Hydrometeorology in Canada

Keynote Address

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to CMOS Congress

May 25-29, 1981

Saskatoon

It has been an interesting experience to have been associated in one way or another with 25 years of hydrometeorology in Canada, first as a practitioner - then for 13 years associated with Inland Waters as a consumer, and now back with AES again. I do want to spend some time looking ahead, to the way in which this hybrid science can profitably develop - but perhaps I'll be forgiven for looking back a little, and commenting on some of the significant developments of the past two-and-a-half decades.

It is not surprising that hydrometeorology, or the application of meteorological knowledge to water resource problems, has been an increasingly important field in this country. Canada's water resources are the key to the economy of many regions, for a variety of reasons. In British Columbia, Manitoba and Quebec, water power provides more than 98% of the electrical energy. On the southern Prairies, irrigation,

INDUSTRIAL AND MUNICIPAL DEVELOPMENT ARE COMPETING FOR A VERY LIMITED WATER SUPPLY, WHICH ALREADY SERIOUSLY CONSTRAINS INDUSTRIAL GROWTH. THE GREAT LAKES-ST. LAWRENCE SYSTEM PROVIDES THE HYDRO-POWER, THE COOLING WATER FOR THERMAL POWER, THE WORLD'S BUSIEST WATERWAY FOR SHIPPING AND THE MUNICIPAL AND INDUSTRIAL WATER SUPPLIES FOR THE INDUSTRIAL HEART OF THE CONTINENT. IN ATLANTIC CANADA HYDRO-POWER, STREAMS FOR ANADROMOUS FISH, AND INDUSTRIAL WATER SUPPLIES ARE OF REGIONAL IMPORTANCE.

SOME ABORTIVE ATTEMPTS HAVE BEEN MADE TO ASSESS THE TOTAL ECONOMIC VALUE OF WATER RESOURCES TO CANADIANS - BUT THE MOST OBVIOUS MEASURE OF VALUE IS HOW MUCH OUR CITIZENS ARE PREPARED TO INVEST EACH YEAR IN STRUCTURES AND FACILITIES TO TRANSPORT, CONTROL, DIVERT, CLEAN AND OTHERWISE MANAGE THE WATER THAT WE USE. FOR SEVERAL DECADES NOW, CANADIANS HAVE INVESTED A SIGNIFICANT PERCENTAGE OF GROSS NATIONAL PRODUCT FROM 1 TO 2% ON WATER STRUCTURES - SEWERS, DAMS, DRAINAGE FACILITIES, TREATMENT FACILITIES, AND SO ON. IN 1980 THIS AMOUNTED TO ABOUT $4 BILLION.

AND EVERY ONE OF THESE STRUCTURES WAS DESIGNED ON THE BASIS OF ANALYSES OF HYDROMETRIC AND CLIMATIC DATA. FOR EXAMPLE, STORM SEWERS AND DRAINAGE FACILITIES FROM HIGHWAYS AND AIRPORTS, REPRESENT ANNUAL INVESTMENTS OF HUNDREDS OF MILLIONS OF DOLLARS AND ARE SIZED TO ACCOMMODATE THE FIVE-YEAR OR TEN-YEAR EXTREME EVENT OF SHORT DURATION RAINFALL, OR RAINFALL

PLUS SNOWMELT. THIRTY YEARS AGO WE HAD ONLY 50, COUNT 'EM, 50 RECORDING RAIN GAUGES IN ALL OF CANADA TO PROVIDE THE BASIC DATA FOR THESE DESIGN CRITERIA; FORTUNATELY NOW WE HAVE 630. THIS IS ONLY ONE EXAMPLE OF DESIGN BASED ON STATISTICAL ANALYSES OF METEOROLOGICAL DATA - BUT IT PERHAPS ILLUSTRATES THE ENORMOUS ECONOMIC LEVERAGE.

ANOTHER TRADITIONAL PROJECT DESIGN CONCERN OF HYDROMETEOROLOGY HAS BEEN IN THE ESTIMATION OF UPPER LIMITS TO FLOOD FLOWS IN A BASIN, BASED ON AN ANALYSIS OF THE PHYSICAL FACTORS, LARGELY METEOROLOGICAL, WHICH CREATE MAXIMUM FLOODS. THE APPLICATION OF MAXIMUM PRECIPITATION AND SNOWMELT ESTIMATES TO DESIGN OF SPILLWAYS OF LARGE DAMS WHERE THE UTMOST IN SAFETY IS REQUIRED, HAS CONTINUED TO INFLUENCE OR DETERMINE DESIGN CRITERIA FOR MAJOR PROJECTS. SUCH STUDIES HAVE BEEN USED IN SETTING DESIGN CRITERIA ON THE PEACE RIVER, THE CHURCHILL IN LABRADOR, THE HUMBER RIVER AND OTHERS IN ONTARIO, AND IN MANY OTHER LOCATIONS.

HOWEVER, CANADA'S EARLIEST DEVELOPMENTS IN HYDROMETEOROLOGY WERE NOT IN RESPONSE TO PROJECT DESIGN REQUIREMENTS, BUT TO MEET OPERATIONAL NEEDS. WHEN THE STORM SPAWNED BY HURRICANE "HAZEL" CAUSED SUCH LOSS OF LIFE (80 PEOPLE) AND PROPERTY ($24 MILLION) IN SOUTHERN ONTARIO IN 1954, THE WEATHER FORECASTS WERE PRETTY GOOD. BUT THE CONNECTION BETWEEN RECORD RAINFALLS AND FLOODING ON SOUTHERN ONTARIO STREAMS WAS NOT WELL-MADE - BECAUSE AT THAT TIME NO AGENCY AND

NO INDIVIDUAL HAD BEEN DESIGNATED TO MAKE THE CONNECTION. IT WAS FOLLOWING THIS EXPERIENCE THAT THE METEOROLOGICAL SERVICE BEGAN WORKING DIRECTLY WITH THE ONTARIO GOVERNMENT TO ESTABLISH A RIVER FORECASTING SERVICE TO CONVERT WEATHER FORECASTS INTO STREAMFLOW FORECASTS. THIS SERVICE LED TO MUCH MORE EXTENSIVE APPLICATION OF METEOROLOGICAL KNOWLEDGE TO DESIGN OF FLOOD CONTROL AND OTHER WATER PROJECTS IN ONTARIO AND SUBSEQUENTLY TO ESTABLISHMENT OF SPECIALIZED HYDROMETEOROLOGICAL SERVICES ON A NATIONAL BASIS.

