations that would help the Canadian meteorological sector achieve this goal.

Recommendation 1

Develop a common framework to better understand the current and forecasted meteorological labour market.

Next steps

This report represents a first step towards the establishment of an analytical framework that will allow for ongoing comparative studies of the meteorological labour market. Over the coming years key definitions and measures of growth and prosperity need to be further refined in collaboration with all of the sector's partners. This process will provide greater precision in reporting and forecasting while further defining the profile of meteorological practitioners and their unique occupational characteristics.

Recommendation 2

Engage the meteorological sector to develop National Occupational Standards that document the skills, knowledge and competencies required by industry.

Next steps

To bring a greater level of understanding to the skill requirements of the meteorological sector, a categorization of occupational areas and subsequent documentation of critical competencies is required. This work, referred to as National Occupational Standards (NOS), will provide the sector with a vehicle to communicate the competencies in demand by employers to the supply mechanisms of the labour market such as post-secondary institutions and potential practitioners. The NOS are a fundamental step in creating defined occupational pathways and identifying skill gaps between labour market demand and the supply of workers. This articulation of labour market requirements through the NOS provides the educational and training community with the means to rapidly respond to industry needs while providing employers with a benchmark to develop more accurate human resource plans for their staff.

Recommendation 3

Clearly articulate meteorological career opportunities and pathways to increase the interest and supply of students.

Next steps

With anticipated growth forecasted for the meteorological sector it is critical that the volume of new entrants into the workforce meets the demand of employers. While the NOS will ultimately serve to increase the applicability of post-secondary education and elevate the expertise of the workforce, steps must also be taken to attract youth to the sector. Clarifying career paths and promoting meteorological careers to secondary school students will allow them to make informed post-secondary decisions. The development of career awareness materials for guidance counsellors and high school teachers, and co-op programs for meteorological post-secondary programs are potential tools to increase interest in the sector.

Recommendation 4

Elevate the meteorological profession by providing recognition for individual expertise and experience through certification.

Next Steps

Certification is an ideal means to communicate the competence of meteorological practitioners to potential clients, employers and the general public. A national certification system based on a demonstration of competence provides individuals with a means to increase their employment mobility, provide competency assurance to clients and potentially decrease the perceived risk to insurers. Professional recognition further clarifies the sector's occupational makeup, encourages the professional development of practitioners and further refines the training required to elevate an individual's expertise.

Conclusion

As highlighted throughout this report, Canada's meteorological sector is growing both in terms of size and importance to the Canadian economy. As the sector continues to mature the general public will gain a greater understanding of its broad scope and the multitude of career opportunities it offers. To ensure the meteorological sector's future, it is critical that effective strategies are in place to address the most pressing labour market issues and that all key stakeholders are working together to help develop resources such as National Occupational Standards and certification. The coming years will see the emergence of new technologies and opportunities related to policy issues such as climate change and it is imperative that Canada is equipped with the highly-trained and qualified meteorological workforce that is required to meet these challenges.

Bibliography

Andrey, Jean and Christopher Knapper (eds). *Weather and Transportation in Canada*, Department of Geography, University of Waterloo, 2003.

Atmospheric Environment Service. *Fostering Growth of Private Meteorology in Canada: AES Five Year Plan.* April 1987.

Brown, Jeremy. "The Value of Weather Forecast Services." Department of Agricultural Economics and Business, University of Guelph. April 2002.

Canadian Foundation for Climate and Atmospheric Sciences. *Submission to the House of Commons Committee on Finance*, October 2, 2003, CFCAS website. [Available Online], Cited March 30, 2005. Available from http://www.cfcas.org/HofCbrief2Oct2003e.pdf

Canadian Foundation for Climate and Atmospheric Sciences. *Submission to the House of Commons Standing Committee on Finance- 2002 Pre-Budget Consultation*, CFCAS website. [Available Online], Cited March 3, 2005. Available from http://www.cfcas.org/FinanceCttebriefSept2002e.htm

Canadian Meteorological and Oceanographic Society. *A Meteorological Industry Strategy for Canada*. November 2001.

Canadian Meteorological and Oceanographic Society (CMOS) (sponsor), Global Change Strategies International (consultants). *Baseline Status of the Private Meteorological Services Sector in Canada*. Final Report. July 5, 2001.

