RESEARCH NEEDS
IN RELATION TO WATER
1975

A Symposium
held
at the
University of Regina
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WATER STUDIES INSTITUTE
Saskatoon, Canada

WSI 9

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FOREWORD

The Water Studies Institute, a voluntary organization of persons interested in water related matters has, as one of its objectives, “The organizing and sponsoring of seminars and symposia covering the broad field of water studies, including controversial issues of current interest.” The inaugural symposium, “Research Needs in Relation to Water” was held October 25, 1963.

With the developments and changes in emphasis over the past decade (plus) it was agreed by the executive that it would be appropriate to sponsor another seminar on this topic. The planning committee, adopted the panel approach to enable maximum audience participation and an interchange of ideas. Thus the speakers in the three sessions, Supply of Water, Water Quality and Environmental Impact were restricted in their presentations.

In addition to the planning Committee which included R. Y. Zacharuk, University of Regina, J. M. Whiting, Saskatchewan Research Council and D. L. MacLeod, Environment Saskatchewan substantial assistance was rendered by Alex Paul, University of Regina, and D. J. Berry, Prairie Provinces Water Board and Chairman of the Institute.

The symposium, with an audience of approximately 80, was smoothly run under the excellent guidance of the general Chairman E. F. Durrant, Environment Canada. Special acknowledgement is extended to the panelists and to the session Chairpersons, S. R. Blackwell, U. T. Hammer and M. Rever DuWors.

R. A. McDonald,
Symposium Committee Chairman
Table of Contents

Forward .................................................. i
Table of Contents ...................................... ii
Executive Committee 1975 .......................... iii
Introduction, D.J. Berry and E.F. Durrant ........ 1
Introductory Remarks, T.P. Pepper .............. 2
Supply of Water, S.R. Blackwell, Chairman ....... 6
  Role of Groundwater in Saskatchewan Development
  V. Beckie ........................................... 7
  Application of Meteorology to Water Supply Problems
  T.L. Richards ...................................... 11
Research Needs in Surface Water
  J.M. Wigham ....................................... 14
Water Quality, U.T. Hammer, Chairman .......... 18
  Water Treatment - A Status Report
  O.K.C. Mang ....................................... 19
  Research Needs in the Area of Waste Water Disposal
  F.J. Montbriand ................................... 22
Water Quality Objectives
  J.D. Weibe ........................................ 25
Environmental Impact, M.R. Du Wors, Chairman .. 29
  Environmental Impact
  A.H. Layock ....................................... 30
  Impacts of Water Management on Wildlife
  W.J.D. Stephen .................................... 33
  Impact Studies of Water Development Proposals
  J. Stabler ......................................... 39
Water Resources in Saskatchewan, G.C. Mitchell .. 44
Discussion ........................................... 48
Summary .............................................. 62

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INTRODUCTION

D. J. Berry, Executive Director PPWB and Present Chairman, WSI

The first Symposium on this topic was held in Saskatoon eleven years ago - October 25, 1963. Much has changed over the past decade and it will therefore be interesting to hear the emphasis of our panel members and to note the change in emphasis from the speakers of 1963.

The historical background of the Water Studies Institute and the Symposium will be outlined for you by a gentleman more qualified on the subject than I, Dr. T. P. Pepper, the first Chairman of the Institute. My task at this time is to introduce the General Chairman of the Symposium, Mr. Fred Durrant. Mr. Durrant obtained a Bachelor of Science degree in Engineering in 1949 from the University of Saskatchewan. He then joined the PFRA and spent the next few years on the design and construction of small dams and irrigation projects in Southern Saskatchewan and Central Alberta. In 1952 he was transferred to the Hydrology Division of the PFRA in Regina. In 1959 he became Chief of that Division and Engineering Secretary of the Prairie Provinces Water Board. In 1965 he moved to Ottawa as Chief of the Water Survey of Canada, a division of the Inland Waters Branch where he remained until he was appointed Study Director of the Saskatchewan-Nelson Basin Board on April 1, 1968. Following completion of the SNBB study at the end of 1972, Mr. Durrant was appointed Regional Director of the Western Region of the Inland Waters Directorate of the Environmental Management Service of Environment Canada, the position which he occupies today.

Ladies and Gentlemen may I now present the General Chairman of today’s Symposium, Mr. Fred Durrant.

E. F. Durrant, General Chairman

Thank you very much Jim. In the Proceeding of 1963 which I read recently, there were a lot of good suggestions for research in the water field and a lot of good research was stimulated. But there were a lot of things that weren’t followed up, and in looking at some of the abstracts for papers to be presented today you can only come to the conclusion that the problems seem to be multiplying much faster than research programs and solutions.

Now I have a very pleasant duty and that is to introduce a gentleman with whom I have had close association for many years. Dr. Tom Pepper completed his MA in physics from the University of British Columbia in 1941 and spent the next five years working on radar during the war with the National Research Council. Following that period he was with Atomic Energy of Canada Ltd. for a short time and in between found an opportunity to get his PhD at McGill. He left Atomic
Energy in 1952, and became manager of a firm manufacturing instruments, but left to join the Saskatchewan Research Council in 1958 as head of the Physics Division. Within a decade he was Assistant Director of the Research Council and in 1972 was appointed Director. He is a member of a number of Professional organizations and the author of a great many papers. In addition, he is a very nice person to know and an interesting person to listen to. It’s my pleasure to introduce Dr. Tom Pepper.

Dr. T. P. Pepper, Director, Saskatchewan Research Council

Mr. Chairman, Ladies and Gentlemen, as I was brushing up on this talk last night in my room, I looked through some of the literature provided by the hotel and found a definition of numbskull. Numbskull is what you get when you hit a problem head on. Numbskull or not, that is what I intend to do today in giving a short account of the history of the Water Studies Institute, a few items of change, and a few water facts which I feel have remained unchanged in the 10 years since we held our first Symposium on Research Needs in Relation to Water.

To begin, here are a few items of historic fact. I am a dilatory diary keeper, and recorded that it was at a coffee break at the Saskatchewan Research Council in our conference room on February 7, 1963, when Hank Wolbeer made the original suggestion for an organization to bring together people interested in water research. I take antistresful delight in mentioning that the idea came during a coffee break conversation and not as the result of a planning committee or a feasibility study. Then on March 14 of the same year about 5 weeks later, in the same conference room, (and speaking of changes, that conference room has been liberated long since to become an office of the Saskatchewan Research Council in our crying need for more space) I convened a meeting of interested people on Campus to see whether we could take this idea of Hank’s one step further. Some 40 people attended and out of that organizing committee was struck to see what concrete form this suggestion could take. The organizing committee was chaired by Tom Nind, then a member of the University staff. Again to mention another item of change, Tom has long since left us in Saskatchewan and for many years has been the President of Trent University at Peterborough, Ontario. Tom and his committee, (and again to mention a change, I believe not a single member of his committee consisting of John Maybank, Clarence Forsberg, Jim Murray and Lloyd Sonmor is here) brought in the organization of the Water Studies Institute and, as our Chairman has said, our first Symposium was held on October 25, 1963. Since that time there have been some 51 people involved in the executive committee, and the Institute has put on a number of Symposia and published a number of proceedings. Actually 5 proceedings have been published up to today’s Symposium, which I gather will also be published. And here we have another change; all of the five Symposia that resulted in publications were held on the Campus of the University of Saskatchewan, for although we’ve had meetings here, the published proceedings of todays Symposium will be the first from the new University in Regina. And here is a major change. The University of Regina didn’t exist 10 years ago. In fact, I expect very little research was conducted in Regina 10 years ago, so here is a very significant change. And one final historical point. I believe that of the original performers at the first Symposium there is only one man who is performing today and that is our General Chairman, General Durrant! He is the only man who has survived the 10 years. Now I think, as far as the history is concerned, that pretty well looks after the points I wanted to mention with one exception. The Terms of Reference of the Water Studies Institute have expanded during the past 10 years and new activities have been added; in particular the implementation of the annual survey of research and research workers in Saskatchewan and the survey of government needs for research.

Now, I wish to consider a few water facts which have NOT changed during the past 10 years. I will mention a half dozen of them to give a picture of the hydrologic cycle. There is no change in the fact that the inflow of water to the province through the main gauged streams runs roughly in the order of 500 billion cubic feet a year or some 12 million acre-feet a year. Let us deal in ratios for the moment and say that this inflow of water is one unit. The outflow of water has remained nominally unchanged and is about 2½ times the inflow. The difference, of course, is being supplied by the downflow from the atmosphere in the form of precipitation, a contribution which has added about 1½ times the inflow. But the downflow of the precipitation in round figures is about 20 times the inflow of the surface water. The downflow in the form of precipitation comes from the water in the atmosphere. The crossflow of atmospheric water is about 70 times the inflow in the gauged streams. So we have a picture of 70 units millying around and crossing aloft, about ¼ of that coming down, and that ¼ being some 20 times the surface inflow. Now, of course, most of that which comes down goes back up again by way of evaporation or evapotranspiration. Some of it however gets into the ground and becomes groundwater. The actual useful contribution of groundwater is about ½ of the surface inflow and so we see that the usable part of the upward movement of the groundwater is about 1/5 the surface inflow. (As a statistical aside I’d like to point out that the amount of water in the atmosphere at any instant is about ½ the total annual inflow).

Now back to groundwater for just one further statistic. The amount of water in the ground represents by all accounts the greatest accumulation of water in the province. It is like a sleeping giant that so far is tapped to only a small degree.

So in summary we have an approximate picture of one unit coming in as surface water, 2½ units coming out, 20 units coming down and 70 units millying around aloft, and about 1/5 unit coming up to the surface from groundwater and being used.

So much for the unchangeable statistics. What are some of the changes that we have experienced in the last 10 years? I will mention a half dozen of these briefly. One change which is just beginning but which I think will be much more markedly felt during the next decade will be the employment of remote sensing for hydrologic studies of snow accumulation, snow melt, and the study of the dynamics of surface water. Another change, and to get a small plug in for my own organization, is the increased ability to purify the saline and brackish groundwater in some of our surface lakes by freeze desalinating. This change, which has occurred during the past 10 years, promises to be very useful for the
employment of our vast amounts of saline and brackish water. I think another change is the increased awareness and appreciation of what subsurface water can do for us in Saskatchewan and how we may be able to employ it to solve some of our water problems.

I should now mention a subtle but significant change. The phenomena I refer to hasn’t changed. It is the appreciation of the phenomena and response to it that has changed. I refer to the significantly different time scales associated with the different aspects of the hydrologic cycle. To be specific, atmospheric water moves quickly. The length of time that the atmospheric water takes to move into the province and in particular the length of time it takes to drop from the clouds on to us is measured in a matter of minutes, or perhaps hours. This is a short time span. Water on the ground and the flow of rivers across the province is measured in days or perhaps up to a month. So we have another time span when considering the surface water. When we go below the surface to the subsurface waters, the time span for the movement of groundwater, and the effects of this movement, is measured in years or in decades. There is an increased appreciation of the complexity of the hydrologic cycle, not only of the multiple intermingleings of the atmospheric, the surface and the subsurface aspects, but also of the fact that these three different aspects have very distinctly different time spans. We have something like three interacting mobiles, a very fast moving mobile, a slower moving mobile, and finally a slowly moving mobile. All are interconnected to make a fascinating spectacle.

I had better get on quickly to two mega-changes which form really a secondary theme to my comments on change. One is the fact that, during the last decade, we have become much more aware of the fact that, to paraphrase a well known quotation, “water is indivisible”. We realize more than ever before that we cannot deal effectively with any one aspect of the water cycle in isolation. Water is a unity. The second mega-change that has occurred during the last 30 years is the acceptance of the fact that our environment is of prime importance to our lives. We have therefore broadened our horizons from thinking only of the one aspect, ie: water, to treating the environment as a whole. Evidence of this is the fact that 10 years ago we had no organization in Saskatchewan dealing primarily with water. We first saw the creation of the Saskatchewan Water Resources Commission. We then saw the creation of the Saskatchewan Department of the Environment. Other provinces and the Federal Government have similarly established Departments of the Environment during the past decade. We have therefore raised our sights and broadened our horizons to thinking of the environment as a whole and to accepting the fact that the environment itself is also indivisible. I think, however, that water remains very much a core aspect of this enlarged picture of the environment. This is because water is not only significantly affected by our environment but in turn significantly affects our environment. The environmental fact that we have an immature topography, due to our recent glaciation, is responsible for the “water” fact that in Saskatchewan 80% of our drainage basins are confined. The quality of our water too is a consequence of our glacial environment, because if the glaciers hadn’t left materials that had a lot of salts in them, we wouldn’t have had the salty groundwater that is so general in our province. The other side of the coin is the fact that our groundwater and surface water runoff produces saline lakes such as Lake Chaplin which is mined for its sodium sulphate. Thus, water is not only a creature of, but a creator of the environment. I think it is significant that water is still very much a focal point in our enlarged view of the total environment.

Now I had intended to end with a couple of quotations. I will omit one of them in the interest of keeping on schedule and because I know our Chairman is a poet in his own right having provided us with some poetry at the first Symposium. I will read a short poem, produced, thank God, not by myself but by Kenneth Boulding, an Economist who has the ability to see the broad picture. He summarizes the importance of water as follows:

"Water is far from a simple commodity,  
Water’s a sociological oddity,

Water’s a pasture for science to forage in.  
Water’s a mark of our dubious origin.

Water’s a link with a distant futurity,  
Water’s a symbol of ritual purity,

Water is politics, water’s religion,  
Water is just about everyone’s pigeon.

Water is frightening, water’s enduring,  
Water’s a lot more than mere engineering,

Water is tragic, water is comical,  
Water is far from the Pure Economical.

So studies of water (the Water Studies Institute) though free from aridity,  
Are apt to produce a good deal of timidity.

Best wishes from the Saskatchewan Research Council and good luck with the Symposium."
SESSION NO. 1 — SUPPLY OF WATER

S. R. Blackwell, Chairman*

Mr. Chairman, Ladies and Gentlemen, the topic for this session "Supply of Water" is very broad. Let us reflect for a few minutes on what it may include. When you think of water supply you will probably think first of its occurrence in lakes and streams and as groundwater. You may also think of its abundance or lack of supply, hence floods or droughts. You may then relate supply in terms of use and of course they include household and municipal uses, irrigation, industrial use, water-based recreation, fish and wildlife, dilution and hydro power generation. We must also think of supply in terms of the water cycle, in terms of monitoring, in terms of gauging networks, instrumentation, streamflow forecasting, making best use of the supply of water, conservation measures, reduction in evaporation losses, reduction in demands and more efficient use, artificially induced precipitation and watershed management. This raises questions about the techniques used to assess and manage our water supply and the inadequacies of the procedures currently followed in such water related sciences as hydrology, limnology, meteorology, glaciology, and so on.

These introductory remarks are not intended to be all inclusive as far as this broad topic of water supply is concerned. My aim has been to get you, the audience, to focus on the topic of this session so that you may react to the presentations by the panelists and be prepared to participate in the discussion period after the presentations have been made.

Role of Groundwater in Saskatchewan Development

V. Beckie *

I am pleased to have this opportunity to participate on the panel on water supply and groundwater in particular. During the past 16 years, briefly as a civil servant and now as a consultant, I have been associated with the development of over 100 municipal and industrial groundwater supplies across Saskatchewan, Alberta and Manitoba. With this background I have an appreciation of the problems encountered in developing groundwater supplies and also have an interest in seeing that groundwater is maintained and utilized as the valuable resource it is.