BUT, OF COURSE, THE COLLECTION OF METEOROLOGICAL DATA AND USE FOR HYDROLOGICAL PURPOSES PRE-DATES THESE DEVELOPMENTS IN THE MID-50'S.

CANADA'S FIRST CONTINUOUS METEOROLOGICAL OBSERVATIONS BEGAN IN THE 1840'S WITH THE RECORDING OF TEMPERATURE AND PRECIPITATION AT SEVERAL SOUTHERN CITIES. BY THE BEGINNING OF THIS CENTURY, SUFFICIENT OBSERVING SITES AND DATA WERE AVAILABLE TO PERMIT CONSTRUCTION OF THE FIRST SPATIAL MAPS OF THESE ELEMENTS. THIS FUNDAMENTAL STEP OF INTERPOLATION AND ESTIMATION OF AREAL VALUES OF METEOROLOGICAL PARAMETERS WAS PERHAPS THE FIRST STEP IN MEETING THE NEEDS OF HYDROLOGISTS IN CANADA.

CANADA'S METEOROLOGICAL NETWORK AND CLIMATOLOGICAL DATA BASE CONTINUED TO GROW, REACHING ONE THOUSAND OBSERVING STATIONS IN THE 1940'S, AND AT THE PRESENT TIME THERE ARE MORE THAN TWO-AND-A-HALF THOUSAND OBSERVING SITES. THE DEMAND FOR MORE SPECIALIZED METEOROLOGICAL ANALYSIS FOR HYDROLOGICAL

APPLICATIONS ALSO GREW WITH CANADA'S ECONOMIC AND INDUSTRIAL DEVELOPMENT. THE CONSTRUCTION OF LARGE DAMS AND RESERVOIRS FOR HYDROELECTRIC GENERATION, IRRIGATION AND FLOOD CONTROL REQUIRED DESIGN CRITERIA WHICH PROVIDE FOR ALMOST ABSOLUTE SAFETY. THE USE OF HYDROMETRIC DATA ALONE WAS INADEQUATE, LACKING BOTH IN RECORD LENGTH AND SPATIAL COVERAGE. CLIMATIC DATA AND HYDROMETEOROLOGICAL TECHNIQUES PLAYED A MAJOR ROLE IN ESTABLISHING SUCH DESIGN CRITERIA IN CANADA.

ON THE OPERATIONAL SIDE, FLOODS HAVE BEEN AND CONTINUE TO BE A SERIOUS PROBLEM IN CANADA. BEFORE THE AVAILABILITY OF COMPUTER STREAMFLOW MODELS, TRADITIONAL HYDROMETEOROLOGICAL TECHNIQUES FOR FLOOD FORECASTING WERE BASED ON ESTABLISHING RAINFALL-RUNOFF RELATIONSHIPS AND USING ANTECEDENT PRECIPITATION AND SNOWMELT INDICES TO FORECAST THE VOLUME AND TIME DISTRIBUTION OF THE RUNOFF. THESE TECHNIQUES ARE STILL IN USE TODAY IN SMALL RIVER BASINS WHERE THEY HAVE PROVEN SUCCESSFUL AND WHERE COMPUTER MODELLING IS NOT JUSTIFIED.

WITH THE INTRODUCTION OF COMPUTER STREAMFLOW MODELS FOR FLOOD FORECASTING ON LARGER RIVER SYSTEMS, THE HYDROMETEOROLOGIST'S ROLE WAS NOT DIMINISHED. STREAMFLOW MODELS DEPEND PRIMARILY ON METEOROLOGICAL DATA TO SIMULATE AND ESTABLISH CURRENT AND ANTECEDENT HYDROLOGICAL CONDITIONS. THE FORECAST CAPABILITY OF A STREAMFLOW MODEL IS DEPENDENT TO A LARGE DEGREE ON THE ACCURACY OF OBSERVED AND FORECAST METEOROLOGICAL VARIABLES. THE HYDROMETEOROLOGIST THUS PLAYS A

VERY MAJOR ROLE IN BOTH THE CALIBRATION AND OPERATION OF A STREAMFLOW MODEL. THE PRODUCTION OF REAL-TIME STREAMFLOW FORECASTS IS PERHAPS ONE OF THE BEST EXAMPLES WHERE CLOSE COLLABORATION IS REQUIRED BETWEEN METEOROLOGISTS AND HYDROLOGISTS.

PERHAPS NOT AS WIDELY RECOGNIZED APPLICATIONS OF HYDROMETEOROLOGY, ARE IN FORECASTING AND REGULATING LEVELS OF LARGE LAKES.

IN THE GREAT LAKES, PRECIPITATION ON THE HUGE WATER SURFACES AND EVAPORATION FROM THEM ARE LARGE COMPONENTS OF THE WATER BUDGET - ESPECIALLY ON THE UPPER LAKES - SUPERIOR, HURON AND MICHIGAN. AES PIONEERED MUCH OF THE WORK LEADING TO MORE ACCURATE ESTIMATES OF THESE TWO MAJOR FACTORS. EVAPORATION IS CALCULATED AND PUBLISHED MONTHLY FROM WATER TEMPERATURE MEASUREMENTS MADE BY AIRBORNE RADIATION THERMOMETRY AND MORE RECENTLY BY SATELLITE INFRARED ESTIMATES OF SURFACE WATER TEMPERATURES.

THE ECONOMIC VALUE OF IMPROVED LAKE LEVEL FORECASTS AND PARTIAL REGULATION AT THE OUTLET OF SUPERIOR AND ONTARIO IS ENORMOUS. ESTIMATED SHORE DAMAGES IN THE HIGH WATER OF '72-73 WERE $28 MILLION ON THE CANADIAN SIDE ALONE. HYDRO-POWER PRODUCTION IN CANADA AT SAULT STE. MARIE, NIAGARA, CORNWALL AND BEAUHARNOIS ON THE ST. LAWRENCE IS NOW WORTH SOMETHING OF THE ORDER OF $1 BILLION PER YEAR. NOT ONLY ARE MONTHLY LEVEL AND FLOW FORECASTS HIGHLY IMPORTANT AND DEPENDENT ON METEOROLOGICAL

INPUT, BUT SHORT-TERM WIND SET-UP AND SEICHE FORECASTS, ESPECIALLY ON LAKE ERIE, GREATLY AFFECT THE FLOW OF THE NIAGARA AND POWER PRODUCTION THERE - AS WELL AS SHORE PROPERTY OWNERS, WHO EXPECT WARNING OF DEVASTATINGLY HIGH SEICHE ACTIVITY.