Changnon, Stanley A., "Changing Uses of Climate Predictions in Agriculture: Implications for Prediction Research, Providers and Users," *Weather and Forecasting*, Vol. 19, No. 3, 2003, pp. 606-613. [Available Online], Cited March 30, 2005. Available from http://ams.allenpress.com/amsonline/?request=get-abstract&doi=10.1175%2F1520-0434(2004)019%3C0606:CUOCPI%3E2.0.CO%3B2

Changnon, Stanley A., et. al. "Rapidly Expanding Uses of Climate Data and Information in Agriculture and Water Resources: Causes and Characteristics," *Bull. Amer. Meteor. Soc.*, Vol. 80, 1999, pp. 821-830. [Available Online], Cited March 31, 2005. Available from http://www.earthscape.org/r2/ams/vol80_99/bams_30_05_0821.pdf

David Suzuki Foundation, *Climate Change: Impacts- Economic Risks*, DSF website. [Available Online], Cited March 30, 2005. Available from http://www.davidsuzuki.org/Climate_Change/Impacts/Economic_Impacts.asp

Doswell, Charles A. & Brooks, Harold E. "Budget-Cutting and the Value of Weather Services," *Weather and Forecasting*, Vol. 13, pp. 206-212. [Available Online], Cited March 30, 2005. Available from http://www.cimms.ou.edu/fldoswell/NWS_value/value2.html

Eto, Joseph et al. *Scoping Study on Trends in the Economic Value of Electricity Reliability to the U.S. Economy*, EPRI & U.S. Department of Energy, June 2001.

Environment Canada, *Climate Change- Canadian Country Studies: A Window on Climate Change in Canada*, Environment Canada Website. [Available Online], Cited March 30, 2005. Available from http://www.ec.gc.ca/climate/overview_canada-e.html

Freebairn, John W. & Zillman, John W. "Economic Benefits of Meteorological Services," *Meteorological Applications*, Vol. 9, 2002, pp. 33-44.

Greenstone, Michael. "The Economic Impacts of Climate Change: Evidence from Agricultural Profits and Random." Working Paper, National Bureau of Economic Research. May 2004.

Houghton, David D. "Meteorology Education in the United States after 1945," *Historical Essays on Meteorology*. Ed. James Rodger Fleming. Boston: American Meteorological Society, 1996. HLB Decision Economics Inc. Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services. November 19, 2001.

IPCC, *Summary for Policy Makers. Climate Change 2001: Impacts, Adaptation, and Vulnerability*. A Report of Working Group II of the Intergovernmental Panel on Climate Change. McCarthy, J. et al. (eds.), New York: Cambridge University Press, 2001.

Katz, Richard W. & Murphy, Allan H. *Economic Value of Weather and Climate Forecasts*. New York: Cambridge University Press, 1997.

Mills, Evan. *Insurance As an Adaptation Strategy for Extreme Weather Events in Developing Countries and Economies in Transitions- New Opportunities for Public-Private Partnerships.* Lawrence Berkeley National Laboratory. Prepared for Agency for International Development; Bureau for Economic Growth, Agriculture and Trade; Office of Environmental and Science Policy; and Climate Change team. June 30, 2004. [Available Online] Available from http://eetd.lbl.gov/emills/PUBS/Insurance_Emerging_Markets.html

Mills, Evan et al. U.S. *Insurance Industry Perspectives on Global Climate Change*, Lawrence Berkeley National Laboratory, U.S. Department of Energy & U.S. Environmental Protection Agency, February 2001.

Meteorological Service of Canada, *Selected Performance Measurement and Financial Information*, Environment Canada Website, 2002-2003. [Available Online], Cited March 30, 2005. Available from http://pda.msc.ec.gc.ca/media/annual_report/2002-03/selectedperformance_e.html

Paull, Colin J. *The Value and Benefits of Using Seasonal Climate Forecasts in Making Business Decisions: A Review*, Department of Primary Industries, Queensland Government. November 2002.

Revill Associates, *A. Report On the Study of the Private Sector Capacity For the Provision of Weather Services In Canada*. DOE Program Evaluation Branch. September 1995.

Rollins, Kimberly S. and Joseph Shaykewich. "Using willingness to pay to assess the value of weather forecasts for multiple commercial sectors." *Meteorological Applications*, Vol. 10, No. 1, 2003.

Schanzenbacher, B. & Mills, E. *Climate Change From an Insurance Perspective*, Institute for Business & Home Safety, December 1997.

Spiegler, David. B. "A History of Private Sector Meteorology," *Historical Essays on Meteorology*. Ed. James Rodger Fleming. Boston: American Meteorological Society, 1996.

Stratus Consulting Inc., "Economic value of current and improved weather forecasts in the US household sector," Report prepared by Lazo, J.K. and L.G. Chestnut for the National Oceanic and Atmospheric Administration. Stratus Consulting Inc., Boulder, CO. 2002.