At the present time about 90% of Saskatchewan's communities with populations of up to 4,000 are dependent on groundwater supplies. These communities along with most rural dwellers make up about 50% of Saskatchewan's approximately 926,000 people who depend on groundwater for a water supply. Two of our eleven cities, Yorkton and Lloydminster, use groundwater as their main source of supply. Other cities such as Regina, Melville, North Battleford and Weyburn use groundwater intermittently or for peripheral industries. Regina used groundwater as the only source of water supply from the early 1900's when Boggy Creek was first developed until 1955 when the Buffalo Pound Lake water supply was put into service. Even at present an estimated average of 8 MGD of groundwater is used mainly by industries, but Regina also uses groundwater for supplying peak demands. Presently the Regina well capacity is in the order of 12 MGD for short pumping periods.

On a provincial basis, rough estimates indicate that present groundwater use is at least 55 MGD and surface water use averages 370 MGD, so that roughly 13% of all water used in Saskatchewan comes from groundwater. When we consider that industries and irrigation account for about 70% of total water use, one has a much better perspective of groundwater's role in municipal supplies.

Availability and Cost of Water for Expansion

I am not aware of any estimates of the amount of unappropriated surface water available for development in Saskatchewan. However, one might generalize that in the area south of the South Saskatchewan River, surface streams are almost fully utilized, and along some streams water is available only for domestic supplies. In the area north of Prince Albert National Park — where population is sparse — water is generally considered quite plentiful but communities south of the Park presently without adequate water supplies find they are hard pressed to finance the cost of developing a surface water supply even if water is available. The result is that for many communities it is either groundwater or no water system. We are constantly plagued with the problem of abundant groundwater where there is little requirement for it. However, it is estimated that in the order

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of 8% of Saskatchewan's groundwater resource, with a quality of 2500 parts per million Total Dissolved Solids or better, is presently developed.

It is difficult to evaluate the cost benefits of groundwater versus surface water, but they are quite substantial if a large enough supply of good quality groundwater can be found. Bob Peters, the President of the National Water Well Association, said to late December 1974 that development costs of surface water are 13c per thousand gallons, whereas groundwater is 5c per thousand gallons. Demineralization costs run at $1.00 per thousand gallons with some prospects that they may reach as low as 30c per thousand gallons.

Need for Records on Producing Aquifers

Now that we have established the importance of groundwater in Saskatchewan it seems logical that we should know something of its availability for future development and expansion. In the developed part of Saskatchewan the larger rivers and streams have had up to 60 years of flow measurements taken on them, so cover several low and high flow periods. Other smaller rivers and streams have had from 20 to 30 years of recorded flows. A groundwater observation well program was started in 1964, so up to 10 years of natural water level fluctuations are available from several of the present 31 observation wells in the Province. The aquifers monitored generally have little development. Observation wells are out of the influence of pumping wells and provide background data on natural water level fluctuations rather than the influence of production from the aquifers. There are few detailed records on producing aquifers — an aquifer at Weyburn is one of the few adequately instrumented producing aquifers that I am aware of. Other centers have intermittently observed and recorded water levels in aquifers they use but the observation wells are usually so close to the pump wells that unless continuous records are taken they are very difficult to interpret. Consequently, we have few records from which to determine if producing aquifers have additional water available for expansion or are being produced at or near capacity.

Meaningful yield estimates or estimates of the productive capability of an aquifer require accurate records of natural and production influenced water level fluctuations, and records of water production. In some centers where professional guidance was not employed geologic and stratigraphic information must be obtained by exploration and pump testing programs before water level records will be meaningful. Limited geologic control resulting in poor well locations and spacings has caused local over-production of many aquifers.

Information on production characteristics of aquifers is vital in evaluating expansion potential but since it is collected for a future need 5 or more years down the road, it has not received the attention necessary. The Saskatchewan Research Council reports that water levels are at their maximum recorded position after the 1974 runoff. Programs of careful monitoring, with continuous water level recording in wells at carefully selected sites, should be started immediately to provide adequate information for the future as water levels begin to decline.

Need for Recharge Coefficient of Aquifers

Most aquifer yield calculations are based on recharge coefficients “borrowed” from what appear to be “similar” hydrogeologic environments out of the Province. Variations in climate, geologic history, and sediments in other areas make use of coefficients from other areas hazardous. Stratigraphic variations in many aquifers are such that local high permeability anomalies can provide most of the recharge to an aquifer so that recharge coefficients of individual aquifers should be evaluated. On the other hand, research to determine recharge rates for a number of typical Saskatchewan aquifers is essential and should be available to groundwater hydrologists at the earliest possible date.

Research into the Feasibility of Recharging Aquifers with Spring Runoff Water

Research should be started to determine the feasibility of annually recharging into and recovering fresh spring runoff water from surficial sand and gravel aquifers and deeper subtilill aquifers. Outwash plains that have large highly permeable surface areas can be recharged in this way from larger sloughs filled with fresh spring water from intermittent streams during spring runoff. In other areas damming of streams over surficial channel aquifers allows for recharge and natural filtration. Suspended solids and organic growths appear to be major obstacles to efficient recharging at present but recharging has to be compared to the cost and possibility of demineralizing saline water sources. Potentially rechargeable aquifers in water short areas might be inventoried and several areas selected for pilot projects.

Utilization of Poor Quality Water

Saskatchewan has been endowed with large supplies of marginal quality water. Research into the utilization of this water by demineralization techniques such as freezing should be continued. Disposal of the concentrated brine so that other aquifers are not contaminated should be studied. In other areas, closer definition of the groundwater flow system might indicate that deeper previously untried aquifers should be tested — experimentation with freeze demineralization of water from these deeper aquifers, such as at Frontier, should be continued. There are other locations in southern Saskatchewan where water quality in deep aquifers warrants checking by government agencies and private enterprise teams because small communities, or individuals, do not have the necessary capital to risk on experimentation.

Extent of Municipal Pollution of Aquifers

Additional research should go into investigating the incidence of municipal and government pollution of aquifers by sewage effluent, by solid waste disposal sites and by road salt storage areas. Sewage lagoons are usually located where they can discharge into the nearest stream or river, which, depending on the
dilution achieved, is a tolerable practice. However, in some areas, potentially developable aquifers have been polluted or made socially unacceptable by this practice (where extensive water softening takes place, the chloride concentration of some sewage effluents is also quite high). The program whereby the Water Pollution Control Branch has sampled a number of sewage effluents should be expanded to include all effluents from larger communities at least once a year with more frequent analysis where potential problems are indicated.

The Application of Meteorology to Water Supply Problems

T. L. Richards *

The supply of water is directly related to the meteorological elements of precipitation, evaporation and temperature as it affects snowmelt. In addition, there are also indirect relationships involving a number of other elements such as wind, humidity, solar radiation and water temperature. Because of the very close inter-relationships between the meteorological elements and the hydrological elements, the Atmospheric Environment Service is able to assist in the solution of water-oriented problems in a number of ways such as the provision of basic data, the provision of analyzed data, expertise in the application of meteorological knowledge to the solution of water-oriented problems, and expertise in meteorological research required for water-oriented problems.

The provision of basic data

The Atmospheric Environment Service has the responsibility for the design and operation of networks of sufficient density to establish a nation-wide inventory of meteorological elements. (It should be noted, however, that the density of reporting stations may not necessarily be adequate for specific hydrological operations or research). Responsibilities also include quality control functions and the archiving and regular publication of data.

Basic data are published in several formats, including in order of early availability:

Canadian Weather Review - a quickly published review of the month’s weather based on essentially unverified data collected by almost 300 major weather reporting stations.

Monthly Record - a much more detailed listing of meteorological elements based on verified data from almost 3000 observing stations across Canada.

Supplementary Precipitation Data - published twice a year to bring together all the long duration precipitation data collected in Canada.

Snow Cover Data - published annually to collect all the snow course data under one cover.

In addition to the published forms the basic data are archived and are available, at cost of copying, in the form of cards, tapes, microfilm and/or hard copy printout.

* Chief, Hydrometeorology and Marine Applications Division, Atmospheric Environment Service, Environment Canada
The provision of analyzed data

Data analyses begin with the basic 30-Year Normals published after the end of each decade. Included in this type of service are regional climatic studies and the Climatological Atlas of Canada. The new IHD Hydrological Atlas, currently in preparation, will include up-to-date meteorological material prepared by the AES.

More specific to the requirements of the hydrologist, is the Storm Rainfall of Canada Series which includes analyses in depth of all the major storms of history. Also available, but for different purposes, are the statistical analyses of short duration rainfall which are kept up-to-date for 150 stations across Canada. This material is also displayed in atlas form.

Additional analyses, based on available utility programs or specially prepared programs, may also be obtained from the AES computer component.

Expertise in the application of meteorological knowledge to the solution of water-oriented problems

Specialized meteorologists and hydrometeorologists are available to provide assistance ranging from brief consultations to massive studies necessary to establish the design criteria for major hydrologic structures. These same hydrometeorologists, who are meteorologists trained to deal with hydrologic problems, are also equipped to assist in the development of streamflow forecasting and flood warning programs, and in the application of radar to hydrometeorology.

The results of such studies are not only provided to the requesting agency, but are also usually made available to the hydrologic community in published form. Other studies, undertaken upon request, or in anticipation of the requirements of the water resource "user", are also published in the scientific literature. A list of AES Publications in Hydrometeorology and Marine Applications is available upon request. Of specific interest to the Prairie Provinces is a report series produced by the Prairie Hydrometeorological Centre, Regina.

Expertise in meteorological research required for water-oriented problems

Not infrequently the needs of the hydrologic community are such as to require new meteorological knowledge obtained through research. In this connection, AES research scientists are available to undertake the required research or to work with other scientists in cooperative undertakings. Such research ranges from a search for improved precipitation and evaporation measuring instruments to improved techniques for quantitative precipitation forecasting. Other areas recently under study include the use of remote sensing by aircraft and satellite to estimate snow cover and its water equivalent, and AES is now into the analyses of the chemical quality of precipitation as well.

Summary

In summary, the Atmospheric Environment Service is prepared to assist and work with those faced with water supply problems through the provision of basic and analyzed data and through specialists in the application of meteorological knowledge and research to the solution of water-oriented problems.

The Prairie Hydrometeorological Centre, Regina and the appropriate Scientific Support Meteorologists of the AES Western (Edmonton) and Central (Winnipeg) Regions are available for consultation and assistance. These specialists are backed by the Headquarters components dealing with basic climatological data and computer services and by national centres of expertise in hydro-meteorology and in meteorological research required for hydrological purposes. In short, there is a team of AES specialists available to assist you with the meteorological and hydrometeorological portions of your water supply problems.
RESEARCH NEEDS IN SURFACE WATER

J. M. Wigham *

Abstract

Some of the developments of the past decade in surface water hydrology are discussed briefly in terms of the impact these will have on research in the future. Research needs also are affected by external factors such as population trends, energy requirements, urbanization and food production methods.

More specific needs in surface water research are defined in terms of improving the knowledge of the physics of the basic processes. Problems more closely associated with operational requirements are also discussed as are some general needs and inter-disciplinary research requirements.

Introduction

It is apparent that surface water problems in the prairie provinces arise because of differences in the time and space distribution of demand as compared to that of supply. The result is regions of surface water deficiency on a continuous or intermittent basis and areas in which water surpluses (floods) create problems. Research needs with respect to surface water supply, in general terms, ranges over the complete gamut, therefore, from supply augmentation to flood prediction.

The methods that can be used in research projects depends to a great degree on the sophistication of procedures proposed and in use. The past decade has been characterized by the application of a variety of mathematical and other techniques involving complex differential equations, statistical data-generation, systems analysis methods, conceptual models, watershed models and operations research methods. There is a need for research into the applicability of some of the techniques for surface water problems of the Prairie region, and to ensure that future developments be examined (and modified if necessary) in like fashion.

The direction and emphasis of the research are determined by the lack of knowledge of the processes involved, and also by the relative importance of the process in the hydrologic cycle and on external factors which will modify the time and space distribution of demand in the future. External factors that might be noted include demands for energy and food production, trends in population and industrialization and urbanization.

Surface Water - Basic Processes

Detailed studies of the surface elements of the hydrologic cycle are required to provide better information on runoff volumes, rates and peak flows. The effects of changes in land use can be determined only if the processes are fully understood.

The major portion of surface water supply on the prairies results from snowmelt runoff. Some elements of this process still are not well defined and a continuation of research effort is indicated.

The volume of runoff from snow melt depends on the water equivalent of the snowpack prior to melt, the "losses" through infiltration and evaporation-sublimation and the catchment area contributing to flows. Measurements of natural radiation before and after the snow cover melts appears promising for providing an estimate of the area/water equivalent. Studies comparing results of these measurements to ones obtained from more traditional sampling are required.

Relationships between soil moisture conditions prior to formation of snow cover and subsequent runoff are needed as are contributing area-soil moisture relationships.

The time distribution of snowmelt runoff is important for flood prediction purposes on both gauged and ungauged catchments. It is affected by the rapidity of melt, snow accumulation and topographic features. Research on water movement through the snowpack and through snow filled gullies is needed to define the time lags involved and to relate these to measurable watershed characteristics.

Research presently in progress, or anticipated, using data from experimental watersheds will provide answers to many of the above problems. The development of watershed models for the Prairie Region also will proceed, and this should prove to be very useful. Companion studies are required, however, to allow application of the research to watersheds with limited data. Needs here include studies on the inter-relationships of certain meteorological variables, the applicability of linear and non-linear methods of describing runoff hydrographs, the development of conceptual models to describe snowmelt processes, and the testing and optimization of models for particular watersheds. Definition of contributing area for a given runoff event is difficult; however, some insight into the variability of contributing area may be gained through optimization studies considering area as a variable.

Surface Water - Operational

The studies required for an understanding of the basic processes are not mutually exclusive from those needed to answer operational problems. A distinction may be made, however, on the basis that operational studies are those related to supplying water for a particular demand.

As previously noted, there are regions, both rural and urban, for which surface water supplies are deficient in quantity and/or quality. The usual solution to
problems of this nature has been to develop groundwater supplies, develop surface water storage reservoirs and/or to import water from other areas. It is possible also, to:
(a) augment local supplies
(b) utilize the available water more efficiently, and
(c) reduce water demand.

Increased local supplies may be obtained by increasing the runoff as a result of decreasing infiltration and by reducing evaporation losses from surface water storages. Perhaps some studies on the use of pavings, injection of solutions to reduce infiltration or spraying to reduce plant evapo-transpiration are required. Evaporation losses from reservoirs and lakes such as Lake Diefenbaker or Last Mountain Lake are substantial if quoted in dollar terms. Research into evaporation suppression is not a new topic, however, perhaps some research on new methods is indicated. Vince Beckie has mentioned the possibility of storing surface waters in underground aquifers.

The water that is available in urban centres could be used more efficiently through re-use of water used for sewage dilution and through making use of storm runoff. The trend towards urbanization may make such use necessary and certainly indicates a need for increased research into the hydrology of urban areas. Studies of the hydrology might include consideration of methods of storage of stormwater runoff through storm sewers and the utilization of such waters for secondary or primary purposes.

Reductions in demand for water probably can be made. Probably the most effective procedure would be through changes in pricing policy. Studies of the relationship of water costs to demand may be required and should include examination of water pricing policies relative to the costs of supply.