ON THE PRAIRIES, THE VARIABILITY IN TIME AND SPACE OF PRECIPITATION AND WATER RESOURCES ARE ALL TOO APPARENT. ONE YEAR AGO, THERE WAS A FOUR-MONTH-LONG DROUGHT WHICH PARCHED THE EARTH ACROSS THE FARMLANDS OF SOUTHERN MANITOBA, SASKATCHEWAN AND PARTS OF ALBERTA. THE FARMERS IN THE RED RIVER VALLEY OF MANITOBA PERHAPS SUFFERED THE MOST FROM THIS DROUGHT. THE RELIEVING RAINFALLS DID NOT OCCUR IN THAT AREA UNTIL AUGUST OF THAT YEAR. YET ONLY ONE YEAR BEFORE, IN THE SPRING OF 1979, THESE SAME FARMERS WERE BATTLING TO SAVE THEIR HOMES FROM THE RAMPANT FLOOD WATERS OF THE RED RIVER AND EXPERIENCED ONE OF THE WORST FLOODS ON RECORD.

STUDIES OF EVAPORATION AND PRECIPITATION FREQUENCIES ASSOCIATED WITH MAJOR DROUGHTS ARE ESSENTIAL TO DESIGN OF ADAPTIVE STRATEGIES - WATER STORAGE PROJECTS, OPERATION OF WATER SYSTEMS, AND AGRICULTURAL PRACTICES. SOME CLEAR DEMONSTRATION OF THE IMPORTANCE OF THESE HYDROMETEOROLOGICAL ANALYSES HAVE BEEN ACHIEVED, BUT WE NEED TO DO MUCH MORE TO ADEQUATELY SUPPORT DROUGHT-PROOFING ACTIVITIES IN THIS REGION. I'LL COME BACK TO THIS.

HYDROMETEOROLOGISTS HAVE ALSO CONTRIBUTED STRONGLY TO OUR UNDERSTANDING OF THE ROLE OF VEGETATION IN RIVER BASINS IN

INFLUENCING THE RUNOFF REGIME. STUDIES HAVE BEEN MOST IMPORTANT ON THE EAST SLOPE OF THE ROCKIES WHERE 80% OF THE WATER SUPPLY ORIGINATES FOR THE SASKATCHEWAN-NELSON RIVER SYSTEM WHICH WATERS THE PRAIRIES. WORK TO DETERMINE THE NATURAL WATER BALANCE OF THE MARMOT CREEK BASIN AND WHETHER MANIPULATION OF THE FOREST VEGETATION COULD INCREASE STREAM FLOW BEGAN IN THE MID 60's. THE WORK WAS EXPANDED BY ALBERTA AND FEDERAL AGENCIES WITH PROMISING RESULTS REPORTED IN SOME AREAS - THAT IS, INCREASES OF 30% IN RUN-OFF FROM SMALL BASINS THROUGH PARTIAL DEFORESTATION; BUT SOMEWHAT DISAPPOINTING RESULTS FROM THE MARMOT CREEK AREA. THE CONTROVERSY STILL RAGES ON THE POTENTIAL VALUE OF ATTEMPTING TO INCREASE WATER YIELDS BY VEGETATION MANIPULATION IN THIS REGION. THIS HAS BEEN A VERY HASTY REVIEW OF SOME OF THE DEVELOPMENTS AND ACHIEVEMENTS OF HYDROMETEOROLOGY IN CANADA IN THE PAST FEW DECADES. I HOPE I HAVE ALSO ESTABLISHED IN YOUR MINDS THE GREAT ECONOMIC CONTRIBUTIONS HYDROMETEOROLOGICAL ACTIVITIES MAKE IN BOTH OPERATIONS AND DESIGN.

IN ADDITION TO THE DEVELOPMENTS IN CANADA, THERE HAS BEEN GREAT PROGRESS IN <u>INTERNATIONAL</u> COOPERATION IN THIS FIELD, AND I'D LIKE TO REVIEW THIS BRIEFLY BEFORE CONSIDERING THE FUTURE OF HYDROMETEOROLOGY IN CANADA.

INTERNATIONAL COOPERATION IN HYDROLOGY AND METEOROLOGY AT THE GOVERNMENTAL LEVEL WAS COORDINATED FOR THE FIRST TIME IN 1946, WHEN THE INTERNATIONAL METEOROLOGICAL ORGANIZATION (IMO) ESTABLISHED A HYDROLOGICAL COMMISSION. THE FIRST SESSION OF

THIS COMMISSION WAS IN FACT HELD IN CANADA IN 1947 AT TORONTO. IT CALLED FOR CLOSE COLLABORATION BETWEEN METEOROLOGICAL AND HYDROLOGICAL SERVICES AND FOR BETTER REGIONAL COOPERATION IN HYDROLOGY. THE WORLD METEOROLOGICAL ORGANIZATION (WMO) SUCCEEDED IMO IN 1950, BUT IT TOOK NEARLY A DECADE TO RECOGNIZE THE GROWING IMPORTANCE OF METEOROLOGY IN SOLVING WATER RESOURCES PROBLEMS AND THE NEED FOR CLOSER COLLABORATION BETWEEN HYDROLOGISTS AND METEOROLOGISTS. THE WMO FINALLY ESTABLISHED ITS OWN COMMISSION FOR HYDROMETEOROLOGY IN 1959. OVER THE NEXT TWO DECADES, THE WORK OF THIS COMMISSION HAS EVOLVED TO COVER ALL ASPECTS OF OPERATIONAL HYDROLOGY. CANADA PARTICIPATES ACTIVELY IN WHAT HAS NOW BECOME THE COMMISSION FOR HYDROLOGY. THE CURRENT PRESIDENT OF THIS COMMISSION IS BOB CLARK, A CANADIAN HYDROLOGIST LONG ASSOCIATED WITH THE INLAND WATERS DIRECTORATE OF ENVIRONMENT CANADA, (AND CO-AUTHOR OF AN EXCELLENT TEXT BOOK ON HYDROMETEOROLOGY). OTHER CANADIAN HYDROLOGISTS AND METEORLOGISTS HAVE BEEN ACTIVE IN MANY ASPECTS OF THE COMMISSION'S WORK.