World Meteorological Organization. *EC Advisory Group on The Role and Operation of National Meteorological and Hydrological Services- Second Session, Geneva*. April 9-12, 2002.

World Meteorological Organization. *Economic and Social Benefits of Meteorological and Hydrological Services- Proceedings of the Technical Conference Geneva*, March 26-30, 1990.

World Meteorological Organization. *The WMO Education and Training Programme. Fourth WMO Long-Term Plan Part II*. Vol. 6, No. 705, 1996-2005.

ANNEX A: Methodology

This Technical Annex describes the development of the survey sample, basic survey processes, response rates, and other data sources used for the study. Also provided is an interpretative guide to the results of the study.

A.1 Sample Development

At the outset, the study faced a number of challenges and issues. Some of these were related to the size of the private meteorological services sector and the sector's lack of definition. Compiling a survey sample (the initial goal was to survey a minimum of 100 employers) posed a challenge for several reasons. A previous study completed by CMOS of the private meteorological sector included a sample of 77 private sector employers, of which only 37 completed surveys, suggesting that 100 firms would be difficult to locate. Also, due to the many industry sectors that use meteorological services or meteorological information, and due to an innovative definition of the target group—firms employing meteorological practitioners—it proved challenging to identify and target all groups that might employ meteorological practitioners.

The survey sample for the study was developed using a number of data sources, primarily those collected from CMOS, ECO Canada, and InfoCanada. A website was also created to enable organizations and individual practitioners to sign up to complete the survey at a later date, thus allowing to target employers and practitioners directly. A complete survey database was compiled from the following data sources: the CMOS membership list, the web sign-up list, deans and professors of Canadian universities and colleges (lists provided by ECO Canada), a core list of meteorological organizations and practitioners, government practitioners and employers (mainly provided by CMOS members), and others in communications, transportation, and other industries (compiled from various sources).

All databases were coded by source and merged into one master contact database. Duplicate entries were "flagged" and removed. Once duplicates were removed, the master contact database included contact information for over 1,400 contacts for organizations believed to employ meteorological practitioners and/or individual meteorological practitioners. An additional set of invitations was distributed by MSC to its own employees, adding substantially to the overall total number of invitations sent out.

A.2 Survey Development and Response Rates

The survey tool was developed in consultation with experts in the meteorological sector, and the National Steering Committee for this study. Key informant interviews were conducted with eight steering committee members and other experts to determine the most important issues facing the sector. Survey indicators were developed to reflect these issues and the survey was then pre-tested with 10 respondents. Post-testing, the web survey functionalities were designed and thoroughly pre-tested by meteorological sector consultants and researchers.

Individuals and organizations in the master database were sent invitations by email to complete the web survey, and an additional set of invitations was also sent by MSC to its own employees, adding substantially to the total number of potential survey respondents. Follow-up telephone, email reminders, and supplementary survey activities (such as selected phone interviews) were conducted. Over a period of 12 weeks, the survey reached its goal of at least 100 organizational/employer completions.

Throughout the survey, a multi-method non-response strategy was implemented, designed to increase response rates among targeted groups (such as employers/managers). Over 1,400 email invitations were distributed between January 5-7, 2005, and approximately 1,300 email reminders were sent out between January 20-24 and late March 2005. In addition, close to 1,500 telephone calls were placed to assess issues such as: confirmation of receipt of emails, survey clarity, and ease of completion, and other problems contributing to non-response (for example "time-outs"). Alternative survey response methods were offered (by fax and telephone) in order to overcome non-response issues such as lack of internet access and time constraints.

A.3 Guidelines for Interpreting Results

The general format followed for this report is as follows: an introduction is provided at the beginning of each section, followed by tables and discussion of the statistical results. Titles for the tables are designed to describe the data collected for each survey question. Data is unweighted, as stratification per se was not included in the original study plan, and because sub-samples (within specific industries) are small. Overall results, however, are deemed reliable, as the total sample size (in excess of 400), allows overall estimates which are accurate ±5%, 95 times in 100.

With survey data collection complete, this report provides the final descriptive statistical results from the survey. Statistics Canada data has been used to aid estimation of the distribution of the meteorological workforce across industry sectors in Canada and is also displayed in this report. Statistics Canada enrolment and graduation data has been obtained and used in concert with data obtained from Canadian universities to aid the discussion of labour supply issues. Focus group findings are dispersed throughout the report and a background literature review is included within this report with a focus on assessing issues of economic value and impacts of meteorology. All tables displayed in this report show survey statistics for data collected up to April 1, 2005, and report data in percentages (with the exception of Tables 6.1.1 and 6.2.1, which display mean data).[8]

Limitations: Due to the small survey sample size, cross-tabulations in the usual sense (comparing responses to questions across regions), could not be carried out without the risk of presenting non-significant differences as meaningful, or identifying responses of individuals or organizations (due to the small numbers of cases in each cell).