The rising cost of fossil fuels and world shortages of food may create pressures for more rapid development of hydro power and irrigation systems. This in turn may make it less attractive to supply water for other purposes with the result that some of my previous suggestions may become economically feasible. It is likely, however, that water resource developments will be multi-purpose ones but the balance may shift toward optimizing projects for power production and/or irrigation. There is a need, therefore, for maintaining expertise in the procedures for analysis of water resource projects. Research is needed into the applicability of data-generation techniques and the development or modification of them for the prairie region. Linear and dynamic programming and network analyses methods of optimization of water resource projects also should receive attention with the emphasis on the development of less costly computation procedures.

Water resources developments will shift more and more to the north of course and as a result a continuation of studies in this region is indicated. Initial emphasis should be on data collection and development of methods for predicting long-term and seasonal yields of our northern rivers.

General Requirements

The complexities of hydrologic processes are such that an interdisciplinary approach to research is desirable, and there is a need to develop such approaches.

Research needs would include examination of inter-relationships between water quality, sediment transport and surface runoff for prairie catchments. Studies to determine sediment yield from cultivated or partially cultivated watersheds are desirable and there may be a relationship between sediment concentrations, water quality and quantities of fertilizer applied.

One of the consequences of changing land use often is a change in sediment transport quantities. Studies on the effects of drainage projects, deforestation projects and the like are required to determine changes in water and sediment yields.

Additional studies are required on the short and long-term statistics of flows, data utilization and sampling processes to assist in design of regional hydrometric networks. The requirements for meteorological data relative to future methods of analysis and relative to hydrometric network developments should be examined.
SESSION NO. 2 — WATER QUALITY

U. T. Hammer, Chairman *

As most of you know, Saskatchewan has as great a variability in water quality in natural waters as anywhere in the world. Water quality means different things to different people. An agriculturist thinks in terms of water for his livestock or water for irrigation. To an industrialist, depending on the particular industry, a particular kind of water quality is necessary so that his costs are not too high. To a limnologist the success of various kinds of organisms from algae all the way through to fish are determined by the water quality, and so on. We can consider many points of view but for most people the need for potable water for domestic use is the prime interest.

Water Treatment - A Status Report

O. K. C. Mang *

Some time ago the Federal Government announced changes in its Science Policy through the National Science Council. Under these new policies a greater share of the National Research budget is to be made available to industry to bolster a somewhat lagging industrial research programme. It would appear that this long overdue approach to continually improve the quality of industrial output will ultimately result in an economical "shot in the arm" on the highly competitive international scene. We recognize that basic research is a responsibility of the Universities and rightly so. However, there are areas in which a great amount of industrial research and development work can be done through close co-operation with Universities. By the proper co-ordination of University scientific disciplines with field conditions of technological application, a more closely controlled programme of research and development could be achieved. Very often the direction in which research should move is discovered in the field, where the action is, and where the unanswered questions in many processes arise and where special studies can be carried out before the next step of technological advancement can proceed. It would appear that by receiving a feedback from those in the field having the most experience in the latest technologies the University would be in the best position to pinpoint those areas where the urgency for specific research exists.

In the field of water and waste water treatment for example, a great deal of research is being carried out by many laboratories. This has often yielded good results and has been invaluable to many areas of industry. In the field of water treatment alone, inter-disciplinary studies could be carried out concerning the most urgent problems that face this industry which in the final analysis is really the most basic of all since it concerns water for human consumption affecting the health and safety of people.

Inter-disciplinary action becomes necessary simply because the potability of water becomes the problem of not only the engineer but of the biological and medical sciences.

It is found that field conditions raise more questions about the technologies of water and waste treatment that can be answered. At the present time we can say that, basically, water treatment has really not changed much in decades, although new chemical and physical processes have evolved for the co-agulation and filtration of impurities from the raw water.

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(Mr. Mang provided a video tape presentation on the Buffalo Pound Lake Plant prior to this address.)

* Head of Biology Department - University of Saskatchewan
Water treatment generally becomes more difficult as natural run-off carries more pollutants from herbicides, insecticides, livestock and human waste. At the present time much work is being done to determine the extent to which pollutants prevail in the raw water supplies and how we might better control their inflow. The fact remains that we know these conditions already exist in the raw water which we have to treat but our responsibility is to remove them in treatment if the public is to be protected from a health standpoint.

Briefly the presently applied technologies offer the following:

1. Chemical treatment involving co-agulation and settlement and disinfection.
2. Physical treatment such as filtration either through sand or activated carbon.
3. Electrodialysis - a physical-chemical separation of impurities by electrolysis across a membrane.
4. Reverse Osmosis - a physical treatment by membrane filtration.
5. Chemical oxidation of organic compounds by use of chlorine, potassium permanganate or ozone.

Most of the above methods can be used separately or in combination or in various sequences.

The treatment of surface water thus becomes a problem of removing the organic wastes which contaminate it. Although this sounds simple there is really no way known at present to completely remove the worst offenders - the polycyclic hydrocarbons in all their forms and degrees of toxicity.

The question now arises how to adequately treat water by using chlorine and still prevent the formation of toxic compounds which can be called "Chlorine organics". It should be noted that until about 3 years ago the analytical means had not been developed to even be concerned about the fact that some of these compounds which now can be identified as known carcinogens, are created by the chlorination process. The concentrations in which they are produced from a given raw water vary and their thresholds of concentrations, dangerous to humans, have not as yet been determined. However, this concern has reached serious proportions and must not be ignored.

Extensive research has been underway for the past few years by the U.S. Environmental Protection Agency, which is carrying out a broad survey of public water supplies from large population areas across the country to identify the presence and concentration of the chlorinated organics.

The analytical tool presently combines the long used gas chromatograph coupled to a mass spectrometer. With the emergence of the mini computer it is now possible to apply this powerful analytical system to identify the fragmentation patterns of literally hundreds of organic compounds.

If the results of the EPA survey shows a general trend regarding levels of toxicity, a new concept of water treatment involving chlorine will have to be developed; possibly a thrust must be made toward using ozone as the main oxidizing agent for treatment. Extensive process development must get underway now, in order to take advantage of the little lead time available.

It is important to note that chlorination has been practiced for about 50 years for the disinfection of water supplies. It is still the best known and most reliable means of providing public water supply safety. However, if carcinogenic effects are being produced we cannot shirk our responsibility in determining this fact in our own plants. We have to be sure ourselves if we are in the decision making process of how water should be treated for maximum public protection. In the final analysis, a plant operation has to be based on the decision of those who run it because when the crunch comes, that is where the question will be asked.

Well, why didn't you know?

The answer will have to be - we did the best we could in the light of the knowledge we had.
Research Needs in the Area of Waste Water Disposal

F. J. Montbriand *

Today’s society is conscious of how its activities are affecting its environment. People have experienced the litter, the smog, the epidemics and suddenly realize they don’t have to put up with these entities. The outcome of this recent awareness is the public’s demand that those in authority do whatever is necessary to protect our environment. This is a real challenge as there doesn’t appear to be any simple answers to some of the problems being faced. Take water pollution in Western Canada, in less than 100 years we have seen the Prairies with the protective grass cover turned into huge cultivated areas subject to erosion. We have also seen the sloughs, the creeks, the watercourses, all modified by construction for rapid runoff. As a consequence the farm lands, some of them artificially fertilized, are being eroded and leached to some degree into our lakes and streams. Also with the population growth, urbanization and industrial development, we are discharging greater quantities of waste water every year. Both of these situations are responsible for the introduction of nutrients and chemical compounds into our waterways. The nutrients are causing nuisance algae growths in our recreational areas. Complex chemicals occasionally have found their way into our water supplies creating taste and odor problems and possible health hazards. It has become apparent to us that the old levels of waste water treatment are not adequate to curb the fouling of our lakes and streams. The answer to this problem has been made apparent through numerous investigations, and is the zero discharge concept.

By this I mean returning used water to a stream in virtually the same state it was withdrawn. The zero discharge concept has been with us for many years. It was first mentioned 100 years ago and has been recently endorsed by the Environmental Protection Agency in the US and should be subscribed to in Canada.

One of the major problems is a nutrient question. There appears to be three ways of tackling this problem. One is to avoid the discharge of waste water entirely to the watercourses. This could be accomplished by using the water for irrigation. A second method is to remove the nutrients by chemical treatment with tertiary treatment processes. Regina is taking one step in this direction with their proposed phosphorous removal by a chemical precipitation scheme. The third approach is to ignore the nutrient aspect and to tackle the algae problem from another direction. This would involve some sort of water treatment or physical removal of algae in the lake waters themselves.

Practically every small community in Western Canada uses the lagoon waste water disposal method which is basically an impoundment of water for a period of time. Using the effluent for irrigation and forage crops with this arrangement appears a logical choice for the zero discharge concept. Here we convert a nuisance into a commodity that is in demand and has the potential of earning out-of-province dollars. During wet years when it isn’t possible to use all the waste water for irrigation, the balance could be chemically treated for phosphorus removal at least before discharge.

In order to further waste water irrigation methods, a soils evaluation laboratory service is needed to provide the necessary application parameters for designers and operators. A couple of demonstration installations would certainly help in providing design and operating guidelines. There are several interesting aspects concerning waste water irrigation that deserve further attention. Because of the wind action, aerosol sprays from the spray irrigation systems could carry for considerable distances. The question is what health hazards are associated with this aerosol spray? Irrigated areas would be quite moist and nutritious, in comparison to the surrounding environment. What chances are there for the development of an insect blight that may affect the surrounding country side? Would we be trading off the nutrient problem for a biocide problem? What is the risk of disease transmission when using forage crops irrigated with waste water which has not been disinfected for direct cattle feed or as a cubed feed?

Waste water irrigation by larger centres may not be feasible because of the lack of economically suitable areas for such undertakings. Under these circumstances, chemical treatment, either alone or in conjunction with irrigation, could be used to achieve this zero discharge goal. Regina is taking the chemical treatment approach with the construction of their new three million dollar Tertiary Treatment Plant. The first stage is primarily for phosphorus removal. Unfortunately, it won’t reduce the chemical oxygen demand (COD) nor the nitrogen compounds significantly. Investigations will be required to ascertain what impact the nitrogen and COD reduction would have on lake algae once the phosphorus reduction has been achieved. This may indicate the degree of tertiary treatment that may be required by centres like Regina in the future. There are several areas associated with chemical treatment that warrant some investigation. If there is algae associated with the inflow into the chemical treatment system, how does it affect the sludge, classifying and the dewatering process? This is a big question, and to my knowledge there has not been any significant work in this area. The second question concerns investigating irradiation as a means of providing disinfection in an approved tertiary treatment. Would the sludge from a physical chemical process be less susceptible to anerobic action in storage ponds after being subjected to such treatment?

As I indicated earlier, algae is one of our chief concerns, primarily because of its nuisance aspects in our recreational areas. Isn’t there something that could be done at the lake end of the spectrum to reduce the algae nuisance? Certainly this is an area that demands some investigation. Because of soils leaching, erosion and other agricultural sources, nutrients entering the lakes may always be sufficient to promote a certain degree of algae growth. Would it be possible to retard this growth by irradiation of the lake water from a floating vessel with an irradiation device? It has been known for sometime that irradiation can effectively kill bacteria, spores, and other micro-organisms. Irradiation has been

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investigated recently as a means of disinfecting at the Burlington Skyway Pollution Control Plant. The results look encouraging enough to warrant further investigation and possibly could be applied to the area of lake algae control. For the present we must press forward with the best know-how for the protection of our environment. Tomorrow we hope we can do better with the aid of the research that we carry out today.

WATER QUALITY OBJECTIVES

Dr. J. D. Weibe *

As was mentioned this morning, the demand for water is increasing while the supply of water remains static or in fact may decrease due to pollution or the evaporation losses from impoundments such as reservoirs. It is therefore imperative that we manage both the quality and the quantity of the water resources, that the water pollution control strategies that we design be analyzed with respect to both. As one commentator said this morning quality and quantity cannot be separated. Now in order to design these strategies we have to have some definition of pollution or water quality. We might define quality as that characteristic of water, the physical, chemical and biological, which will allow the water to be put to a specific use. I say specific use because water quality is relative to the use to which it is put. In order to evaluate the quality associated with a particular use we must know which characteristics are detrimental to the use of that water.

For many years water quality was measured by the sense of sight, smell and taste. But with increased knowledge and advanced technical methodology, we are now measuring a number of parameters in order to assess quality. The yardsticks by which we measure this quality are called water quality objectives. This morning I wish to discuss water quality objectives and how we arrive at them. Since each of us requires water of a different quality, there will be different objectives for different uses. The question as to which objectives to gear our management strategies to, particularly in multiple use situations, is subject to political, economic and social considerations. This is, perhaps, where some of the socio-economic considerations should be taken into account. Generally, under the circumstances of multiple use, the objectives that we decide upon are those that protect the most sensitive use. Many water scientists today are describing water quality in terms of parameters and objectives relating to the goal of maintenance of aquatic habitats. It is generally agreed also that water quality that will support aquatic life and contact recreation, will protect other uses.

I would like to define water quality objectives very quickly. One definition might be a minimum level or maximum level of a certain parameter required for a beneficial use. In the past, we have used such parameters as Biochemical Oxygen Demand (BOD). As was mentioned earlier this morning, given the current concern with chlorinated organics and from our experience with mercury, cadmium, PCB’s, etc., we realize that these parameters are not sufficient to give us a good assessment of water quality in relation to public use. Therefore, at the present time, we have taken a blanket approach to analyzing water quality by analyzing for a large variety of parameters, metals, organics, etc. One of the problems is that we don’t really know what all these parameters mean in terms of water use. In order to find this out, we need a major research program on

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understanding the processes that occur in water. This is something that at the Canada Centre of Inland Waters (CCIW) many of our programs are geared to: the understanding of water processes.

I would like to turn to some of the major research needs as we see them today. In general we require more eco-systems studies to understand and ultimately predict the response. We need to develop methodology for eco-systems analysis in order to select indicator organisms, and in order to set design monitoring systems of critical receptors. We need to do some studies on mixing zones. This is a concept in water quality management where certain areas of an outfall or river mouth are designated a mixing zone where water quality objectives need not apply. We have to do some research on the time exposure of organisms to gradients of pollutants within this mixing zone, and their behaviour in and around these mixing zones. A great deal of work must be done on antagonistic effects of pollutants. In many cases when we design objectives or recommend them, we are looking at the toxicity of a single pollutant to an organism. The way this is usually done is to define the objective. You take the tolerance limit and multiply it by an application factor to give some minimum objective. This application factor is based on chronic effect. In many cases this isn't known and we apply an arbitrary safety factor, to arrive at some kind of objective designed to protect the environment. A great deal of research must be done on developing either of these application factors. This requires an analysis of the long term effect of various pollutants on these organisms. When we do this, we are only looking at one parameter, and there are indications now that some of these parameter toxicities are additive. In other words if there is so much of this particular parameter in the water then you have to cut it in half if you want so much of another one. Work in this area is in its infancy.

Health concerns - we need new indicators to determine recreational water quality. Ear, nose and throat infections are common these days in swimming waters. Coliform indicators are not efficient enough to indicate problems in this area. Probably some pseudomonas and some fungi should be looked at. We need to know more about the role of bacteria in taste and odor problems. We need to develop assay procedures for viruses. Another problem that is now receiving a great amount of attention is viruses in recreational and drinking waters. We have no assay procedures at this moment that are sensitive enough or reliable enough to determine concentrations of viruses because the methodology is not available. We have no epidemiological investigations that relate viruses to outbreaks, although we do know that water is a vector for infectious hepatitis. We have not looked into the transmission of micro-bacteria, viruses, parasites, etc. in irrigated pastures.