THE INTERNATIONAL HYDROLOGICAL DECADE (IHD) FROM 1965 TO 1974, PLAYED A VERY MAJOR ROLE IN BRINGING TOGETHER HYDROLOGISTS AND METEOROLOGISTS BOTH INTERNATIONALLY AND HERE IN CANADA. UNESCO AND WMO WERE THE KEY INTERNATIONAL BODIES COORDINATING ACTIVITIES IN THE IHD PROGRAM. CANADA WAS A MEMBER OF THE COORDINATING COUNCIL SET UP TO GUIDE AND COORDINATE THIS PROGRAM. OF THE THIRTY PARTICIPATING COUNTRIES IN THE

INTERNATIONAL HYDROLOGICAL DECADE, CANADA'S NATIONAL IHD PROGRAM WAS ONE OF THE LARGEST. BY THE END OF THE DECADE IN 1974, THE CANADIAN PROGRAM INCLUDED MORE THAN 300 PROJECTS UNDERTAKEN BY FEDERAL, PROVINCIAL AND UNIVERSITY AGENCIES, WITH ADDITIONAL SUPPORT FROM INDUSTRIAL AND MUNICIPAL AGENCIES. SOME OF THE BEST AND MOST FAMOUS PROJECTS WERE THOSE ON SNOWPACK AND SNOWMELT UNDERTAKEN RIGHT HERE AT THE UNIVERSITY OF SASKATCHEWAN. TOTAL FINANCIAL SUPPORT FOR ALL THESE PROJECTS AMOUNTED TO MORE THAN $42 MILLION. THIS PROGRAM HAS LEFT A LASTING AND VALUABLE LEGACY FOR WISE MANAGEMENT OF CANADIAN WATER RESOURCES. MORE THAN A THOUSAND PAPERS REPORTED ON THE RESEARCH IN THESE PROJECTS; AS WELL, WE NOW HAVE MUCH BETTER NETWORKS AND DATA BASES. POSSIBLY THE MOST IMPORTANT AND LASTING CONTRIBUTION OF IHD TO CANADA IS THE WIDESPREAD COOPERATION THAT DEVELOPED IN AND BETWEEN THE HYDROLOGICAL AND METEOROLOGICAL COMMUNITIES, STARTING WITH THE CANADIAN NATIONAL COMMITTEE FOR THE IHD WHERE SENIOR REPRESENTATIVES OF FEDERAL, PROVINCIAL AND UNIVERSITY ORGANIZATIONS WORKED IN CLOSE COOPERATION TO GUIDE THE PROGRAM. THIS COOPERATION HAS EXTENDED THROUGH THE PROVINCIAL COMMITTEES TO THE WORKERS ON INDIVIDUAL PROJECTS, SINCE NEARLY ALL PROJECTS INVOLVED SEVERAL ORGANIZATIONS.

MORE RECENT INVOLVEMENT BY CANADA IN INTERNATIONAL HYDROMETEOROLOGY INCLUDES PARTICIPATION IN A PILOT PROJECT ON THE APPLICATION OF WORLD WEATHER WATCH (WWW) ACTIVITIES TO HYDROLOGICAL FORECASTING. CANADA AND THE UNITED STATES

COOPERATED IN A JOINT STUDY. THE SAINT JOHN RIVER BASIN IN QUEBEC, MAINE AND NEW BRUNSWICK WAS CHOSEN TO BE THE PILOT PROJECT BASIN. THIS PROJECT TOOK THREE YEARS TO COMPLETE AND INVOLVED MANY ASPECTS OF APPLYING METEOROLOGICAL SERVICES TO HYDROLOGICAL FORECASTING. THE MOST SIGNIFICANT STUDIES WERE IN THE APPLICATION OF DATA COLLECTION PLATFORMS (DCP) AND THE USE OF METEOROLOGICAL SATELLITES FOR BOTH THE RETRANSMISSION OF DCP DATA AND THE PROVISION OF REAL-TIME METEOROLOGICAL DATA FIELDS TO SUPPORT HYDROLOGICAL FORECASTING. AT THE END OF THIS PROJECT IN 1979, AN INTERNATIONAL WORKSHOP WAS ORGANIZED AND HELD IN FREDERICTON WITH PARTICIPANTS FROM A NUMBER OF COUNTRIES OF NORTH AND SOUTH AMERICA AND EUROPE. THE PURPOSE OF THAT WORKSHOP WAS TWO-FOLD. THE FIRST WAS TO DISCUSS THE RESULTS OF ALL THE STUDIES UNDERTAKEN. THE SECOND, AND PERHAPS MORE IMPORTANT, WAS TO DISCUSS THE APPLICATION OF THE EXPERIENCE GAINED THROUGH THE SAINT JOHN RIVER BASIN PILOT STUDY TO OTHER RIVER BASINS IN THE WORLD. ONE RESULT OF THE SUCCESS OF THE PILOT PROJECT WAS TO ENCOURAGE SIMILAR PROJECTS IN OTHER REGIONS OF THE WORLD. SEVEN BASINS WERE SPECIFICALLY IDENTIFIED FOR THAT PURPOSE, PRINCIPALLY IN SOUTH AMERICA. A SECOND RESULT WAS A STRENGTHENING OF THE SCIENTIFIC TIES BETWEEN THE SIXTEEN AGENCIES INVOLVED IN FORECASTING FLOODS IN THE SAINT JOHN RIVER BASIN AND A CONSEQUENT IMPROVEMENT IN THE CONTINUING FLOOD FORECAST SERVICE IN THAT REGION.

I HAVE MENTIONED BRIEFLY JUST ONE OF THE MANY

INTERNATIONAL PROJECTS WHICH HAS AFFECTED HYDROMETEOROLOGY IN CANADA. CANADA ACTIVELY CONTRIBUTED TO MANY PROJECTS AND BENEFITED FROM THEM. CANADIAN HYDROLOGISTS AND METEOROLOGISTS HAVE GAINED INTERNATIONAL RECOGNITION THROUGH THEIR INVOLVEMENT IN THESE ACTIVITIES AND HAVE BECOME SOUGHT-AFTER AS LEADING EXPERTS BY THE INTERNATIONAL COMMUNITY.

CURRENT AND FUTURE CONCERNS OF HYDROMETEOROLOGY

LET ME NOW TURN TO THE MAIN, CURRENT AND FUTURE PRIORITIES IN THE APPLICATIONS OF METEOROLOGY TO WATER PROBLEMS. THESE ARE CLOSELY RELATED TO SOME OF THE CENTRAL CONCERNS OF THE COUNTRY.