A.4 Other Data Sources

Key informants from the National Steering Committee for the study along with other experts, aided in the development of the survey tool by providing insight into the most important issues currently facing the Canadian meteorological sector, and those issues that will be important in the future.

Focus group discussions were held in MSC offices in Toronto, Montreal, Vancouver, Edmonton, and Halifax. The discussions focused on validating survey findings and determining future directions on topics such as labour supply issues, the development of NOS, and professional certification programs. Generally, there was a good balance of employers and practitioners at each session, allowing for a thorough discussion of issues facing the sector. Importantly, these groups expressed consensus on many issues addressed in the report, and likely remedies. This consensus went beyond the traditional public and private meteorological sectors and included academia and practitioners in related sectors such as broadcasting and transportation.

Email invitations to attend focus group sessions were sent to all survey respondents living or working in Toronto, Montreal, Vancouver, Edmonton, or Halifax (and surrounding areas) who indicated an interest in participating in a session in Section F of the survey. Follow-up phone calls were made to email recipients to confirm attendance status. On the day before each focus group session, reminder phone calls were made to participants who had confirmed their attendance.

8 In many cases table totals exceed 100% as respondents were able to choose " all that apply."

Between six and nine participants attended each discussion group, providing a representative mix of participants including employers and practitioners from the private sector (including weather broadcasters), MSC, and educational institutions, across sectors in most locations. Participants actively engaged in discussion, providing insights into issues and challenges facing the meteorological sector.

A.5 Measuring the Meteorological Sector

The lack of baseline data on the broader meteorological sector presented significant obstacles to measuring the size of the meteorological sector, and for planning the surveys of the sector. The remedy was to estimate the meteorological population data by industry sector, using historical Statistics Canada census data on occupations and industries, and then to plan for weighting and extrapolation to obtain population estimates. A key part of this extrapolation was estimating the numbers of employers, firms, and solo practitioners in these groups as of 2005, using the rate of growth of these occupations in the period 1996 to 2001 to estimate the numbers in these groups as of 2005.

The following table provides assessment of the population of meteorological practitioners, based on information available to date from Statistics Canada, and data from the survey, as shown by selected industry groups.[9] Groups chosen include those most likely to employ meteorological practitioners, with the "core" groups of practitioners being those most likely to have university or college degrees (column 2) being found in private meteorology business services and the federal government.

9 Industry groups chosen for tabulations show Statistics Canada divisions and groups known to have meteorological practitioners, and one residual group. Key industry groups with practitioners by size are: the federal sector, meteorology-scientific-business-services, transportation, and broadcasting-communications. Groups with modest numbers of practitioners include the provincial governments, education and utilities. An "other private sector group," which includes most of Canada's businesses such as those in resources and manufacturing, had few practitioners. The groups formed, and Statistics Canada occupational divisions or groups included in each are: Meteorology business services (Group 77); Airports, transportation (Division G + (Group 83); Broadcasting/Communications (Group 48); Utilities (Group 49); Education (Division O); Other private sector, such as resources and manufacturing (Divisions A to F, I to L, P, Q, R); Federal Government (Group 81); Provincial Government (Group 82).

Table A.5.1

Estimated Number of Organizations Employing Meteorological Practitioners and Distribution of Practitioners[1]

	Employers/Firms	Meteorologists & Technicians[2]	Total Meteorological Practitioners[3]
PRIVATE SECTOR			
Traditional Meteorological Businesses	90	530	560
Transportation (air and marine)	520	200	5,380
Communications	140	50	490
Utilities	150	40	510
Other Industries	120	30	220
Sub-Total	1,020	850	7,160
PUBLIC SECTOR			
Federal Government (MSC)	20	810	1,470
Other Government	20	80	160
Education[4]	30	120	420
Sub-Total	70	1,010	2,050
Total	**1,090**	**1,860**	**9,210**

1 Percentages may not total 100% due to rounding.
2 As defined by Statistics Canada and projected to the year 2005.
3 Including an estimated 788 solo-practitioners and contractors.
4 Estimated from data supplied by Canadian colleges and universities, 2005.

Population Data: A key part of the information used was the population data estimated from historical Statistics Canada census counts for meteorologists and meteorological technicians[10], with one addition estimated for weathercasters, an occupational category for which no data is available from Statistics Canada. This data on the estimated population of meteorological practitioners is shown in the chart on the prior page, which shows the estimated number of practitioners across eight industry groups.