Another major area of research is that of bio-accumulation. Not withstanding what we know about metho-mercury, etc., we still do not understand the mechanisms of bio-accumulation, the effect of bio-accumulation on the receptor organisms, or the effect of ingestion of these organisms by higher competitors.

Therefore, in order to elucidate some sort of water quality objectives with respect to persistent, or by accumulatory substances, we have to use body burdens and since we understand so little about body burdens, obviously the objectives are mainly guesswork.

As was mentioned this morning, one of the major problems today is that of organics in our water supplies. This has been highlighted again by recent public concern regarding the presence of potentially carcinogenic chlorinated organics in the Mississippi River, and the findings of the Environmental Protection Agency that the chlorination of the public water supplies may produce these organics.

Although the persistence of certain pesticides and other organics and the bio-accumulation in aquatic organisms of chlorinated hydrocarbons has been known for some time, it hasn't been until recently that we have really started looking at chlorinated carbons in our drinking water supplies. The establishment of objectives for these drinking water supplies is difficult because of the methodology we use to estimate the amount of organic matter in water in our drinking supplies. There is a test called the organic carbon absorbable test which is probably the best currently available and which allows some differentiation between a toxic organic and a natural organic. One of the research needs is to develop better methodology for organics.

There are many organics in our water supplies that we are ignorant about and that we can't measure. We don't know what they are, but we do know that there is a mass of organic material and some of it is toxic. Therefore we need better identification and characterization methods. There is a lack of information on the fate and effect of many of these organics on aquatic organisms and on man. There is a lack of specific information on the chemical nature of these substances emanating from treatment plants, particularly complex and chlorinated organics. There is a lack of data relating residue levels in organisms to concentrations in water. In other words we don't really know how or what kind of concentration in water would result in a certain concentration in an organism.

The feasibility of organic functional group analysis at low levels should be explored as a method of analyzing organics in water. We do not know enough about the metabolites of pesticides and other organics and their effects on biota. And specifically we still don't know the potential for bio-accumulation of PCB's and halides which are fairly widespread in the environment.

Another area that hasn't been touched to any great degree is that of organo metallics. We now know that organo metallic compounds which are used in many processes are extremely toxic. The CCIW recently found that lead can be methylesed in sediments of wastes. Research should be done on other metals. Previously it was thought that lead cadmium and certain other metals could not be methylated. Recent indications are that they can be. Other metals should be looked at in terms of methylation. We don't have enough data on selenium, arsenic and many other metals. Also data on the physiological affects on humans caused by low concentrations of cadmium, chromium, silver, selenium, lead, mercury, etc. in water, are not known. Cause-effect relationships have not been established.
SESSION NO. 3 — ENVIRONMENTAL IMPACT

Dr. Maureen Rever Du Wors, * Chairman Session No. 3

I am very pleased that the members of my panel are people who have an interest in a very broad approach to environmental management, in particular water management. No longer does interdisciplinary mean only a group of engineers, soil scientists, agrologists and meteorologists. It has to include biologists, economists, sociologists, and perhaps shortly we will also include people like lawyers, and historians. I think that we can look back over the last few years and note some rather major steps that have been taken with the establishment of the federal and provincial Departments of the Environment and interdepartmental committees within the government which are fostering an interdisciplinary approach to these kinds of problems. The divisions within these departments are attempting to give leadership in education to the public sector, in particular to the young people who are going to be very much involved with decisions about the environment some day. One of the difficulties I have, and I expect most of you have, is that we were educated in a disciplinary time. And when you have a group of people who are disciplinary oriented, it is an educational process in itself to attempt to deal with people who have very different approaches and different concepts of solutions to complex environmental problems. I think there is a real necessity to establish credibility at different levels between the public, the government, and research organizations, so that it will be possible through public participation, through symposiums such as this where you have mainly professional people involved, through the government decision making process, to make decisions which will be the best possible compromise. We have to deal with problems such as those imposed by confidentiality, and I think that progress is being made in this direction in terms of the kinds of relationships which are possible between research oriented people, the educated public and government organizations. I think that there are real difficulties involved when specifications which are written into problems that engineers and technologists deal with must become part of the format for questions which social scientists attempt to answer. I think that it is important that people like yourselves take a leading role in attempting to encourage universities, technical institutes, governments, and so on, to try innovative approaches to interdisciplinary training so that young people who take on environmental management duties now and in the future will not have the major difficulties which we ourselves encounter when we try to break down our disciplinary biases. Often this is a costly kind of education in terms of time and effort, but I think that in the long run it is the approach which must be taken to environmental management.

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ENVIRONMENTAL IMPACT

Dr. A. H. Laycock *

In the last decade we have become much more conscious of the environmental impacts in water development programs than ever before. The earlier orientations of some ecologists toward a preservation of natural environments have become more moderate and there is now a wider acceptance of man as an important element in most environments. An interesting balance is indicated in the Water Resources Council principles and standards for planning water and related land resource development - which became law in the United States in 1973 (Water Resources Council 1973). The two major objectives of society as a whole were defined as: (a) to enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency and (b) to enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. The beneficial and adverse effects of alternative plans upon regional development and social well-being were also to be considered but the stress was upon the first two; national economic development and quality of environment. It is true that the Council is not receiving complete support from the EPA, some construction agencies, and from certain environmental groups, but the broader definition of objectives is now widely recognized as being better than either the "construction whatever-the-cost" and the "complete ban on construction" extremes.

The search for improved environmental perspectives has been a wide one and most disciplines have been modified by it. Economists such as Galbraith and Stigler have usefully noted the conflicts between goods production and amenities protection. The best combination, mainly the point at which the marginal utility curves cross, varies with individuals, regions and the changing state of the economy. In Saskatchewan, for example, a greater stress might be placed upon production than upon amenities protection because development pressures upon the environment are less severe than in more densely populated areas of the world.

Many frameworks for evaluation of water management programs in a broad perspective have been outlined. One that I like is that of Gilbert White in his book "Strategies of American Water Management" (1971) in which water management is examined in the light of purpose, means and management agency. Thus, development may be single or multiple purpose, and single or multiple means, with a wide range of in-between categories and degrees and types of environmental impact. Management may be private or public with many degrees of ownership, control, restriction and guidance. Many agencies have been widely identified as being rigidly single purpose and single means oriented (for example with too little regard for environmental considerations by construction agencies and little regard for anything else by wildlife management agencies). Analysis frameworks are useful in identifying these groups and assessing their programs. It is often useful to construct a matrix for the assessment of each proposed development. Its use tends to promote interdisciplinary discussion and may lead to a better understanding of interrelated problems and it may also serve as a comprehensive checklist for the determination of data and research needs (Rickett et al. 1973). Model building is too often narrow and lacking in such comprehensive matrices, but if there is adequate input from all concerned, and free exchange of information, the environmental issues will usually be subject to reasonable resolution.

The Syncrude development in Northern Alberta is a current issue that is more water problem oriented than most people realize. The supply is more than adequate for this scale of development, but problems may arise in a few decades with major expansion. The major problem is that of confining effluent discharge to the lease area in accord with provincial Department of Environment regulations. In the next 25 years this will result in tailing ponds covering approximately as large an area of mineable oil sands as will be mined. The hot discharge waters from the plan will keep the 12 square mile area of ponds open throughout the winter and evaporation will be a major problem - creating ice fog and rime ice conditions much more severe than those which have closed Great Canadian Oil Sand operations on many days in past winters. Salt water discharge into the mines from underlying evaporite formations cannot be dumped into the Athabasca River and must be stored or in part evaporated. The post-development landscape will include great piles of waste, due in part to a swell factor of almost 50%, and to high dyke bounded sludge that will take many years to settle. The high-grading operations will have left part of an inefficiently mined resource and an ugly, almost useless, environment.

Is this what we want? With present technology and government regulations, this is what we will get. With matrix use we might review alternatives in purposes and means and the role of government. Perhaps removal of part of the tailings to lands farther north not covering mineable formations and a stress on environmental enhancement, rather than upon restoration of a biologically unproductive landscape, would be better. Perhaps some of the salt water could be permitted to flow into the Athabasca River - the present salt levels are far below any damage thresholds. We are virtually precluded from studying alternatives that lie outside present regulations, and research and discussion are greatly inhibited by the secrecy that prevails in government and industry. Surely we can open up the information exchange by government action with or without greater public ownership of the industry. Surely we can do a better job of managing the land and water resources of the region for enhancement of national economic development and enhancement of the quality of the environment.

The greatest need in this and so many other water developments is a better professional and public perspective concerning resource management. With it, the research required for it, and with better information exchange such as we are getting at this Conference, our misgivings about environmental problems will be greatly reduced.

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IMPACTS OF WATER MANAGEMENT ON WILDLIFE
W.J.D. Stephen*

Water, from the North American wildlife manager's viewpoint, may range from dew on the grass, to succulent vegetation, all that is necessary at some time of year to support some species such as sharptailed grouse and other upland game species, through to the Arctic, Pacific and Atlantic Oceans. In other instances, it is not water per-se but the container, such as the river banks and flood plain, that is important to a species, such as white-tailed deer in the Qu'Appelle River. The same could be said of the North and South Saskatchewan, Red Deer and Bow Rivers, to mention a few. That, of course, is not the only habitat of these species, but the shape and plant species composition of these containers create habitat ideal for many other wildlife species. Waterfowl are, of course, completely dependent on various quantities and qualities of water at various times of the year. Small wetlands or sloughs (about 2 - 4 acres) seem to be ideal for breeding, medium and large size wetlands (greater than 200 acres) seem best for flocks aggregating during migration. The quality of that water has a wide variety, from sewage lagoons to sea water; from clear mountain streams to water that is 'too thick to drink, but too thin to plough'.

Water resource management and development in Western Canada has been characterized as water storage and regulation (LaRose, 1969), and there is little evidence that I can discover to indicate that the situation has changed significantly since then. There seems to be little question, however, that industrialization, urbanization, larger farming units, the rising costs of farm operations and the rising value of farm commodities will, if they have not already, influence these water management and development policies, procedures and practices. In a final comment to introduce the subject of impacts of water on wildlife management, mention should be made of the international significance of Canadian water. The prairie-parkland area of Western Canada is the source of 98 out of every 100 bushels of wheat produced in Canada (Lodge, 1969) yet it is also the source of five out of eight ducks shot by hunters in North America (Pospahala et al, 1974; Crissey, 1969). The conflict of interest is readily visible when one considers that Canada and the United States in a Treaty signed in 1916 "...insuring the preservation of such migratory birds as are either useful to man or are harmless, (have) resolved to adopt some uniform system of protection which shall effectively accomplish such objects ... " (Migratory Birds Convention, Schedule to the Migratory Convention Act, R.S., c. M-12). In the United States, 35 percent of the wetlands had been drained by 1955 (Shaw and Fredine, 1956). While there is no reason to expect the pattern will be different in Canada (LaRose, 1969), what will the impact of water management and development projects and programs in Canada be on the obligations imposed on Canada by the Migratory Birds Treaty and clients of other wildlife management agencies in Canada with their mandates to provide recreation based on wildlife?

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The Science Secretariat commissioned a study of water resources research in Canada (Bruce and Maasland, 1968) since your first symposium in 1964. Three major points which are relevant to wildlife managers, among the many they made related to water research in Canada, are worth repeating. The first was that Canada is and will continue to be for the next decade a country with a relatively large water resource for a relatively small population. Second, that Canada can learn a great deal from its southern neighbour about methods appearing on the horizon in 1968 but need not in the next decade devote very large amounts of its own limited research funds and staff to those problems. Instead Canada can concentrate its efforts on appraising the extent, magnitude and quality of the resource and on optimum use. Parenthetically, it may be observed that decade is almost over. Thirdly, they recommend that complete re-appraisal of the priorities stated for distribution of research funding and performance be made in 1972 at the latest. As far as I know, that has not been done, at least in a widely distributed public document.

Bruce and Maasland (1968) characterized water resources research in eight major and 45 sub-categories. The sub-categories perform are interrelated and sometimes overlap. I am going to highlight those categories I believe to be of relevance to wildlife managers.

In the major category water cycle, they stated that a thorough understanding of the extent and variability of Canada’s water resources, both on a national scale and locally, is of the utmost importance in ensuring optimum management of these resources. Development of rainfall-runoff relationships, through computer models of the hydrological cycle in river and lake basins, surface and groundwater interrelationships and geomorphology is necessary. While the program to establish and instrument these basins is well developed there had been (up to 1968) no proportionate effort to analyze the results and begin development of the types of generalized equations and relationships needed.

To make maximum use of Canada’s substantial investment in instrumentation and observation phases of the program, of special importance to Canada, is the development of suitable mathematical models of snowmelt and the contribution of melting snow to surface water. Knowledge of the frequency of rains of various intensities over small drainage basins is important both for wildlife management and for establishing design criteria for drain and storm sewage systems. What is really required is an estimate of rainfall frequencies over an area say from one acre to 25 square miles. Very little research effort has been put into determining the representativeness of point rainfall values and into studies of small scale areal variability of rainfall in various Canadian climatic zones.

Most of the Canadian studies of evapotranspiration have been to aid estimates of irrigation water requirements. Very little knowledge is available on the applicability of various evaporation estimation techniques in Canadian climates.

In discussion of the general Water Cycle and precipitation, they pointed out that better knowledge of precipitation distributions and of precipitation run-off relationships would be most valuable... for very small and for large watersheds. For middle-sized basins and perhaps small ones also, a more direct approach in many cases is to analyze regional streamflow characteristics in relation to weather, soils, geology, stream characteristics, basin cover, etc., and thus derive, from gauged basin data, methods of estimating flood and drought frequencies for the millions of small basins which can never be gauged and on many of which water control of conveyance structures must be built.

Canadians have also undertaken substantial and successful research efforts on the estimation of soil moisture from climatic data and other means but have done much less on infiltration rates and characteristics of Canadian soils and on movement of water within soil profiles. Only a small effort has been directed toward the water requirements of plants and interception of precipitation by vegetation. Streams in the Prairies and other agricultural areas carry sediment loads from the erosion of valuable soils and deposit the sediment loads in reservoirs thus reducing useful storage.

Aside from the Prairie region there are few major shortages of water in Canada in the regional sense. Costs of distribution of water from the nearest available supplies are becoming limiting factors. Forest cutting and snow management practices can increase the yield of rivers by significant amounts and change the timing of run-off. Although the ultimate objective is water yield improvement, the research is multi-disciplinary and calls for the synthesis of the various disciplinary parts. The techniques for conducting such studies are far from perfect.

Methods of using water of high salinity in agricultural areas to produce economic yields would be of considerable value in the Prairies. Some of these economic yields can be in the form of wildlife or recreation based on wildlife. Reduction of water demands by industry by process modification and re-cycling of water may not only decrease the volume of water required by the industry but reduce the pollution load discharged by the plant. Typical irrigation systems deliver to farms only little more than one half of the water they take from rivers, reservoirs and aquifers. Irrigation is characteristic of water short areas and thus conservation of some of this wasted water for other uses such as wildlife or recreation based on the water itself would be of considerable value. Changes in water balance adjacent to natural and new reservoirs are local phenomena but may be of considerable importance to agriculture or other resources such as wildlife in these particular areas.