MOST OF THESE CONCERNS ARE VERY CLOSELY TIED TO ENERGY REQUIREMENTS AND ENVIRONMENTAL OBJECTIVES. INCREASINGLY CONCENTRATED POPULATIONS AND INDUSTRIAL DEVELOPMENT HAVE CREATED GREATER DEMANDS ON OUR ENERGY, WATER AND OTHER RELATED RESOURCES. THE INCREASED CONSUMPTION AND EXPLOITATION OF THESE RESOURCES HAVE AFFECTED THE QUANTITY AND QUALITY OF WATERS THROUGH THE ENTIRE HYDROLOGICAL CYCLE. THE NEED TO ASSESS THESE IMPACTS HAS CREATED PRESSING PROBLEMS WHICH PUSH SCIENCE TO THE LIMITS OF ITS KNOWLEDGE. THE IMPACT OF CLIMATE VARIABILITY; THE TRANSPORT OF AIR POLLUTANTS ACROSS PROVINCIAL AND NATIONAL BOUNDARIES; THE CONSEQUENCES OF ACID RAIN IN OUR LAKES AND STREAMS; THE DEVELOPMENT OF MASSIVE HYDROELECTRIC GENERATION SYSTEMS IN REMOTE AREAS. THESE ARE SOME OF OUR NEWER CONCERNS.

THEY ARE JOSTLING FOR ATTENTION AND SUPPORT WITH IMPORTANT NEW APPLICATIONS OF MORE TRADITIONAL STUDIES - FLOODS AND DROUGHTS, AND WITH NEW WAYS OF MEASURING HYDROMETEOROLOGICAL PARAMETERS.

THERE ARE SEVEN MAJOR MATTERS REQUIRING GREATER ATTENTION. FIRSTLY, THE PROBLEM OF FLOODS IS STILL VERY MUCH WITH US TODAY. FLOOD DAMAGES IN CANADA STILL EXCEED $100 MILLION EACH YEAR ON THE AVERAGE. THE MOST COMPREHENSIVE PLAN EVER ATTEMPTED IN CANADA TO ALLEVIATE THESE DAMAGES IS THE FLOOD DAMAGE REDUCTION PROGRAM. IT WAS INITIATED BY THE INLAND WATERS DIRECTORATE OF ENVIRONMENT CANADA IN 1975 WITH THE SUPPORT OF OTHER FEDERAL AGENCIES OF THE CABINET. THIS PROGRAM, BEING IMPLEMENTED BY SEPARATE FEDERAL/PROVINCIAL AGREEMENTS WITH EIGHT PROVINCES AND TERRITORIES, HAS AS ITS BASIC APPROACH, THE DELINEATION AND MAPPING OF FLOOD PLAINS BASED ON THE ESTIMATED 100 YEAR FLOOD, ESPECIALLY IN AND ADJACENT TO LARGE URBAN CENTRES. ONCE FLOOD PLAINS ARE DESIGNATED, EACH LEVEL OF GOVERNMENT COMMITS ITSELF TO DISCOURAGE OR PREVENT BUILDING AND FURTHER DEVELOPMENT IN THE FLOOD PLAINS. THIS IS DESIGNED TO PREVENT CONTINUING INCREASES IN THE AMOUNT OF PROPERTY AND LIVES AT RISK. THE PROGRAM ALSO PROVIDES FOR UNDERTAKING VARIOUS REMEDIAL MEASURES FOR <u>EXISTING</u> FLOOD-PRONE AREAS.

ONE OF THESE MEASURES FOR THE REDUCTION OF FLOOD DAMAGE IS THROUGH SUB-AGREEMENTS ON FLOOD FORECASTING, WHICH INVOLVES THE DEVELOPMENT AND IMPROVEMENT OF OPERATIONAL TECHNIQUES AND THE BETTER USE OF METEOROLOGICAL THEORY,

OBSERVATIONS AND FORECASTS. AES STAFF HAVE BEEN ACTIVE IN SUCH SUB-AGREEMENTS. THERE IS ALSO GREATER SCOPE FOR HYDROMETEOROLOGICAL INVOLVEMENT IN DEFINING THE MAGNITUDE OF THE 100-YEAR FLOOD IN MANY RIVER SYSTEMS, AND THUS AIDING IN DELINEATION OF FLOOD PLAINS.

LAST YEAR'S DROUGHT HERE IN THE PRAIRIES IS A HARSH REMINDER OF OUR VULNERABILITY TO CLIMATIC EXTREMES. IT HAS BEEN ESTIMATED THAT THIS DROUGHT COST THE ECONOMY OF THE PRAIRIE PROVINCES SOME $2 BILLION. IT IS IMPERATIVE THAT WE CONTINUE TO SEEK WAYS OF REDUCING LOSSES DUE TO FUTURE DROUGHTS. THE DEPARTMENT OF ENVIRONMENT (DOE) INITIATED A SPECIAL PROGRAM IN 1979 TO INVESTIGATE DROUGHTS IN CANADA. THE ATMOSPHERIC ENVIRONMENT SERVICE PARTICIPANTS IN THE PROGRAM ARE CURRENTLY INVESTIGATING THE NATURE, CAUSES, EFFECTS AND PREDICTABILITY OF DROUGHTS WITH INITIAL EFFORTS BEING DIRECTED TO OBJECTIVELY DEFINING AND SPECIFYING THE TIME AND SPACE ASPECTS OF HISTORICAL DROUGHTS ON THE CANADIAN PRAIRIES. SOME OF THIS WORK IS BEING DONE IN COLLABORATION WITH THE INLAND WATERS DIRECTORATE AND WITH THE PRAIRIE FARM REHABILITATION ADMINISTRATION (PFRA). PFRA AND IWD ADMINISTER WATER SUB-AGREEMENTS WITH THE PROVINCES OF MANITOBA AND SASKATCHEWAN AND HAVE THE RESPONSIBILITY FOR DEVELOPING DROUGHT-PROOFING STRATEGIES. THROUGH A PFRA-SPONSORED DROUGHT ADVISORY COMMITTEE, DETAILS OF THE WORK OF THE AGENCIES CONCERNED WITH DROUGHT ARE BEING EXCHANGED AND AREAS OF MUTUAL ASSISTANCE ARE IDENTIFIED.