10 Details on meteorological practitioners and technicians are available from Statistics Canada at: http://www12.statcan.ca Population counts are projected from 1991-2001 data, with the exception of broadcsting-communications, which was estimated from Info Canada and survey data.

Limitations and Curiosities: A known sample of meteorological practitioners as they have been identified by various sources, including CMOS, ECO Canada and sources such as InfoCanada existed for the study. It should be emphasized however that there are some limitations and curiosities in this sampling frame. For example, the known sample does not estimate some persons who have been invited by third parties. Illustrations are the larger population of radio and television stations, which received a notice from the Radio News Announcers Association about the survey, and staff of MSC who were invited to participate by the National Steering Committee's MSC representative.

A.6 Survey Response Rates

Response rates by industry group are as shown below. The same industry groups noted above are shown below, where the response rate is calculated as the percentage of those actually sampled for the survey (invites, less those found not to be or not to employ meteorological practitioners). An overall response rate exceeding 30% was obtained, with details as noted below. **Reliability of estimates**: with a sample of 400 practitioners, survey estimates are statistically reliable at ±5%, 95 times in 100.

Table A.6.1
Response Rates, Employers, and Practitioners

INDUSTRY GROUP	SURVEY SAMPLE	SURVEY RESPONSES	% RESPONSE TO MARCH 7th
Meteorology business services	182	142	78
Airports, transportation	64	31	48
Broadcasting/Communications	95	50	53
Utilities	13	10	77
Education	350	59	17
Other private sectors (such as resources and manufacturing).	62	38	61
Federal Government	*277	116	42
Provincial Government	112	19	17

*Based on sample in CMOS and other lists.

A.7. Focus Groups

Focus group discussions were held in Toronto, Montreal, Vancouver, Edmonton, and Halifax. The discussions focused on validating survey findings and determining future directions on topics such as labour supply issues, the development of National Occupational Standards (NOS), and professional certification programs for Canada's meteorological sector.

The focus groups proved to be highly informative, indicating a high degree of consensus on various needs in the "meteorology profession." The discussion groups were well attended, with an average of 6-9 employers and practitioners participating in each session (this included participation from a wide range of employers and practitioners from the private sector (including weather broadcasters), MSC, and educational institutions. Generally, there was a good balance of employers and practitioners at each session, allowing for a thorough discussion of issues facing the sector. Groups provided a highly focused view, with consensus on nearly all issues addressed in the recommendations. This consensus went beyond the traditional public and private meteorological sectors and included academia and practitioners in related sectors such as broadcasting and transportation.

ANNEX B:
The Economic Significance of Weather Information

Some notes from the literature and regarding historical topics in the evolution of meteorology in Canada.

Overview: A strong economic case exists for assessing the importance of meteorology to society as much greater than its labour force size would suggest. This case hinges on a variety of considerations, including the power of accurate meteorological forecasts by professional meteorologists, and assessments by other meteorological practitioners to save lives and to save money in the operation of key industries, including transportation, agriculture, energy, and indeed virtually all sectors.

Types of Impacts: The importance attributed to meteorology is enhanced by the growing incidence of catastrophic weather events, and significant long-term changes in weather as reflected in phenomena such as El Niño and broader climate change. Broad weather impacts are noted for Canada, such as over $5 billion in Prairie agricultural losses to drought in 2001 (David Suzuki Foundation, 2005). As well, a wealth of international commentary addresses extreme weather and climate changes and its impacts in the U.S., and in the developing world.[11] Such assessments are also reflected in a widespread body of research on topics such as insurance and climate change (Schanzenbacher and Mills, 1997 and Mills et al., 2001).

The Importance of Meteorology in Canada Today: As well, the significance of these phenomena is greater for Canada, a country more influenced by weather than most. The frailty of modern human systems and technology (as illustrated by the lack of resilience in Quebec Hydro transmission systems in the great ice storm of a few years ago), makes accurate weather forecasting highly important. These changes are reflected in an increasingly complicated process for utilization of meteorological information (Changnon, 1999 and Changnon et al., 2003; Paull, 2002; Doswell and Brooks).

General Population Impacts: Economic impacts of meteorology on households and individuals have been noted to be substantial (Stratus, 2002). A considerable amount of literature supports these conclusions.

These points assign an importance to improving the quality of meteorological training in general (in the private as well as the public sector), which has stark importance to Canada today.