Side effects on water quantities are an increasingly worrisome feature of man’s activities such as logging, building cities, constructing highways and so on. If drainage were provided, about 2 million acres of potentially productive land in Canada could be brought into production. This drainage requires substantial investment and has physical, financial and chemical limitations (LaRose, 1969). However not all of those wetlands are significant for wildlife production and habitation. Wildlife managers have tended to have an application rather than program focus on the loss of wetland wildlife habitat.
Research in water quality management and protection is economically and socially a very important field of water research and one which receives an overwhelming measure of public support. Canada is still at a point where well conceived research and abatement programs can avoid the gross pollution of water resources which affects parts of the United States. It is worth noting parenthetically that the largely man-caused eutrophication of Lake Erie which has caused so much horror, when found naturally in Last Mountain Lake or on an average prairie slough makes it a haven (or heaven) for ducks, geese, other migratory birds, fish, muskrats and a variety of other wildlife. The discharge of warm water from conventional steam and nuclear power stations into lakes and rivers appears likely to become a significant problem to the wildlife manager mainly because ducks, geese and other migratory game birds may attempt to winter further north than they ever have before. In the field of water quality control, the possible harnessing of biological processes in lakes and reservoirs to ‘harvest’ pollutants or make the effect of pollutants less noxious seems promising.

In making judgements concerning priorities of water developments and their economic and social impact, Canada has been generally content to rely on the accumulated wisdom of water resources administrators and has not equipped these administrators with many social science tools to help make decisions. As the Canadian economy becomes more complex, this approach cannot be expected to yield decisions in the best interests of the public at large. Computer based techniques for quality control, storing, processing, retrieval and publication, designed to put data in the hands of users and planners as quickly as possible, while not a research need, is definitely a need in support of water research and water planning.

Very little research is underway in Canada on planning, economic, legal or institutional aspects of water resources development. One of the most serious deficiencies in Canadian data collection programs is in precipitation data, the density of stations (in 1968) corresponded approximately with that of Afghanistan. There are good reasons for this, but it does not help the water resource planner. Much more comprehensive data are required on water use, flood damages, drought costs and recreational use and values. In general, Federal-provincial jurisdictional problems have prevented the development of the efficient, comprehensive systems of water control operations that many developed nations enjoy.

The remainder of the recommendations made by Bruce and Maasland (1968) relate mainly to hydrologists, engineers and other water administrators. I will not mention them. With respect to wildlife managers I alluded earlier to their application rather than program focus. The single most significant piece of data collection concerning water and other wildlife habitat has been the Canada Land Inventory which covers the current and potential agricultural area of Canada. However, the remainder of Canada has not been covered, and while various classes of land have been identified there is no absolute value placed on these classes for migratory birds or other wildlife nor are they comparable to other land classes, on any general basis, with respect to other potential resource uses. Thus we are faced with the prospect of a project by project evaluation of the pros and cons and compromise largely based on the biases, rhetoric and eloquence of various proponents. While Bruce and Maasland (1968) did not give much prominence to needs for research in recreation supply and demand specifically, I suggest that wildlife managers must.

One final component in the research need equation is the Federal Environmental Assessment Review Process. The Government Reorganization Act of 1970 stated among other things that the Federal Government itself should not have any environmental disasters on its conscience. That mandate has led to the formation of an Environmental Assessment Review Panel (EARP) within Environment Canada and five Regional Screening and Coordinating Committees. Projects which involve federal land, federal funding or federal initiatives are subject to the process, with the exception of federal Crown Corporations which are encouraged to comply. The principal is that the polluters pay; that is, the federal proponent department is responsible for conducting a preliminary environmental assessment of their development project which is subject to review by Environment Canada for deficiencies in the plan which might lead to ecological disruption of “significant proportions”. “Significant proportions” leads to the second principal and the need for Regional Screening and Coordinating Committees. The rule of reason is to be applied and only major projects should be referred to EARP. That is understandable because of the diversity of funds dispersed by the federal government such as Local Initiatives Program, Opportunities for Youth and so on, many of which have an environmental focus. The research problem here is the need for reasonable guidelines with general application instead of having to undertake a full-blown research program every time a new reservoir or river diversion is proposed or to undertake catch-up studies long after the water development project is underway as was the case with the W.A.C. Bennett Dam in B.C.

There is high political profile for a natural world, the good old days, in which wildlife is often equated with a pollution-free existence, based mainly on a very active media, Jacques Cousteau, John and Janet Foster and John Livingstone to mention a few national and international personages. Wildlife management agencies themselves have had little to contribute to that prominence as evinced by a recent study in Alberta (Decision Making Information, 1974). They have been more preoccupied with such things as proposed gun control legislation, allocation of diminishing recreation opportunity, increasing demand for outdoor recreation of all kinds, urbanization, industrialization and so on. Most wildlife management agencies in Canada have still not clearly separated their wildlife management responsibilities from advisory services in resource development. Most wildlife biologists are hoping for some method whereby they can walk up to a wetland, stick a finger or some other instrument in the water and be able to say definitively what it is worth to migratory birds or other wildlife and predict the effects of a particular water management or development project.

Basic or long term research has become a “dirty word” to politicians, proponents of resource development and funding agencies. However, predictions based on seasonal or annual variances, I contend is a valid approach to solving
today's problems of environmental impact and in some cases requires the testing of hypotheses over long periods of time and answers to some very fundamental questions.

REFERENCES


Migratory Birds Convention, Schedule to the Migratory Convention Act, R.S., c. M-12.


IMPACT STUDIES OF WATER DEVELOPMENT PROPOSALS

J. Stabler *

I am not going to talk about new research needs in relation to water development, but rather I am going to talk about a technique that is currently in vogue, impact studies, and say what I think we might expect from this type of study and some drawbacks that I see from the use of these studies.

There was a time in the not too distant past, when economic growth was accepted almost without reservation by the majority of citizens of western countries as one of, if not the primary objective of the collective private and public endeavor. Water in one form or the other played an important role in this development. Falling water generates power. Water spread over the surface of the land greatly increases the alternatives for agriculture in arid regions. Water flowing through deepened and widened channels provides an alternative to truck and rail transport. All of this in addition to the recreational, municipal, industrial uses to which water is put. Perhaps the acceptance of development as an objective was somewhat uncritical, the side effects too readily ignored or simply unnoticed. In any case, we have become aware in recent times that some considerable abuse of the environment occurred in this pursuit of economic growth and higher material living standards. Since the 1960's the number of persons, skeptics if you like, who would not accept uncritically the pursuit of economic growth has increased; their voices have been heard.

Whether the skeptics have been successful in the attempt by some of their members to de-emphasize economic growth as a publicly supported objective is questionable. It is certain, however, that they have succeeded in making the public more aware of the undesirable side effects of economic growth. One of the consequences of this increased awareness has been the requirement imposed by various levels and jurisdictions that impact studies be conducted prior to approval of major public or private development projects. The purpose of the impact study is to expand considerably the information base from which the development decisions are made. A comparison of direct costs with direct benefits, formerly the standard method of evaluation is supplemented by the inclusion of all indirect to unintended side effects, both positive and negative. The impact study is not intended as a decision making tool, the use of which would help to protect the environment. Conceptually, expansion of the framework within which development proposals are evaluated represents a logical improvement in the decision making process. More complete information should lead to better decisions and as some critics argue, negative indirect effects have in the past sometimes out-weighted positive direct effects of certain developments. This type of error would be avoided in the future as a consequence of the impact studies. Development will not proceed if the sum of the direct plus indirect costs exceeds the sum of direct plus indirect benefits.

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I think it is necessary to distinguish between the improvement in concept which the use of a broader framework represents, and the improvement in practice that the impact studies are likely to bring. In particular there are at least two problems with impact studies as an aid in decision making, and this is the basis upon which I am criticizing impact studies, their usefulness as a tool of the decisions making process, not as a method of gathering information for research purposes.

The first, and I think the lesser problem with impact studies, has to do with the length of time required to perform the all encompassing in depth analysis required for a real impact study. Seldom less than two years, sometimes more than five are required depending upon the complexity of the situation and the amount of effort devoted to the task for proposals involving truly unique circumstances where really very little or nothing is known about the potential indirect effects and where these effects are of potentially significant proportions. Two to five years can be justified as the cost of not making a serious error. Development proposals such as the Arctic Pipeline or the transport of petroleum through Arctic waters are illustrative of circumstances which probably require the impact study. To insist on spending two or more years on impact studies on proposals where circumstances are not unique or which would replicate the impact study. To insist on spending two or more years on impact studies on proposals where circumstances are not unique or which would replicate the impact study in a way that the world does not stand still while the impact study study is underway. The question of how to expand Saskatchewan Power Corporation (SPC) generating capacity either with another hydro-electric generator on the Churchill River or with another thermal generator in the South may be a case in point. Apparently it was thought that when the Churchill River Study was initiated there would be time to perform the impact study, evaluate the results and then decide which alternative to choose. Events associated with the petroleum shortage and a renewed interest in coal precluded this course of action. SPC apparently found itself in a position where it was necessary to choose between the two alternatives before the Churchill River Study was completed. By delaying, they faced the possibility of not being able to build either facility in time to be constructed without a published impact study, while the Churchill River Study continues. I am not criticizing the decision. I believe this represents a responsible decision on the part of SPC and other government officials. But it does illustrate the problem with three-year impact studies.

What is the solution to the first problem? If impact studies are to play a useful role in the decision making process, a method has to be found to shorten the time required to appraise non-unique proposals. One possible means of accomplishing this may be through the use of general simulation techniques to model the indirect effects of various types of development proposals. Such models would be similar in use to the general economic cost benefit models which can be used quickly to approximate the direct effects of virtually any type of development proposal. For example, and I am not a natural scientist, so I don’t know that this is the case, but it would appear that rivers can be grouped into types, each displaying certain characteristics. It would seem, therefore, that it should be possible to develop general simulation models for each type of river, and then any general effect of a proposed alteration could be quickly approximated through the use of the general model. Areas of concern identified in the first approximation could then be investigated in greater detail rather than investigating everything in great detail. Such an approach would not be as accurate as the detailed studies now being conducted. But the saving in time could be substantial, therefore making the impact study a useful tool in decision making processes. In any case complete accuracy is not required.

I say this because in terms of the indirect effects of a development proposal, I don’t really think we are interested in whether the magnitude of the indirect effect is $10,782.57. What we want to know is whether it is $10,000 or $150,000 or a million dollars. In any case by assigning a realistic range of values to the parameters of the simulation models, virtually any set of conceivable circumstances could be investigated. I am not suggesting a reduction of research effort as such, but rather a diversion from the detailed analysis of current impact studies to the building of general models which could be useful in a number of circumstances and which would be used to form a first opinion of any development proposal and would perhaps point out where areas of detailed research would be required.

The second problem with impact studies is a more serious one. Direct costs and direct effects of development proposals are measured in terms of dollars. Some indirect costs and some indirect effects are also measured in dollars which makes possible any easy adjustment of the direct measurement. Often, however, the indirect effects produce changes which are not remotely connected with the market and are therefore incapable of being stated in dollar terms. A decision maker is therefore faced with evaluating and weighing results stated in terms of dollar benefits and dollar costs, plus a mixed bag of effects described in terms of changes in the physical, biological or social environment. I suspect that most of us tend to place the greatest emphasis on what we understand best. All of us understand dollars. Few people understand the physical and the biological and the social environment in the way that specialists in those fields do. Thus, greater emphasis is probably put on the dollar measurements and information stated in other terms is consequently downgraded.

I think that this is unfortunate as far as the use of impact studies and decision making processes is concerned because I suspect that the more important indirect
effects are often those which can not be stated in dollar terms. I am relatively certain that this is so in the particular case of hydro-electric development in the Canadian North. In the Churchill River Study we are now in the process of completing our analysis of those indirect effects that can be measured in dollar terms. And we have done this in some considerable detail. The list includes the loss of potentially marketable timber and this is stated in terms of number of cords, and a very precise measure of this loss has been made. Also the increase in potential fish catch, and loss of some trap lines has been measured and in developing this estimate we can tell you how many muskrat, how many beaver, how many lynx, how many of each species each trapper in the Churchill area has caught in the last ten years and the price that he received for that fur.

A great deal of information, probably more than is required for use in an impact study, is to be used in a decision making context. In any case while these studies are not finalized, it is apparent at this stage that the measurement of indirect effects, other than the positive downstream power benefits, will not alter in any way the results of the comparison of direct costs with direct benefits. The excess of direct benefits over direct costs amounts to hundreds of millions of dollars, while the measurable indirect effects, again power benefits aside, amount to dozens of thousands of dollars. Unmeasured in dollar terms is the loss of certain wildlife habitat, loss of a series of rapids, possible changes in social circumstances, flooding of archeological sites, and so forth.

There are a number of other areas in the Canadian North presently under development and still more being considered for development. Hydro power from rivers in the Yukon and Northwest Territories is seen as a logical source for transporting Arctic gas and oil to the South. Cursory examination of the characteristics of these river basins suggests that circumstances in these other northern areas do not differ greatly from those in the Churchill area, as far as measurable indirect effects are concerned. In other words, it would appear that if direct benefits exceed direct costs, this fact will not be modified by taking into account the measurable indirect effects. How will the information reports in non-quantifiable terms be treated? I don’t think we know. But if they are stated in the scientific terminology of the particular discipline and are difficult to interpret by the generalist decision maker, I think we can infer that they will not be weighed as heavily as they otherwise would be.

What can be done about the second problem? Attempts are being made to develop methods of quantifying the so far unquantifiable side effects of developments either in terms of dollars or by other types of indexes. I think these efforts should be continued, but efforts to date suggests that success is a long way off - if it can be achieved at all. In the meantime I think that some improvement is possible in the way that this information is reported. In most of the studies that I have looked at, non-measurable indirect effects are simply described in very great detail representing a very great amount of very careful work, usually stated in the technical terms of the particular discipline involved. Left unanswered or given superficial treatment is the implied question, so what? Effort put to answering this question in terms of broad social consequences, could I think go some way toward improving the usefulness of this information. We hire biologists to study biological phenomena, a geologist to study geology, but we have not put the necessary effort into translating what the specialist finds into terms that the generalist can understand. Perhaps this one area in which co-operative effort between physical and biological scientists on the one hand and social scientists on the other could prove beneficial and make these impact studies more useful in the decision making context.
WATER RESOURCES IN SASKATCHEWAN

Luncheon Address

G. C. Mitchell *

Many of you know me, but all of you can better evaluate what I am going to say if I list some of my relevant characteristics.

- I am not a professional although I had some professional training.
- I am not a researcher although I had some research experience.
- I cannot claim status as a professional manager in the sense that I did not receive academic training in that field.
- I am interested in research and researchers.
- I have tried, albeit inadequately, to explain government to researchers and research to bureaucrats.

Research means many things to different people:
- some consider that only the purest of research is entitled to the name;
- others will accept the reality of applied research;
- others say there is such a thing as mission or problem-oriented research;
- still others would classify certain broad measurement studies as research;
- many harassed managers call everything research that takes more than a day to do and that leads to a better decision.

In thinking about what to say to the Institute today, it was helpful to me to review the proceedings of your first symposium on water research needs held eleven years ago. Two things stand out.

First, there were some excellent suggestions for research, particularly in the physical sciences areas, some in the biological sciences, and none in the social sciences area. "Environment" was only mentioned once and in the context of the soil environment for plant roots.

Second, the research needs identified then are still needs. Some work has been done. In most cases we have not got the answers we need but we could not expect that these answers would come easily.

What has happened since 1964?
- The organization of research activities has changed somewhat reflecting some consensus that a broad, multi-discipline approach to research is desirable.
- Considerably more emphasis has been placed by governments, both national and provincial, on planning and planning studies.