I AM GLAD TO NOTE THAT THERE IS A SESSION ON DROUGHT AT THIS CONGRESS AND I LOOK FORWARD TO HEARING OF RECENT DEVELOPMENTS IN THIS VERY IMPORTANT TOPIC.

THIRDLY, ON THE ENERGY FRONT, THE DEVELOPMENT OF HYDROELECTRIC POWER CONTINUES TO BE A HIGH PRIORITY IN MANY REGIONS OF CANADA. ALTHOUGH THE PROPORTIONAL CONTRIBUTION OF HYDROELECTRICITY TO THE NATIONAL ELECTRICITY SUPPLY HAS DECLINED SINCE 1950, HYDRO CAPACITY CONTINUES TO INCREASE IN CANADA AND AND IT REMAINS A MAJOR SOURCE OF ENERGY. IN 1980, SIXTY-EIGHT PERCENT OF TOTAL ELECTRICAL GENERATION IN CANADA WAS PRODUCED FROM WATER POWER. THE REPLACEMENT VALUE FOR THIS HYDROELECTRIC POWER, USING THERMAL PLANTS, WOULD BE $5.4 BILLION/YEAR USING THE CURRENT DOMESTIC PRICE FOR OIL, OR $11.7 BILLION DOLLARS USING THE WORLD PRICE. THE ECONOMIC IMPORTANCE OF HYDROELECTRIC POWER TO CANADA AND THE PRESSURE FOR MORE DEVELOPMENTS ARE OBVIOUS. HOWEVER, IN NEARLY ALL CASES, POTENTIAL DEVELOPMENT SITES LIE IN FAIRLY REMOTE REGIONS WHERE METEOROLOGICAL AND HYDROLOGICAL DATA FOR DESIGN AND ENVIRONMENTAL ASSESSMENT ARE SCARCE. THE PRESSURE BEING APPLIED TO COMPLETE THE NECESSARY STUDIES TO PERMIT DEVELOPMENT OF SUCH SITES IS ALMOST AS GREAT AS THE INNOVATION AND SKILL NEEDED TO ESTIMATE THE DESIGN HYDROMETEOROLOGICAL PARAMETERS - AS THOSE OF YOU INVOLVED IN THIS WORK WILL AGREE.

RECENTLY, THERE HAS BEEN AN INCREASING INTEREST IN SMALL-SCALE AND LOW-HEAD HYDRO SITES. SUCH DEVELOPMENTS ARE

ENVIRONMENTALLY VERY ATTRACTIVE, BUT THE SELECTION AND DESIGN OF THESE SITES TO ENSURE THAT THEY ARE ECONOMICALLY VIABLE, ALSO REQUIRE VERY ACCURATE HYDROMETRIC AND METEOROLOGICAL DATA AND ANALYSES, OFTEN FOR SMALL STREAMS FOR WHICH LITTLE OR NO HYDROMETRIC DATA ARE AVAILABLE.

A FINAL HYDROMET CONCERN RELATED TO ENERGY IS THE URGENT NEED TO PROVIDE BETTER ESTIMATES OF WAVE HEIGHTS AND FORCES, ICE FORCES AND ICE SPRAY ON OFF-SHORE DRILLING PLATFORMS.

A FOURTH AREA OF MAJOR CONCERN IS WATER POLLUTION ADJACENT TO URBAN AREAS ARISING FROM COMBINED STORM AND SANITARY SEWER SYSTEMS, ESPECIALLY IN OUR OLDER CITIES. IN SUCH SYSTEMS, RUNOFF FROM RAINFALL AND SNOWMELT IS CARRIED IN THE SAME SEWERS WITH WASTE WATER FROM RESIDENTIAL AND INDUSTRIAL WATER USERS. IN TIMES OF HEAVY RAINFALL AND SNOWMELT, OVERFLOW INTO THE SANITARY SEWERS OCCURS AND THIS OVERFLOW DISCHARGES RAW WASTES DIRECTLY INTO A RIVER OR LAKE WITHOUT TREATMENT. THE STORM WATER ITSELF MAY BE HEAVILY POLLUTED FROM MATERIAL ACCUMULATED ON STREET SURFACES, FROM PESTICIDES AND FERTILIZERS, AND FROM ATMOSPHERIC FALLOUT. THE NEED FOR BOTH A REDUCTION OF COSTS OF STORM WATER CONTROL AND FOR A REDUCTION OF POLLUTION DUE TO STORM WATER OVERFLOWS, AND FROM THE STORM WATER ITSELF, HAS LED TO THE DEVELOPMENT OF SOPHISTICATED TECHNIQUES FOR THE MODELLING AND DESIGN OF URBAN STORM WATER MANAGEMENT SYSTEMS, BASED ON RAINFALL INTENSITY DATA. THESE SYSTEMS HAVE EITHER A BUILT-IN

STORAGE CAPACITY OR MAKE USE OF IN-SEWER STORAGE CAPACITY TO PERMIT REGULATION OF FLOWS IN THE SEWERS, THUS ALLOWING DOWNSTREAM COLLECTOR SEWERS TO BE OF MODEST SIZE AND COST. THE OPTIMUM DESIGN AND OPERATION OF SUCH A SYSTEM REQUIRES A CONTINUOUS PROGRAM FOR SIMULTANEOUS MEASUREMENTS OF RAINFALL AND SEWER FLOWS AND TIMELY FORECAST OF THE MOTION OF "CELLS" OF HEAVY RAIN ACROSS THE CITY. THESE METEOROLOGICAL REQUIREMENTS ARE FOR PRECIPITATION OBSERVATIONS AND FORECASTS WITH SPATIAL DIMENSIONS IN THE ORDER OF SEVERAL KILOMETRES AND A TIME SCALE IN MINUTES. THESE ARE AN ORDER OF MAGNITUDE FINER THAN THAT OFFERED BY CONVENTIONAL NETWORKS. FURTHER DEVELOPMENT OF THESE URBAN STORM WATER MANAGEMENT SYSTEMS WILL UNDOUBTEDLY REQUIRE BETTER QUANTITATIVE RADAR PRECIPITATION MEASUREMENTS FOR EFFECTIVE DESIGN AND OPERATION.