11 See, for example, Mills (2004), who addresses these issue mainly from an insurance perspective, estimating over 300 million individuals killed or injured annually by weather events, and related world-wide costs of over $1 trillion over the past 20 years. Similarly, WMO (2002) notes specific U.S. losses equalling 15% of GDP, with the greatest losses in construction, agriculture, and recreation.

Need for Improved Research Models: As well, an extensive body of literature points to the need to develop more sophisticated economic models to fully assess the economic impacts of meteorology, and to allow improved results-based decision-making, for example on how best to invest in improving meteorological systems (Freebairn and Zillman, 2002, Doswell et al.). More basic research appears to be needed. For example, the researchers were unable to find significant research in Canada on how businesses use weather forecasts to improve business decision-making.[12]

These observations and the important but relatively thin research findings noted below, point to the importance of increased research in these areas which, without doubt, has direct Canadian implications, as well as an implications pointing to the need for more international cooperation in research in understanding the economic impacts of investments in meteorology.

Growth and Change in the Meteorological sector: As David Spiegler writes in: "A History of Private Sector Meteorology"the factors which have in the past contributed to the growth of private sector meteorology in the United States fall into four categories: economic, technological, political, and military.[13] This is reflected in our discussion, where the economic significance of meteorology is given particular significance.

Internationally, meteorological services have largely been a function of national weather services up until the past few decades where quasi-public enterprises have emerged in a number of larger countries, and where private sector meteorology has been a growing business sector.

In Canada, meteorology has developed in much the same way, with the public sector dominating the meteorological services market. This situation has persisted in spite of a number of efforts to define a role for MSC, which would better delineate the roles of private and public sector meteorology and aid the development of the private sector. These discussions regarding the roles of the public and private sector continue today, although not in a regulated way (i.e. under the auspices of a sub-sector council or similar responsibility centre which would bring all public and private parties together).

12 While a number of studies of general population assessments of weather services are conducted by MSC on a regular basis, and studies are conducted of performance factors, such as timely delivery of forecasts, no studies were noted on business or specific sectors. In contrast, Changnon (2003) notes that, over the past two decades, seven studies of agricultural businesses and their use of climate predictions were conducted in the U.S.

13 David B. Spiegler, "A History of Private Sector Meteorology," Historical Essays on Meteorology 1919-1995, Ed. James Roger Fleming, Boston: American Meteorological Society, 1996.

<u>Value of the Private Sector:</u> A 2001 CMOS study of the private meteorological sector in Canada, A Meteorological Industry Strategy for Canada, estimated the value of the private Canadian market at between $55-65 million. Approximately $13.3 million in services are provided solely by the public sector through MSC, with the private meteorological sector accounting for 21% of Canada's meteorological services market.[14] In contrast, more than half of all meteorological services in the United States are provided by the private sector.

MSC spent $66.5 million in 2001 on the development of value-added services. Yet the value of the capital stock of Canada's meteorological infrastructure continues to decline while the demand for more accurate forecasting services, both in Canada and internationally, increases.[15] To meet these demands, the role of private and public sector service providers will need to be better defined, to optimize growth in both sectors.

Proposals to foster the growth of Canada's private meteorological sector have been "on the table" since 1987 and recommend the devolution of value-added service provision to the private sector so that taxpayer dollars could be more effectively allocated within the public sector.[16]

Private sector meteorological output in Canada has grown over the past 25 years, but analysts note that continued public sector provision of value-added services poses a challenge for future growth of Canada's private meteorological sector. In the United States, public sector meteorology is concerned primarily with the maintenance of meteorological infrastructure—leaving value-added service provision almost entirely to the private sector.

<u>Determining the Value of Meteorological Services:</u> Determining an actual dollar value for meteorological services and information for taxpayers in Canada, however, remains a challenge. Part of this challenge is rooted in the division of benefits of meteorological information. Two types of benefits are generally derived from meteorological information—private and social.

Private benefits are those that primarily affect those organisations and individuals who work in the private sector. The 2001 CMOS report estimated that "Each one percent increase in the net value of the meteorological capital stock leads to a 0.5% increase in total factor productivity and a 1.18% increase in the nation's GDP."[17] As the value of meteorological capital stock (i.e., infrastructure) continues to deteriorate, so too does Canada's potential to increase

14 Canadian Meteorological and Oceanographic Society. "Appendix C: Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services," A Meteorological Industry Strategy for Canada, November 2001.
15 See: CMOS (2001) and Paull (2002).
16 Atmospheric Environment Service, Fostering Growth of Private Meteorology in Canada: AES Five Year Plan, April 1987.
17 Canadian Meteorological and Oceanographic Society. "Appendix C: Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services," A Meteorological Industry Strategy for Canada, November 2001.

the GDP through growth in productivity. It is estimated that if the meteorological capital stock had been maintained at the same level of 25 years ago, GDP would have increased by $15.02 billion per annum. Agriculture and transportation industries, which depend on meteorological information for their day-to-day activities, provide a sector-specific view of benefits, while aggregate economic modelling is more useful in determining the overall importance of weather information to Canada's economy.