- Environment is the "in" thing - a new dimension added to decision-making. The biologist and ecologist have finally got their place in the sun. But this place was already occupied by engineers and economists, sociologists and other disciplines who have not learned to work together in any optional sense. The result, while exciting, is somewhat psychedelic.

The long-standing problem of ineffective communication between the research community and government and other non-university institutions has been tackled but, in my view, not resolved. Indeed, I do not think that smaller organizations (I include many provincial government agencies in this category) even know what relevant research information is available to help them in problem-solving. The Saskatchewan Research Council has provided a very helpful service although its terms of reference are narrow. Government agencies have not fully and effectively used the skills available through the SRC.

The Great Plains Research Centre is a relatively new mechanism and many of us have high hopes for it. High hope that it can bring the skills of a broader range of expertise to bear on our kinds of problems.

Individual university personnel continue to make outstanding contributions to public policy development in various ways. But a fundamental problem still exists. The decision-maker or policy advisor has particular problems to resolve. We are satisfied if the researcher can help us make sounder decisions. We do not look favourably on responses in the form of requests for long-term, pure research projects that can provide better answers years after the decision has to be made.

The researcher tends to be suspicious of outside people because they do not fully understand the research process. If researchers accede to our urgent needs for information for short term decision-making, they fear they will lose their professional virginity.

The federal government, through Energy, Mines and Resources and later Environment Canada, evolved a program called "The Water Resources Research Support Program". It was conceived originally in response to a concern that research funding through NRC lacked a mission-orientation and did not fund research projects in the social sciences. This new program provides for innovative research relevant to departmental concerns and for water resources research in the natural and social sciences with emphasis on water management issues and, I quote, "by fostering the interest of university researchers it thereby utilizes their knowledge and expertise in solving water research problems, and provides opportunities for their participation in socially-relevant environmental research". In 1974-75, $1.0 million was provided for this purpose.

It appeals to my parochial sentiments that the University of Saskatchewan received $125,000 for work on the "Hydrology of the Prairie Environment". However, I am concerned that the programs supported in Saskatchewan and other parts of Canada contain virtually nothing in the social sciences.

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The other new thing that the federal government has done is to establish the Burlington Research Center for Inland Waters. This is an imaginative concept. It presents a challenge to provincial agencies and prairie universities in that we must exert every possible influence to ensure that the research program at that center has a much broader focus than the problems of the Great Lakes.

Looking at federal initiatives - I must say, "The Lord giveth and the Lord taketh away". The Lord (the federal government) has given a research support program, the Burlington Center, and has channelled fairly significant funding into that center. We have done joint river basin investigations but the Lord has taken some things away. Two examples are:
- withdrawal of financial support for the surface water and ground water geological mapping program of the SRC; and
- loading of a considerable portion of hydrometric and water quality monitoring and data analysis on the provinces (at the expense of other provincial programs, in some cases).

On the provincial side, our efforts in recent years have concentrated on baseline collection (particularly in the case of water quality) and on a series of river basin investigations. We have given highest priority to the water-short basins and more heavily developed streams like the South Saskatchewan and the Qu’Appelle. More recently, the focus is shifting to the Souris, Churchill and Lower Saskatchewan. I believe a reasonably sound procedure has evolved for water resource planning and development. Our planning projects further into the future and it is broadly-based when it needs to be. While provincial agencies co-ordinate the study activity, specific aspects have been farmed out to the SRC, private consultants and university experts.

During the current fiscal year, Environment Saskatchewan has funded some $200,000 in various water-related research projects. This is apart from the water component of the various jointly-financed basin investigation programs. I am very pleased that the Qu’Appelle Implementation program will be even more broadly based than indicated by the recommendations of the Qu’Appelle Study Report. It will not only include environmental and water management aspects, but will provide funding for planning and development to improve economic opportunities.

Our water research needs today still include most of the things raised at your first symposium eleven years ago. Broadly speaking, we still need to focus on finding better ways to converse, distribute and use a limited resource of marginal quality in a sparsely settled province. This suggests the need for further examination of hydrology on the prairies and on the environmental, social and economic consequences of technically-feasible water storage and distribution systems.

On the environmental side, I foresee that our major long-run challenge relates to the problem of maintaining water quality in our shallow reservoirs and lakes. We can and are taking steps to upgrade our municipal waste treatment facilities as a means of eliminating a major source of the nutrients that speed up the eutrophication process. Effluent irrigation and close regulation of intensive livestock operations will help but the long-term problems of nutrient and silt loading of our water bodies from runoff from cultivated lands still exists.

The Department of Agriculture has made a significant extension effort to inform farmers on how to reduce erosion but the fact remains that tons of topsoil are lost each year. From a policy standpoint, it would be very helpful to have studies done on the long-run significance of this loss both in terms of the productivity of the land and the impairment of water quality. Such data would permit us to evaluate the need for more positive erosion and control programs.

Many of our farms and smaller urban centers depend on ground water. Often this ground water is highly mineralized. Some promising work has been done by SRC on the freeze-thaw method of desalination and pilot projects are in use in some locations. The reverse osmosis method has been known for years but is still a costly method of treatment. This remains an area requiring the further attention of research councils, the Burlington Center and universities.

There is great interest in the development of renewable resources in the North. There appears likely to be markets for the sustained yield of our forests. We know that the ecosystems in the North are fragile. We are in the second year of a two-year study of forest harvest practices and effects on the environment including stream flows and water quality. The findings of this study should facilitate the development of environmentally sound, long-term, forest harvest control regulations.

Before I conclude my remarks, I want to raise one other need. I refer to the matter of public involvement in decision-making with respect to resource use including water. My experience has confirmed my emotional bias that sounder decisions are made if the interested public is provided with information and given an opportunity to make their views known. Environment Saskatchewan, and earlier the Saskatchewan Water Resources Commission, has made a conscious effort to involve people in our basin studies and in implementation programs. There is a need for research directed toward devising more effective methods to encourage public participation. A part of this research should be directed toward evaluation of past efforts here and elsewhere. The traditional and important role of the elected representative must not be overlooked but I am sure that methods can be devised that would reinforce that essential linkage in our democratic society.

May I conclude by saying that your Institute has made a significant contribution in bringing government and university people of various disciplines together. Your work should be encouraged and a special effort made to develop the Institute as an avenue for inter-disciplinary communication.

I appreciate this opportunity to make these brief comments to you.
DISCUSSION

SUPPLY OF WATER — SESSION 1

Mr. Lakshman, Saskatchewan Research Council

I have comments for the panelists as a whole. My first comment is that Water Resources Management is an important factor in the formulation of guidelines for hydrologic research, but in Saskatchewan there is very little socio-economic input into the forecasting of water resources. There are various agencies, Provincial and Federal, attacking hydrologic problems by bits and pieces, but to be useful one should make an attempt to provide enough data for forecasts of social and economic trends. These should be introduced into research applications if they are to be useful. Following this, is the fact that we should have a mechanism to translate the results of the research to applications. We should establish a dialogue between the people who are doing the research in the province and the people who are making the policies. It is a two-way dialogue.

One other thing that comes to mind is the application of research methodology in the province. We have been following old and sometimes obsolete techniques which are applicable in the areas of their origin. We don't consider the fact that our province is entirely different. For example, in the hydrologic model or in the forecast of water resource potential we have this tendency to follow the research papers and blindly apply the results with a few changes here and there. We have got to find new techniques which are quite unique to the province as a whole, and then provide some socio-economic input into the entire model and develop a dialogue, process, or mechanism by which we can translate the results to coherent and convenient laws or policies. There are a lot of changes taking place which are apparent, but not obvious in certain features. For example, a recognition of the fact that water quality and quantity are inseparable. You can influence the water quality tremendously by increasing the water quantity in some areas, by clear cutting in some areas, drainage of ditches and drainage of sloughs and potholes. Some body should take a comprehensive look at the entire thing, rather than attacking the problem in bits and pieces.

S. R. Blackwell, Chairman

I think your points are well taken. Would one of the panelists care to make any comments on this.

T. L. Richards - Panelist

I agree that we require socio-economic assistance. Some years ago during the time of an acute shortage of meteorologists in our organization, I hired a geographer and this was one of the best things that we could have done. It added a new dimension to our work and as a result, our Meteorological Applications Branch employs a number of geographers. The second question on dialogue between the researcher and the policy maker - it takes an extremely good man at the management level to translate the researchers jargon into the policy makers jargon and, federally, our water people are in an excellent position right now as they have the best man that we know of to do this. I can't comment on the provincial scene.

D. L. MacLeod, Environment Saskatchewan

We make very extensive use of the information provided by Atmospheric Environment Services and we are a little disturbed that we have not been receiving some of the information put out by your organization on a regular basis in the past year or so.

T. L. Richards - Panelist

I think the primary target here is the monthly weather review. I checked before I left to see when the last issue was distributed, and it is March of 1974. This is an excessive delay, and the reason is that on April 1, last year, we invested in a computer. It had all sorts of bugs which actually didn't happen at our shop but happened in the construction. This threw us six months behind, instead of the normal 4 months. I was talking to the people in charge and they have extra help working now and are hoping in six months time to be back to the 4 months delay. We are aware of the problem and we think that part of it has been solved.

D. L. MacLeod, Environment Saskatchewan

I have two questions for Jack Wigham. You mentioned soil moisture prior to the snow arriving on the ground. I would like to know if you have any ideas as to how soil moisture information could be obtained on such a large area as Saskatchewan. The second question has to do with the evaporation suppression suggestion you made. You refer to Lake Diefenbaker, and I might say that something in the order of a half million acre-feet per year is the evaporation loss, and I would be very interested to know if you have any suggestions as to how we can suppress such a large loss of water.

J. M. Wigham - Panelist

With respect to soil moisture, perhaps we might have to get at this from some kind of antecedent precipitation evapotranspiration index, or the use of a continuous watershed model that would evaluate this indirectly from factors other than soil moisture measurements. And with respect to the evaporation suppression work, it is the depth that is important. The area is important in that it probably makes it more difficult to suppress evaporation because of wave action and this perhaps, is where we require some research as to methods of maintaining a mononuclear layer or something similar, on water bodies of this size and in this type of climate.
E. Ripley, University of Saskatchewan

I was wondering about some of the other publications of AES and whether there was any possibility of speeding them up in the future. I notice the 30 year normals didn’t start to appear until last year and some of them aren’t out yet. More important, I wonder if there is any possibility of the AES doing more work analyzing the synoptic weather patterns on the prairies. Another point: there is at present no upper air data collected in the province. We could do with at least one station. We have only one or two radiation measuring stations in the province. I would like to know if there is any possibility, or any plans, to expand this type of work in Saskatchewan by the AES.

T. L. Richards, Panelist

Analysis of synoptic weather patterns is done every six hours in our forecast office and would certainly be available from them. All the major storms of history are analysed synoptically in depth-area duration and are available in the Storm Rainfall of Canada Series.

R. Ripley, University of Saskatchewan

Perhaps what I really mean is a climatological analysis of synoptic meteorological events, some means of tying this together in a meaningful pattern. A certain amount of this has been done by people like Reid Bryson trying to simplify these six hour maps. Trying to use these things is impossible.

T. L. Richards, Panelist

As far as upper air data and radiation data, these networks are up to world meteorological organizations standards as far as density is concerned. They are also a regional responsibility so that the central or western region could tell you more. I see Don Bower is present and perhaps he has an answer on behalf of the region.

D. Bower - AES, Western Region

As far as Saskatchewan is concerned, there have been two stations planned for quite some time, but every time they come up they are shoved back for financial reasons. One of these sites has the buildings, and Saskatoon is the other site that is proposed.

WATER QUALITY — SESSION 2

W. Nicholaichuk, CDA Research Station, Swift Current, Saskatchewan

Are surface water quality standards adequate? Should we be extending our effort into the area of treatment, or should we be looking at improvement of these standards? The other comment I would like to make is in regard to sewage effluent irrigation. I would like to inform the people here that the CDA Station at Swift Current, in co-operation with the City is involved in a sewage irrigation project. We are attempting to monitor some of the parameters that have been mentioned. One of these is aerosol contamination of the air. Is the methodology really worked out in this area? We have a micro-biologist at the Research Station at Lethbridge who has been looking at particular colloids regarding contamination of the forages, and I think we do have some criteria established in terms of number of daylight hours required to achieve a certain kill.

I would like to make a comment regarding fertilizer contributions to surface water. My research efforts in this regard suggest that fertilizer application losses due to surface water are minimal in terms of the pounds of fertilizer applied, and the amount that is moving off in surface water. However, I think it is an area which has to be pursued because of the importance of trace amounts of phosphorus in order to reduce the contamination of surface water. This gets back to agricultural management, prevention of erosion, and surface water loss.

Dr. J. D. Wiebe - Panelist

In answer to the first question regarding water quality, the only comment I could make is that public standards should take precedence, in other words why put the stuff in, in the first place? These contributions can be man controlled in my opinion, through the surface runoff. We must create standards to control public input. I have no bones to pick with the water quality standards. I think the people in the Environment Departments are doing what they can to try and compose a meaningful set of standards. However, I have to emphasize that we must know what we are looking for. Let’s look for it and then set standards later. We have a long-range program ahead of us. How long can we afford to wait, and if we do wait - will our standards come too late?

O. K. C. Mang - Panelist

It is reassuring to know that there has been some intensive research being done on the waste water irrigation. The point that I was trying to raise is that there is a need to inform the design or consulting fraternity and the operators, of means and methods of doing the irrigation. They need a set of guidelines in order to develop applications over larger areas. At the present time there are communities that are undertaking irrigation with waste water without these necessary guidelines.
I would like to make a couple of comments and observations on the studies that have been done in New Orleans and are being done elsewhere. Before everybody jumps off the deep end, I would like to point out that the highest levels of chloroform were found to be generated in the New Orleans water supply and these levels are such that by taking one teaspoon of Vicks cough medicine, which we all have done and do, you get more chloroform in that one teaspoon that you will get by ingesting water at the level that was found in the New Orleans water supply over a period of 1 think 2, 3 or 4 years. Maybe Dr. Wiebe has more data on this. I am not saying that we don’t need to have an investigation, but I don’t think we have to panic.

The other thing that I was going to comment on is my conception of zero discharge. You just don’t discharge. Fred implied that you discharge, but that you take out everything that is in the water that shouldn’t be there. I don’t know how you will ever do it in terms of treatment and I think that if you are going to get into this, you have got a real area of research. Zero discharge for industrial waste is probably practicable in some cases, although there is a lot of work that has to be done. I question whether the general public is ready to recycle sewage to the head end, treat it, and drink it. I think that before we ever promote recycling of waste water back into the drinking water system, we have to know a lot more about what is in the water, as these gentlemen have been saying. We haven’t even an iota of the necessary information at the moment on any of these compounds. I think we are talking about zero discharge for some industrial wastes, and a lot better treatment for municipal wastes, but not completely eliminating it from the water courses of the continent.

Dr. J. D. Wiebe - Panelist

I agree with you that the chlorinated compounds are not an acute problem, but the problem is that we just don’t know what the long term effects of these are. I believe chronic exposure to this kind of thing over 10, 20 or 30 years is the problem, not the ingestion of a teaspoon full in 3 years worth of water.

T. Hammer - Panel Chairman

I agree with you. We take cough syrup in a slug for a week, then we lose our cold. The long term effects are the important ones. If we get a small amount of one rain drop a day, in 30 years we collect a lot of water. Some, of course, evaporates and we secrete some of it. At the same time I think we have to look not only at what is in the raw water right now, we have to be concerned about what we seem to overlook. We have to purify every day but at the same time we have got to know what is left. That is where we should be concentrating - how effective is our treatment. We may very well know what is going into it, we know what is there, but what do we end up with?