A FIFTH MAJOR CONCERN IS THE CONTINUED PRESSURE TO IMPROVE THE HYDROMETEOROLOGICAL DATA BASE, ESPECIALLY AREAL ESTIMATES FOR RIVER BASINS OF PRECIPITATION, SNOW COVER AND EVAPORATION, AND PARTICULARLY IN NORTHERN AND ALPINE AREAS. MORE RESEARCH IS NEEDED TO DEVELOP COST-EFFECTIVE DATA COLLECTION SYSTEMS SUITABLE FOR USE IN THESE REMOTE REGIONS. RIGHT NOW, MOST AGENCIES LOOK TO THE USE OF DATA COLLECTION PLATFORMS, (DCP'S) WITH SATELLITE RELAY OF DATA, TO HELP SOLVE THE PROBLEM. HOWEVER, THE VARIETY OF PLATFORMS, MULTITUDE OF SENSORS FOR MEASURING SOME CLIMATIC ELEMENTS AND LACK OF SUITABLE SENSORS FOR OTHER ELEMENTS, LEADS TO THE URGENT NEED

FOR CLOSE COOPERATION BETWEEN ALL AGENCIES IN DEVELOPING COMPATIBLE PLATFORMS AND SENSORS. CONTINUED RESEARCH AND DEVELOPMENT IS NEEDED ON SENSORS AND PLATFORMS SUITABLE FOR USE AT CANADIAN STATIONS FOR MEASURING METEOROLOGICAL, HYDROLOGICAL, PRECIPITATION QUALITY AND WATER QUALITY ELEMENTS.

BETTER AREAL ESTIMATES CAN ONLY BE ACHIEVED THROUGH THE DEVELOPMENT OF MORE EFFECTIVE TECHNIQUES TO INTEGRATE RADAR, SATELLITE AND AIRCRAFT OBSERVATIONS WITH TRADITIONAL GROUND-BASED MEASUREMENTS FOR DIRECT USE IN HYDROLOGICAL APPLICATIONS. SOME PROMISING DEVELOPMENTS ARE APPEARING. FOR MAPPING THE AREAL EXTENT OF SNOW COVER, THE ATMOSPHERIC ENVIRONMENT SERVICE HAS DEVELOPED TECHNIQUES TO USE DIGITAL METEOROLOGICAL SATELLITE DATA FROM THE TIROS AND NOAA/6 SATELLITES TO PRODUCE MAPS IN NEAR REAL-TIME FOR THE SAINT JOHN RIVER BASIN AND ITS 53 SUB-BASINS. THESE ARE USED IN SUPPORT OF FLOOD FORECASTING AND RIVER FLOW MANAGEMENT. EXTENSION OF THESE TECHNIQUES TO OTHER REGIONS OF CANADA, SUCH AS THE PRAIRIES AND MOUNTAINS WHERE SNOW COVER REGIMES ARE QUITE DIFFERENT, STILL REMAINS TO BE ATTEMPTED.

ACQUISITION OF EQUIPMENT IS UNDER WAY TO IMPROVE THE WEATHER RADAR NETWORK ACROSS CANADA. SIX NEW LOCATIONS ARE PLANNED BY AES. ALTHOUGH THE NETWORK IS DESIGNED PRIMARILY TO IMPROVE OUR CAPABILITY TO ISSUE RELIABLE SEVERE STORM WARNINGS, THERE ARE OBVIOUS SPIN-OFF BENEFITS IN PRECIPITATION DETECTION AND MEASUREMENT FOR THE HYDROLOGICAL COMMUNITY. THE

DETERMINATION OF AREAL RAINFALL FROM RADAR DATA AND ITS INTEGRATION WITH GOES SATELLITE DATA TO PRODUCE AREAL PRECIPITATION ESTIMATES OVER EVEN LARGER AREAS, IS A VERY EXCITING PROSPECT, ESPECIALLY FOR OPERATIONAL HYDROLOGISTS. THIS DEVELOPMENT PROJECT IS CALLED RAINSAT AND WE HAVE, WITHIN THE PAST FEW MONTHS, RECEIVED EXTRA FUNDING FOR IT, WITHIN THE CANADIAN SPACE PROGRAM.

IT IS IMPORTANT, THOUGH, TO POINT OUT THAT DEVELOPMENTS IN THIS FIELD HEAVILY INVOLVE THE PRIVATE SECTOR. FOR EXAMPLE, ONE OF THE PAPERS TO BE PRESENTED AT THIS CONGRESS DEALS WITH THE IMPLEMENTATION OF A REAL-TIME DATA ACQUISITION SYSTEM FOR CONTINUOUS STREAMFLOW SIMULATION AND FORECASTING. THIS SYSTEM USES ON-LINE DATA FROM WEATHER RADAR, DCP'S, AUTOMATIC DATA LOGGER REPORTS AND THE REGULAR AES TELETYPE DATA, AND HAS THE CAPABILITY TO RETRIEVE DATA AND PRODUCE A FORECAST RIVER HYDROGRAPH IN LESS THAN A MINUTE.

THERE REMAIN TWO MAJOR ASPECTS OF THE INTERACTION OF METEOROLOGY AND WATER PROBLEMS I WOULD LIKE TO COMMENT UPON.

THE FIRST OF THESE IS THE QUESTION OF CLIMATE VARIABILITY AND CHANGE. THE INCREASE OF ATMOSPHERIC CO_2 CONCENTRATIONS APPEARS INEXORABLE - AS MEASURED FROM LOCATIONS IN THE WEST, NORTH AND EAST OF CANADA AND ELSEWHERE. MANY OTHER CONTAMINANTS ARE ALSO ON THE INCREASE, WHICH, LIKE CO_2, WILL CHANGE THE RADIATION BALANCE OF THE EARTH'S ATMOSPHERE. THERE REMAINS SOME ARGUMENT AS TO THE SUBSEQUENT EFFECTS ON WORLD

CLIMATE AND ON THE CLIMATE AT LATITUDES OF CANADA - BUT THE MOST COMMON PREDICTION IS THAT THE CLIMATE WILL BE SIGNIFICANTLY WARMER AND DRIER IN SOUTHERN CANADA AND THROUGHOUT THE GREAT PLAINS OF THE UNITED STATES AND CANADA BY THE MID 21ST CENTURY. IF THESE PREDICTIONS ARE CLOSE TO CORRECT, AND A SEVERAL DEGREE WARMING IS EXPERIENCED IN THE NEXT 50 TO 75 YEARS - THERE COULD BE A DRASTIC REDUCTION IN WATER AVAILABILITY ON THE SOUTHERN PRAIRIES. THE PRESSURES FROM THE UNITED STATES TO GAIN ACCESS TO CANADIAN WATERS COULD BECOME VERY INTENSE.