Federal government investment in meteorological capital stock has declined steadily since 1976, and so have Canadian economic productivity levels. The ability of industry sectors to predict productivity losses and plan for gains is directly related to the quality of weather information available.

Similar to private benefits of meteorological information, the importance of this type of information to organizations, households, and individuals is made apparent by the willingness of Canadians to pay for weather information. The CMOS (2001) report notes that $60 million is generated annually by the sale of weather forecasts and products by private organizations in Canada. The deterioration of meteorological capital stock, however, has cost Canadians approximately $2.6 billion in social benefits since 1976.

<u>Value to Households and Businesses:</u> Another important consideration is the ability to gauge taxpayers' or businesses' willingness to pay for meteorological services and information. Both the CMOS (2001) study and a similar study conducted for the American National Weather Service (NWS), entitled Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector (2002) discuss the willingness of consumers to pay for weather information services. Currently, little Canadian data exists on the actual value of weather information to households. While the NWS study determined that, on average, each American household pays $13 per year for weather information, the study also focused on determining the amount consumers would be willing to pay for services of increased quality and accuracy. In a survey conducted for the study, "more than 86% of individuals indicate[d] that they are willing to pay at least $10 for current services and 80% value current forecasts at $32."[18] The outcome of a cost-benefit analysis conducted for the study showed that the value of improved weather information stood at approximately $16 per household in 2002.

Estimated economic benefits from the use of meteorological services in reported studies vary. Many of the estimates per individual or business are low, however, in this case, many decision-makers are often involved. As Freebairn and Zillman point out, the Anaman & Lellyett (1996) contingent valuation estimate of the average value of public weather services to Sydney, Australia households is $24 per year per household, while agricultural decision-making based

18 Jeffrey K. Lazo and Lauraine G. Chestnut, Economic Value of Current and Improved Weather Forecasts in the U.S. Household Sector, November 2002.

on weather information amounts to estimated gains of $1 per acre. As there are millions of households and acres to which these per-unit benefits apply, the economic value of weather information for larger business sectors (e.g. large construction projects, for airlines and other large businesses) report estimates in the hundreds of millions of dollars per year.

The limited Canadian literature assessing willingness to pay estimates the value of weather information using a demand-based approach.[19] An automated weather information telephone service was presented to businesses in the Greater Toronto Area. Industry sectors using weather information on a daily basis, such as "Construction, landscaping/snow-removal businesses, TV and film, recreation and sports, agriculture, hotel and catering, and institutions such as schools and hospitals,"[20] were included in the study. Findings indicate that estimated benefits of the automated telephone service range from $0.60 to $2.17 per call, for an average of $1.20 per call. Rollins and Shaykewich estimate $16.5 million in benefits on approximately 13.75 million calls per year.

Existing Research Models are Weak: As Freebairn and Zillman (2002) illustrate, there is a need to conduct more descriptive analyses of the economic value of weather services in order to determine the quantitative benefits of these services. Most reported studies on the estimated benefits of meteorological services in Australia and other countries have used prescriptive models of decision-making by individual businesses, with a heavy emphasis on agriculture. Very few prescriptive studies have incorporated market reactions. Descriptive studies have been concerned primarily with the use made of meteorological services, and only a few have provided estimates of benefits. In recent years, a number of contingent valuation surveys have been undertaken. Given that many once fully publicly-funded National Meteorological Services now impose charges for some of their services (recovering up to 40% of their total costs of operations in a few countries), and some private sector value added services have emerged, the use of market prices becomes more relevant. However, the dominance of public good properties of most meteorological infrastructure and services will require further use of descriptive, prescriptive, and contingent valuation methods.

The potential for growth within the private meteorological sector, at least in the American example outlined above, it is argued, is enormous. With approximately 105 million households in the United States using weather information on a daily basis, an increase of about $3 per household per year for improved forecasting services, would produce a substantial economic impact. In the Canadian context, it has been estimated that a transfer of responsibility for value-added service provision from the public to the private sector could increase private sector revenues from between $55-65 million per year to between $159.6-186.2 million per year—an increase that could result in significant expansion of the number of firms in the private meteorological sector.[21]

19 Kimberly Rollins and Joseph Shaykewich, "Using Willingness-to-pay to assess the economic value of weather forecasts for multiple commercial sectors," *Meteorological Applications*, 10(1), 2003.