Mr. Lakshman, Saskatchewan Research Council

I have two questions for Dr. Hammer, and the third one is for the panel as a whole.

There is a general controversy regarding the production and elimination of algal blooms. I have read some papers on factors that limit the growth of algal blooms. They say that phosphorus, even to a small extent as 6 or 7 micrograms per millimeter, can provide enough subsistence for algal growth. There are also other factors that support algal blooms, even if you can take quite a bit of phosphorus from the water. In view of this observation, do you think it is realistic for us to expect that we can clean up our surface waters of the algal blooms in the future? The second question concerns harvesting of algae as a source of protein. Do you think this sort of thing is possible; using water pollution as a means of producing something useful?

The third question concerns the instrumentation for water quality analysis and surveillance. I think the success of a water quality management program to a large extent depends on its data gathering system. The pollution abatement guidelines that we have established for any particular system have to rely heavily on the surveillance tactics used. How do you project the potential in Saskatchewan especially from the practical operational point of view, and from your own water treatment plants’ point of view? How do you think we can manage to produce enough data to cope with the present and to anticipate the future requirements of your water treatment plants?

T. Hammer, Chairman

Regarding the first question in which you said 6 to 7 micrograms of phosphorus is sufficient to produce algae growth, I think it was way back in 1947 when it was discovered you needed only 10 micrograms of phosphorus to produce bloom conditions of algae. So rather small quantities are required. I don’t think that it is possible to eliminate the algae problem altogether by removing phosphorus or by removing any nutrient. I don’t think you can go to that extent. For example, in the Qu’Appelle Basin, if you remove phosphorus at Moose Jaw and Regina, obviously phosphorus is going to come in from the surrounding environment and there is no way of eliminating the problem completely. Perhaps you can reduce it, but I think it is illogical to expect elimination. Regarding the harvesting of algae (and I think your question was whether it could be done on a practical basis from the lakes themselves,) I have heard of no practical scheme to do this. Oswald at Berkley has done this sort of experimental work for a number of years, and the people in Winnipeg are doing almost identical work now. They found they could grow algae very abundantly and harvest them very well from rather limited sized ponds. As I recall, it produced an excellent product that would have to be mixed with other food stuffs to feed livestock, chickens and so on because it was too high in protein. However, at that time the cost was too great. Now with food stuffs increasing in cost, perhaps, it may be practical - I don’t know. But as far as doing this out in the lakes themselves, I certainly can’t foresee any technology that would make it practical.
The third question I would just as soon turn over to someone else.

Panelist

The gentleman asked about the data collection on algae. I think we have collected enough data, (which I think Dr. Hammer would confirm, having done it himself,) to last us for a long time. The object of the exercise as I see it now is to utilize this data. We can identify various kinds and we know what algae is made of. What we are concerned with now is how we can remove this material with these dissolved organic materials that have exuded into the water we are about to treat. We can take out the organism itself in the treatment plant. We have managed to learn how to do this by the use of chlorine. However, we do not know in what forms the organic compounds come out of the plant after treatment and this is where the crux is. So the object of the exercise, I must repeat, is to find out what we have done. We must analyze what has come out of the plant. If nothing comes out of any consequence, then we have nothing to worry about. All we have to do is try and eliminate this physical form from the lakes so it becomes aesthetically acceptable. This is very difficult to do as Dr. Hammer has said. We will never completely eliminate the algae in the lake.

Panelist:

I would like to address the question on monitoring and surveillance. I think in Western Canada as well as in the east we generate a lot of zeros with the monitoring and surveillance systems. Probably the attack that we should be taking is to pin-point problem areas and go after them in depth and analyze the complete system; take a systematic approach and then formulate some kind of control strategy with that system. We are studying the Great Lakes on something like a 5 year monitoring basis. In other words, monitoring every 5 years because variability within the 5 years is just so small that there is no point in monitoring every year. I think it is a matter of pin-pointing areas, going into them in depth, and making regional programs for those problem areas rather than massive monitoring and surveillance schemes that cover the whole area.

T. Hammer, Chairman

One comment I would like to make, I don’t think we should aim at eliminating all the algae. If you do that you won’t end up with any fish, and people who are interested in our recreation certainly won’t approve of that.

E. F. Durrant, General Chairman

I took another interpretation of Mr. Lakshman’s question, regarding administration of pollution abatement guidelines having in mind our capabilities for remote sensing or on-site sensing. More than once somebody has established some level of toxicity, or some guideline for controlling something or other and we in our operation where we have a lot of monitoring responsibilities, find that we don’t have the analytical techniques to monitor effectively. Let’s take an example. We might have a guideline that says there should not be more than 2 units of something in a bag of water and our analysis technique permits us to get down to the closest 100. That is the kind of problem we have and need research on. Pinpoint the problem areas and look through the whole system of how we are going to sense this so that we can have the back-up material for monitoring and control.

Tim Thiele, Ducks Unlimited

I would like to address this question to Mr. Montbriand. Have you done any research on the gravity flow and back flood irrigation of effluent as opposed to the use of sprinklers and also can you use 10 or 20 cells in the sewage treatment plant as opposed to the normal? In other words, 10 or 20 cells spread over 2,000 or 3,000 acres instead of 400 or 500.

Panelist - Fred Montbriand

These are interesting problems. My background has been in consulting engineering and not as a researcher, so I am not able to answer. Possibly one of the other panel members here might be able to offer some comments. Perhaps Murray Prescott or Rodger McDonald could offer some comments in this area.

Murray Prescott

I am not sure I understood the first part of the question. With regard to the second there is no limit to the number of cells that you can construct for a lagoon. Essentially it comes down to a matter of economics. But we have very few multiple cell lagoons in the province and we find that as you go through into the third, and in one case we have a 5 cell operation, that the quality does improve. Now what happens to some of the dissolved organics that Ozzie is worrying about, I don’t know. Phosphorus is reduced during the summer months, but then it builds up again in the winter. I think the net result of phosphorus reduction is not all that good. The first part of the question had something to do with back flood irrigation. I think our philosophy is that you can irrigate any land with any water, but there are limitations. You have to know what these limitations are and we have a problem in that the municipality is trying to get rid of effluent. I was talking to Dr. Davis this morning and he pointed out that as he drove by Davidson, he noticed the lagoon full to the brim. This is because Davidson has an arrangement with the farmer, and the farmer irrigates at the times which suit him best. The municipality’s prime interest is getting rid of effluent. You can do it on the basis that the municipality controls the operation, and if it is not all that conducive to growing the crop, because they have to get rid of more than they should be really applying at any time there is a lot of rainfall, then that is their operation problem. I suppose you could do it on a flooding proposition, but it might be more critical in terms of what you can get the soil to take. Our deputy Minister, being an agrologist, can probably give you a better answer than I can.
T. Hammer, Chairman

I could answer something to that. In Melbourne, Australia they use flood irrigation of 20 acre paddocks. And, of course, during the rainy season they have a lagoon system for taking off the excess. But they have a 42 square mile acreage, and this is run by the City of Melbourne. This, of course, has been an on-going project there since 1898. So it is not new. Their net cost is 50c per person a year to get rid of their sewage.

Eric Davis, University of Saskatchewan

Seeing that Murray brought up the subject of cost and Mr. Chairman brought up the subject of cost, it strikes me that in view of the news broadcast that I heard as I was coming down this morning which stated that this country will be essentially out of oil by 1985, and be mostly out of gas by 1990, it is possible that the proponents of more research for the increased removal of materials from waste waters and fresh waters are on a collision course. Possibly we will have to have a saw-off in the future. Maybe not total environmental control, but partial environmental control. Maybe if things get worse we will have to go back to less than what we are doing now. Would you care to comment on that.

Panelist

One of the concepts that we are looking at now is the idea of examining environmental problems and saying that we are willing to accept a loss of a certain amount of environmental well being. These are the areas of trade-off where political, economic, and social considerations can be made. There have to be and there are certain limits that we can’t, in all honesty as professionals, go beyond, because we know if we do for certain reasons we’re at some point where the eco-systems simply will not function. So I think that concept is being taken into account in most programs now.

ENVIRONMENTAL IMPACT — SESSION 3

Comment from Audience

I would like to react to some remarks that have been made by Mr. Laycock, both as a federal civil servant and what might be called a naturalized Albertan.

While the problem that he referred to is specifically related to Alberta, I think that it has general application. He implied that there was a suggestion of incomplete and secret environmental assessment of the Athabasca Tar Sands and accused both government and industry of being accomplices in this. With industry it is necessary to keep information confidential. After all, if they are going to spend millions of dollars in an environmental assessment in a competitive process, it is bad business to make that freely available to your competitors. So that explains why they keep their mouths shut. With regard to government, after preliminary studies which were made at least in 1970 which tended to define the problem in a preliminary way, negotiations were started for an agreement, by both Canada and Alberta, to undertake an environmental assessment and I think that Fred Durrant can testify that the propagation of some of these federal-provincial agreements to cost share in environmental assessment are affected by many extremities, and I can give you some of the examples in Alberta if you want, but I don’t think they are pertinent here. I just want to say that until those agreements are concluded, of necessity they must be confidential.

A. H. Laycock

I agree part way, but this is one of the big problems. Just how far does one agree. For example, is it necessary to keep secret the report by Meneley and Christiansen on ground water for over a year and a half? Is it necessary to keep the Kellerhouse Report on surface water a secret for almost a year? I doubt it. The same tends to apply to industry reports. The industry reports concern a resource that is very well defined. This is not a matter of looking for oil in the conventional manner. The resource is fairly well defined. The major technology involved has been invented not by industry but by the Alberta Research Council, Dr. Clark for example, and various other people. A very large part of this information is public information. I agree that there are some aspects of technology that GCOS would like to see and GCOS perhaps has greater grounds for keeping some things secret than perhaps Syncrude at this particular stage, but I think that one can overdo this and I am sure that it has been badly overdone. I think that it is a government responsibility to make a great part of this information public for industry as well as shall we say for government, in part because this decision making is on behalf of the public.

E. F. Durrant

I would like to direct a question to our biologists on the panel or people with biological background. I have just drawn a map of a part of the prairies pre-1800 and on it I have marked those areas that have been removed from wildlife habitat by works of man. Now the second map I want to draw is a map of today where I
change the legend. I draw here those parts of the prairies where the wildlife habitat still remains and the rest has been withdrawn for agriculture operations over the past 100 years. All the wildlife habitat has gone except stream valleys for because the land is too steep to farm, or too arid or something wrong with it for it. Now we have had farming, or a few wetlands or uplands where you can't farm. Now we have had farming, or a few wetlands or uplands where you can't farm. Now we have had farming, or a few wetlands or uplands where you can't farm.

Panelist

I am not sure I understand all of your question Fred, but to a large extent that occurs naturally with the fluctuating water cycle on the prairies where we have wet years and dry years. In other words, what was ploughed last year because there is good runoff this year becomes a slough which is good duck habitat. Now if I understand the rest of your question correctly, if all of the water on the agricultural land were drained and put in large reservoirs would it replace the millions of small basins which are required for production? I think the answer is no.

E. F. Durrant

If this reservoir is proposed and we are doing one of these studies that Dr. Stabler was referring to, we are going to lose all of that area as wildlife habitat. I am referring to the container as well as the water. And we have got very little of it left you see, except for this fluctuating thing for water fowl, but for the other species we have got very little left. Do we know enough about the means or methods for actually moving into an area now used for agriculture and planting trees or doing something else to make it a habitat area which will replace what is lost in the reservoir and costing it out and saying this might be part of the project.

D. Stephen

I think the details might be fuzzy, but the general principles are well enough known and could be proceeded with. As I referred to with wetlands, there are many small ones of a very ephemeral nature which are really insignificant to water fowl. There are many uncultivated wooded areas that are a tenth of an acre in size that are of very little use to wildlife of any kind except as occasional roost for a magpie. So that, in general, the possibility of developing wildlife habitat on agricultural land to replace that lost by reservoir development I think is there, and very largely that can be done naturally and merely takes time.

Mr. Lakshman

I think the basic objective of an impact study is to define the problem, define the parameters involved, define the inter-relationships among the parameters and then find if certain processes are irreversible. And certain aspects of this should be mentioned in any impact study because some of the land uses that we adopt today may generate some changes which are completely irreversible. Probably this is one of the basic faults in most of the impact studies. The idea that some aspects are not studied in detail, the result of which is an impact study done in one area cannot be translated or transferred or applied to another area similar in nature. The reason is the parameters have not been defined properly, the processes have not been studied.

One of the things that I want to comment on is the time scale of research, especially in impact studies. A research worker, depending upon his field, discipline, and enthusiasm, finds he has to devote a considerable number of years to collecting the necessary data. But the fellow who gives the funds is interested in instant results, and would like to have his results yesterday. This is a problem. Somewhere along the line we have to compromise and it does happen that we come to a compromise on two to five years of time. But there is a basic dilemma involved in impact studies. The very fact that an impact study involves a lot more disciplines than one discipline. Therefore the cycle involved in each discipline is varied. For example, if you want to study the impact of certain water development programs on wildlife, the wildlife habitat cycle is quite different from a water quantity or quality cycle, or a meteorological cycle. There is a gamut of life spans. What is a good cycle for research in water quality and quantity may be insignificant when we come to wildlife habitat or water fowl habitat. A case in question would be the subject of snow cover, and the precipitation tendencies, and the water quality and quantity, and the consequence on the wildlife habitat. Now in such cases, there has to be some way of determining an optimum period for impact studies.

J. Stabler

The point that I was making in the talk is that as presently conceived or presently utilized, impact studies are attempting unsuccessfully to perform two functions; a research function and a usefulness as a decision making tool. To some extent these functions are incompatible with one another. Research requires a long time. If we learn anything in 2 to 5 years we've really done well. But we need to make decisions in a much shorter time frame. What I was suggesting is that the research and decision making functions be split off. The effort that is now going into defining in detail from scratch, the over-reaction of various development proposals be diverted, instead, into the development of general models which could be used to simulate quickly the impact of various development proposals.

In cases which are truly unique where we do not have any knowledge of the impact of a potential development I think we necessarily have to combine the two. The research to define what the circumstances are and then use the results in a decision making context. But I do think that the number of cases that are truly unique are few in number. And we do have a pretty good knowledge of the general impact of various types of development and we do have information and capability which could be used to develop these general simulation type models.
General Discussion

Walter Kupsch, Director, Churchill River Study

It occurred to me this morning when we talked about the North and the South, the North being a water surplus area and the Southern part being deficient in water, that nobody mentioned any work or possible plans on water diversion from the north to the south. I want to raise that question. Is there any work being done on that? Is anyone seriously considering bringing large amounts of water from the north to the south?

E. F. Durrant

There were 2 or 3 considered in Saskatchewan by the Saskatchewan-Nelson Basin Board. One was a possible diversion of the Clearwater River which runs into the Athabasca River and joins at Fort McMurray, a diversion of that river into the Athabasca River southward through Turnor Lake over to the Churchill River System in Saskatchewan. Another one that was recognized was the possibility of 1500 cfs. Another one that was recognized was the possibility of about 1500 cfs. Another one that was recognized was the possibility of about 1500 cfs. Another one that was recognized was the possibility of about 1500 cfs.

Questions from Audience

I would like to ask Walter if he objects to diversion per se or if he objects to studies of diversion. If he objects to studies of diversion I would violently disagree with him. If he objects to a diversion as such there are very good arguments for such objection in many cases.