THUS, IT IS ESSENTIAL THAT HYDROMETEOROLOGISTS AND WATER SPECIALISTS BECOME ACTIVELY INVOLVED IN THE CANADIAN CLIMATE PROGRAM TO BEGIN CONSIDERING THE IMPACT ON WATER RESOURCES OF LIKELY FUTURE CLIMATES AND TO DEVISE ADJUSTMENT STRATEGIES.

THE FINAL SUBJECT I'D LIKE TO TOUCH ON DEALS WITH THE CHEMISTRY OF THE ATMOSPHERE-WATER INTERACTION, RATHER THAN THE PHYSICS. THROUGHOUT METEOROLOGICAL CIRCLES, THERE IS A GROWING AWARENESS THAT ATMOSPHERIC CHEMISTRY IS BECOMING AS IMPORTANT AS ATMOSPHERIC PHYSICS IN ADDRESSING THE PROBLEMS OF THE DAY, CHANGES IN THE OZONE LAYER, CO_2 INCREASES, AND THE LONG-RANGE TRANSPORT OF AIRBORNE POLLUTANTS.

IT IS NOW RECOGNIZED THAT A MAJOR SOURCE OF CONTAMINANTS CAUSING DEGRADATION OF WATER QUALITY, IS THE DEPOSITION FROM THE ATMOSPHERE IN BOTH WET AND DRY FORMS. WHETHER WE CALL THIS HYDROMETEOROLOGY OR SOMETHING ELSE, THIS

MUST BE RECOGNIZED AS A VERY IMPORTANT FIELD FOR EXPANSION OF RESEARCH AND MONITORING FOR METEOROLOGISTS AND AS A MAJOR FIELD IN WHICH WATER SPECIALISTS NEED METEOROLOGICAL ASSISTANCE.

"ACID RAIN" OR ACID DEPOSITION IS BEST KNOWN IN THE MANIFESTATION OF THE LONG-RANGE TRANSPORT OF AIRBORNE POLLUTANTS AND IT IS THE TOP PRIORITY ENVIRONMENTAL PROBLEM IN EASTERN NORTH AMERICA - WITH pH OF PRECIPITATION HAVING FALLEN BELOW 4.5 OVER A WIDE REGION, AND HAVING ALREADY DECIMATED AQUATIC LIFE IN HUNDREDS OF SENSITIVE LAKES, WITH THOUSANDS MORE ON THE WAY. BUT THIS IS NOT THE ONLY PROBLEM. THE ATMOSPHERE IS NOW THE MAIN SOURCE OF LEAD, PCB'S NITROGEN AND MERCURY INPUTS TO THE GREAT LAKES. AND THIS HEAVY CONTAMINANT LOADING TO THE GREAT LAKES COMES FROM THE SAME INDUSTRIAL SOURCES THAT HAVE BROUGHT US ACIDIC RAIN, MAINLY THE US MIDWEST AND OHIO VALLEY. THERE IS LITTLE DOUBT THAT WE URGENTLY NEED AN AIR QUALITY AGREEMENT WITH THE UNITED STATES - TO PARALLEL THE BOUNDARY WATERS TREATY TO BRING TRANSBOUNDARY AIR POLLUTION UNDER SOME DEGREE OF CONTROL. EVEN TO THE OCEANS IT IS ESTIMATED THAT EIGHT TIMES AS MUCH MERCURY COMES THROUGH THE ATMOSPHERE THAN IS DISCHARGED BY THE WORLD'S RIVERS, AND AMOUNTS OF SELENIUM AND ARSENIC WHICH ARE TRANSPORTED BY THE ATMOSPHERE TO THE OCEANS ARE ABOUT EQUAL TO RIVER DISCHARGES.

SO THE TOXIC CHEMICAL BURDEN OF MANY OF THE WATER BODIES OF THE WORLD ARE STRONGLY AFFECTED BY THE ATMOSPHERIC PATHWAY. BUT OUR WORK IN THIS FIELD IS BARELY BEGINNING. WE

HAVE ONLY A HANDFUL OF LOCATIONS IN CANADA MEASURING TOXICS IN PRECIPITATION. OUR MEASUREMENT TECHNIQUES AND THEIR STANDARDIZATION ARE UNRELIABLE FOR MANY IMPORTANT SUBSTANCES, LIKE MERCURY. AND WE HAVE NO AGREED MEANS FOR MEASURING DRY DEPOSITION - WHICH MAY BE 50 PERCENT OF THE TOTAL ATMOSPHERIC DEPOSITION OF ACIDITY AND SOME TOXICS TO LAKES.

THE PROBLEM OF pH AND CONTAMINANT SHOCK ASSOCIATED WITH SPRING SNOWMELT IS ONE WHICH REQUIRES A MUCH BETTER UNDERSTANDING OF HOW CONTAMINANTS ARE INCORPORATED INTO THE SNOWPACK, CONCENTRATED AND THEN RELEASED FROM THE PACK DURING THE MELT PROCESS. A BETTER UNDERSTANDING OF BASIC SNOWMELT PROCESSES IN CONJUNCTION WITH THE FLOW OF CONTAMINANTS IS REQUIRED.

THESE SEVEN PROBLEMS ARE A FORMIDABLE LIST INDEED. BUT I AM CONFIDENT THAT WE WILL GRADUALLY SOLVE THEM. I HAVE THAT CONFIDENCE BECAUSE THE HYDROMETEOROLOGICAL COMMUNITY, AND THE METEOROLOGISTS WORKING ON THE OTHER PROBLEMS I HAVE DISCUSSED, HAVE A LONG TRADITION OF FINDING INNOVATIVE SOLUTIONS AND DOING GOOD RESEARCH. AND THEY HAVE DONE THIS IN CLOSE COLLABORATION WITH THE WATER RESOURCE COMMUNITY - SO THEY WERE CONTINUALLY DIRECTING THEIR EFFORTS TO SOLVING REAL, NOT IMAGINARY PROBLEMS. THIS FIELD OF APPLIED RESEARCH HAS AN ENVIABLE RECORD OF ACHIEVEMENT AND CONTRIBUTION TO THE WELL-BEING OF CANADIANS. EVEN THOUGH THE PROBLEMS IN THE YEARS AHEAD APPEAR TO BE FORMIDABLE, I AM CONFIDENT THE SUCCESSES WILL CONTINUE.