20 Ibid.

21 Canadian Meteorological and Oceanographic Society. "Appendix C: Optimizing the Public and Private Sector Roles in the Provision of Meteorological Services," *A Meteorological Industry Strategy for Canada*, November 2001.

Uses of weather information by business: Not only does weather information play an important economic role in terms of revenue generated from the sale of value-added services, other industries, such as the insurance industry, are financially affected by weather events. Schanzenbacher and Mills (1997) report that a leading group of international insurers and reinsurers have joined together as the United Nations Environment Programme (UNEP) Insurance Industry Initiative on the Environment. Since natural disasters represent 85% of all insured losses and (according to the Reinsurance Association of America) more than 50% of the losses from natural disasters over the past 40 years have occurred since 1990, this is a timely initiative.

As the uncertainties associated with climate change exacerbate the barriers to proactive involvement by insurers and present obstacles to establishing an actuarial rate, risk management through the use of accurate meteorological information will become increasingly important in the future. It has been noted elsewhere, however, that the expansion of publicly funded insurance schemes, such as those operated by the U.S. Federal Farm Program can have a variety of effects on the value of forecast information. Crop insurance, which covers “catastrophic” weather events, for instance, “appears to decrease the value of improved climate forecasts” (Paull, 2002). Similarly, as governments roll back restrictions in certain areas (e.g. planting restrictions in agriculture), the value of weather forecasts to industrial decision-makers tends to increase.

Risk management is particularly important in variable weather climates such as Canada’s and other countries as well. These considerations accentuate the need for accurate forecast information to managers and decision-makers in primary industries (e.g. agriculture). For example, it is estimated that a “typical major drought reduces the gross value of agricultural production by about 10%, and the Gross National Product by about 1%” (Paull, 2002). In order to mitigate possible weather-associated risks, Seasonal Climate Forecasts (SCFs) have become more accurate and widely used among primary industry managers and decision-makers, although a need still exists to ensure the accuracy and accessibility of SCFs in order to promote wider usage. While SCFs are intended to benefit their users, some barriers to achieving maximum benefits have been noted. As SCFs are used to manage risks in primary industries affected by weather (e.g. agriculture), there are risks associated with the incorrect use of SCFs themselves, most of which stem from the technical format of forecasts. Increased reliance on the technology used to generate automated forecasts highlights a critical need for increased technological training, so that highly accurate interpretations of automated forecasts are ensured.

The value of using weather forecasts in business decision-making was estimated to be greater than $100,000 annually by one-third of decision-makers participating in a series of studies in the US on the usage of climate predictions (Changnon, 2004), with 50-60% estimating values between $20,000 and $100,000. However, non-use of this information is prevalent among decision-makers in weather-effected industries. As Changnon points out, non-usage of predictions tends to occur for three reasons:

1 A lack of economic decision models in many firms, which;
2 Make it difficult to evaluate outcomes from use of uncertain predictive information; and
3 The accuracy of predictions is often viewed by many as being too low.

In all, annual agricultural impacts resulting from the effects of weather average USD $10.4 billion, a value that ranks ahead of weather effects on energy use ($8.6 billion), and on other sectors of the US economy. Weather-related economic impacts and effects, as noted above, indicate a need for increased business awareness of the financial benefits of using meteorological information.

As evidenced by the broader literature on the economic and social benefits of weather information, it is apparent that the meteorological sector in Canada, as in most countries, provides a valuable service to Canadian industries and society in general. While opportunities for expansion of the Canadian meteorological sector do exist, it is important to note that barriers currently exist, particularly within the private meteorological sector, to optimizing mechanisms for the provision of weather-related service products in order to promote private sector growth.

As seen in the literature examined, risk-management in a number of industries and decision-making in industries such as the insurance industry and government can be aided by the accurate provision of meteorological information. For instance, in its report, *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, the Intergovernmental Panel on Climate Change (IPCC), indicates that climate change will become a major factor in government decision-making in the future, due to the all-encompassing impacts of weather.[22] Importantly, private sector growth will require support from the public sector, specifically in the form of infrastructure investment in meteorological capital stock. While demand for value-added meteorological information appears to be increasing, the provision of accurate information will depend on the capacity of the private sector, in terms of human resources, access to markets, and partnerships with other stakeholders, to provide this important information to all Canadians.

22 Intergovernmental Panel on Climate Change, *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Geneva, 2001.