Walter Kupsch

I didn't object to diversions or even studies of diversions. I was merely asking a question as we get this question thrown at us all the time in the Churchill River. I didn't object to diversions or even studies of diversions. I was merely asking a question as we get this question thrown at us all the time in the Churchill River.

While I am up here I would like to mention something that we talked about during coffee, and that is the remark that came out after Jack Stabler commented about the impact studies and the difference between the tool for decision makers and the research, and that you can't combine these two things. I think the point is quite right. There is a need for various disciplines, various lead times, not only because wildlife goes in five year cycles and you need only a year to study hydrology or something like that. There is another thing in there and that is some disciplines, something like that. There is another thing in there and that is some disciplines, something like that. There is another thing in there and that is some disciplines, something like that. There is another thing in there and that is some disciplines, something like that. There is another thing in there and that is some disciplines, something like that. There is another thing in there and that is some disciplines, something like that.

Jack Stabler

I wish I could reassure you Grant. I think probably the closest we can come to it is in the present discounted value business which has been around for a long time and isn't very satisfactory, but is probably the best thing we have at the moment.

E. F. Durrant

What that really means Jack, is that a benefit that would accrue in 50 years has almost no value at the present interest rates. So that although we're important, our great grandchildren aren't.
SUMMARY

E. F. Durrant, General Chairman

What I would like to do is hit the highlights - things that came out of the various presentations that impressed me.

Introduction - T. P. Pepper

I rather enjoyed Tom Pepper's global approach to the hydrologic cycle. In Saskatchewan where we have an outflow 2½ times the inflow and the water in the atmosphere at 70 times the inflow, he explained that you should put most of your research where you have most of your water, but that is not necessarily true. I thought it was an interesting way of looking at the cycle. Tom also mentioned something that isn't a truism, but nevertheless needs to be kept in mind at a symposium such as this.

None of us whether engaged in research or application can look at only one part of the hydrological cycle. We have to look at the environment as a whole.

Session #1 - "Supply of Water"

The first speaker, Vince Beckie, underlined the scarcity of data on aquifers that are developed and under production. That has been true for a number of years. It continually puzzles me why we don't do something about it, because every time you come up against a groundwater problem in an area where the aquifer is developed it is a lot of theory and a lot of hunch and that kind of thing rather than actual data on drawdown or what have you. That in turn would help us with the second problem he mentioned: understanding the recharge system and process for different aquifers. We need more research here. He also mentioned that we should study the possibility of recharging aquifers with fresh water to guide and influence the water quality of usable aquifers. And finally he said we don't know enough about the pollution of aquifers and I think most of you who have run into problems related to water would agree heartily.

Lloyd Richards presented a quick summary of what the Meteorological Branch thinks of its role in the provision of data and the analysis of data and the studies and reports that their people do, and mentioned the expert advice that is available to people with problems in the meteorological or hydrometeorological area.

Professor Wigham broadened the surface water topic by moving into water resource systems a little more. The first point he made was that there is a need to see how applicable the existing hydrologic models are to prairie conditions. Around the world and perhaps more strongly in the USA, a lot of models have been developed to try and produce runoff data from meteorological and other input and many of these models have many coefficients in them that permits you some flexibility in applying them to local situations. But as he suggested the main parameters in determining prairie runoff are sometimes not even included in these imported models and perhaps we need to examine these, although there is a lot of work in that area underway. He also said we need to better understand the basic snowmelt processes here in the prairies and again there is research work underway, particularly in the Bad Lake area, under the auspices of the Division of Hydrology, University of Saskatchewan, but it is a continuing need. He mentioned better concepts or systems of measuring moisture conditions in watersheds prior to runoff as an index in these runoff models. He was referring both to soil moisture as well as better methods for determining the water equivalent of the snow pack. And again there is some work underway using pack radiation, natural radiation from the ground and its attenuation to determine the water equivalent of the snow pack. The question of soil moisture I suppose is going to get swept under the rug for another 10 years, because I don't know of anybody who has a fail-safe soil moisture monitor. Soil moisture is one of the most difficult things in the world to measure unless you take a sample home and cook it. He touched on another problem briefly, which is important for people to recognize: that prairie catchments have a variable contributing area and nobody has developed a quick and easy way to take this into account in hydrologic analysis. He mentioned as the pressure for energy and perhaps food and fibre increase, we're going to have to look to systems analysis to try to optimize the regulation and use of our surface water supplies, but also in conjunction with other supplies. And in mentioning this I think he clashed with a later speaker who quoted someone who did suggest that the use of models for this purpose is somewhat inadequate in that models are too narrow. You can't put enough parameters in there to take care of all the variables. But, nevertheless we should encourage people to keep trying, as mentioned by Jack Stabler. Without a computer model there is no way that you can study some of these problems quickly and run through 50, 60 or 70 alternatives to get an idea of the 5 better ones that are more worthy of detailed study.

Discussion

In the discussion, Mr. Lakshman of the Saskatchewan Research Council pointed out the lack of socio-economic input, not only in the modelling that has been done to the present, but also in most management decisions. We need some system or some method or technique for getting new economic and democratic trends worked into our analysis and eventually worked into our management decisions.

Discussion brought the question to Lloyd - how come, over the past 4 or 5 years you are improving the rate of delivery of meteorological data and then all of a sudden it slipped? He had the best answer in the world - he bought a new computer.

Session #2 - "Water Quality"

Then we moved on to the Water Quality session and enjoyed an entertaining and colorful tape, prepared by Ozzie Mang, showing what is in the water that you drink, and if some of you are allergic to water I am sure you will be more so now. He went on to emphasize the need for the Federal Government to inject more funds into research which is undertaken by industry and a concomitant need for
co-ordinating university and industry efforts in water quality research. He cited a number of recent treatment problems that he had run into and I won't go through them again. He also mentioned that there are fewer cavities in Moose Jaw. They are fluoridating their water and we in Regina are not.

Mr. Montbriand mentioned a catch phrase, the zero discharge concept and I thought he meant zero discharge of contaminants. Someone else I was talking to later thought it meant zero discharge of anything, which of course is a very bad water use concept - you don't get it back. But in any case in introducing it and the subsequent discussions it was revealed that we don't know enough to say whether we must move towards a zero discharge concept or whether we can accept something radically different than that because we don't understand what is in a lot of these effluents. Neither do we know how to treat them economically as we understand economics today. He also mentioned some of the problems that might be associated with spray irrigation or effluent irrigation with sprinklers. I hadn't thought of the aerosol problem before. I have always used that word in association with my shaving cream, but I realize that there could be some drift which might upset people downwind. The question of algae control in lakes was also brought up during his presentation. And he mentioned something that I hadn't run into before and that is the possibility of irradiating lake bottoms and doing away with a lot of the bacteria thereby reducing the rate of nutrient release. But I think we should bear in mind the later comment by Dr. Hammer, that if we over-surge the growth of algae, then we won't have any fish. But it is an interesting possibility.

I think Dr. Wiebe introduced a point that he could have emphasized more and people commenting on it could have emphasized more, and I was very pleased that he brought it up. We need a much better understanding of the effects of chronic exposure to toxic elements both singly and in combination. Now by chronic we mean over a period of years. How do you get that in a hurry? We hadn't even heard of mercury in water a few years ago and then all of a sudden somebody has to set standards for it and your standards should be based on how much exposure can you accept over your life time, and on the basis of 2 to 3 years of data this is a very difficult thing to do even if you are an ardent statistician. So I would like to underline his point and the comments of others that the chronic effects of toxic elements both singly and in combination is indeed an area where we need a great deal of research. He also said we need new indicators for our recreation water quality. What is safe for swimming, for water skiing and so on, and our objectives, where we have them, are still somewhat arbitrary and there are unknowns. Of the unknowns he mentioned - viruses. We need better assay procedures for viruses and a better understanding of how to get rid of them. We need a better understanding of the chain of events, let's call it the biological concentration of pollutants through the ecological chain where the worms eat the algae and something else eats the worms and the fish eats that and we eat the fish and the toxicity of some element might be radically different in what we eat than what was in the water originally.

Walt Nicholasuk from Swift Current mentioned the work that the Department of Agriculture is doing on irrigation using sewage effluent and doing some work as well on aerosol contamination. But he did question whether we have adequate methods to measure all of the aspects of aerosol contamination. And in this discussion Mr. Montbriand commented that if sewage effluent of irrigation appears to be a good way of unloading some of our problems on the soil, we need good guidelines for the operators of sewage effluent irrigation. Most of the classical treatment in operating sewage disposal plants is not necessarily what the fellow needs to know if he is going to be a farmer. In the same discussion Murray Prescott added some comments which should ease our alarm concerning the possible creation of chloroform from chlorination of drinking water. But after his comments I can assure you that I will never again use Vicks Cough Syrup. One thing that I learned today is that I get more chloroform when drinking one dose of cough syrup than I would with 3 or 4 years of drinking treated water.

Recycling came up in that discussion as well and Murray identified the need for more knowledge of what is in the water before we start on any kind of recycling.

There were some interesting questions again from Mr. Lakshman after this session and I thought I would underline these. Can we clean up algae blooms in our prairie lakes? The answer was a categorical no. But perhaps we might be able to reduce it. And I think we all understand that this is because the natural nutrient input from the soils in our area leaves us with this legacy. The harvesting of algae also was mentioned and I think the panel agreed that they have not heard of any cases where practical algae harvesting experiments had been set up, but that good work had been done on what protein value you can get out of a small pond being managed for algae production. Murray Prescott mentioned to me at one time that in lake experiments of this type were being conducted in the Hannah Lakes in Ontario.

Eric Davis concluded the discussion with an interesting point. If we talk about the removal of more and more exotic effluents, one of the things we are faced with is the consumption of more and more energy and he suggested that might be a problem before too long. It was an interesting observation.

Session #3 - "Environmental Impact"

The panel on Environmental Impact was introduced by the Chairman with a plea to all of us to do what we can, whenever we can, to take the lead in moving people toward an interdisciplinary approach throughout the educational system. I can't agree more. I think our children should find out at an early age that they can work together, rather than finding out at my age that your colleague in Wildlife might be a human being. So I am all for the inter-disciplinary approach as was everyone here, and I think it would be well to underline that not only in the working world, but starting early.

Mr. Laycock mentioned two objectives that the USA has adopted in recent legislation. One was the legislation related to water and environmental assessment, etc. The two principles are that they want to enhance productive efficiency and secondly to enhance the environmental goals. The point he made was in order to achieve two somewhat opposing objectives, there is a need for compromise. Therefore it is necessary to search for improved environmental
guidelines and economic objectives which reduce the conflict between these two objectives. How, I don’t know, but there is a need. He also gave us an interesting insight into the oil sands problems, but as a federal civil servant I will reserve comment at this point in time.

We then moved to Doug Stephen. I want to thank Doug for his broadening of the concept of water at the beginning of his talk. He stated that water includes the dew on the grass and that from a wildlife point of view, or environmental point of view, they are interested in the container as well as the substance itself, the container being the lakes and river banks. I think that is an interesting broadening of the concept that we should keep in mind in any work we might do. He touched on a number of matters of interest that must be kept in mind in this business of doing environmental assessments and determining environmental impact. He also went through a list of things that Bruce and Maasland had identified in an earlier paper and some of these I noted because they still are very relevant: a thorough understanding of hydrologic processes and geomorphology, more effort to analyze the results from research basins, more effort directed toward getting a capability of predicting water conditions in watersheds, more regional hydrologic studies, more work to help us understand how we can use these waters for wildlife, high salinity waters. And Doug suggested that use of these waters for wildlife is not always overlooked. In these production might be a possibility, which is sometimes overlooked. In these concerns identified by Bruce and Maasland and repeated by Doug, was the observation that we avoid the degradation of the rest of North America. And I rather enjoyed his comment that the natural conditions we consider good in last rather than the conditions created artificially in Lake Erie. But one point he made that I would like to emphasize is the need for a better bridge between research knowledge and what is applied by people designing or making management decisions. We have a lot of knowledge produced through research and perhaps the conventional way of reporting in papers in certain journals almost prevents it from reaching the people who are going to apply this knowledge because they didn’t read the journals. He mentioned the storage of data and information, and methods for retrieving this so that you can actually get it into the hands of the planners. We need to do a lot of work to design that bridge. We need that bridge very much. I heard the same comment at a symposium in Winnipeg last October on reservoir ecology. How do we find out how reservoirs affect the ecology and the research people who were there said well we know that it does, but the people who designed reservoir’s said, why didn’t you tell us? The inclination isn’t there, the bridge isn’t there. There was one comment brought forward from that paper which I don’t entirely agree with and that is that federal jurisdictional problems have prevented comprehensive water development systems from evolving, systems which other countries enjoy. I think we have come a long way certainly since that paper was published (1968) and in this area there is very good progress.

Dr. Stabler set out something that all of us are beginning to accept now: growth as a philosophy is losing its popularity and consequently direct benefit cost analysis must now be supplemented by indirect effects that we determine through Impact Studies, but the largest associated problem is one of time. A lot of the things that we are trying to do in assessing impact are somewhat new. Not always new knowledge or understanding of cause and effect, but it is somewhat new in that we are trying to determine rather quickly some quantifiable result from a certain action and we don’t have the tools and techniques for that. And so we have a time lag from when we feel we want to build something until we can fully determine its environmental effects. We need work of some kind which will help us shorten that time gap. And I think that the comment that Dr. Kupch made is somewhat related to the comment that I attributed to Dr. Stabler. If we keep flying off half cocked to do a study of the impact of this thing, and that thing, and we concentrate our resources in trying to satisfy what appears to be the needs for people to know what the impact is going to be, the needs of the people and the press and news media, we will be committing all our resources and all our skilled people to these urgent items and we might not be getting the basic understanding that we require not only of processes and systems that I have mentioned in the summing up, but also we might forego a somewhat more systematic survey of resources than we could otherwise mount.

In closing, I would like to express my thanks to the panelists, the participants, and to the audience for their contributions and their patience.

D. J. Berry, Chairman, Water Studies Institute

On behalf of the executive of the Water Studies Institute I would like to thank the speakers, the panel chairman, Grant Mitchell, Dr. Pepper and our General Chairman, Fred Durrant, and of course, all of you who had a hand in this symposium.
<table>
<thead>
<tr>
<th>Report No.</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSI 1</td>
<td>Symposium No. 1 - Research Needs In Relation to Water</td>
<td>October, 1963</td>
</tr>
<tr>
<td>WSI 2</td>
<td>Symposium No. 2 - Water and Climate</td>
<td>November, 1964</td>
</tr>
<tr>
<td>WSI 3</td>
<td>Symposium No. 3 - Rural Water Supplies</td>
<td>January, 1966</td>
</tr>
<tr>
<td>WSI 4</td>
<td>Symposium No. 4 - Water Resources Of Western Canada</td>
<td>November, 1967</td>
</tr>
<tr>
<td>WSI 5</td>
<td>Symposium No. 5 - Water, A Northern Resource</td>
<td>October, 1971</td>
</tr>
<tr>
<td>WSI 7</td>
<td>Report of the Sub-Committee on Water Related Projects - Research and Management</td>
<td>October, 1973</td>
</tr>
<tr>
<td>WSI 8</td>
<td>Saskatchewan Water Studies Publications and Search Index</td>
<td>November, 1973</td>
</tr>
<tr>
<td>WSI 9</td>
<td>Symposium No. 6 - Research Needs in Relation to Water - 1975</td>
<td>February, 1975</td>
</tr>
</tbody>
</table>