National Energy Board

Office national de l'énergie

Short-term **Natural Gas** Deliverability *from the* **W**estern **C**anada **S**edimentary **B**asin *1998 - 2001*

An **ENERGY MARKET ASSESSMENT** • June 1999

National Energy Board

Office national de l'énergie

Short-term Natural Gas Deliverability *from the* **W**estern **C**anada **S**edimentary **B**asin *1998-2001*

An **ENERGY MARKET ASSESSMENT** • September 1999

Cat. No. NE23-82/1999E
ISBN 0-662-28161-6

This report is published separately in both official languages.

Copies are available on request from:
Publications Coordinator
National Energy Board
444 Seventh Avenue S.W.
Calgary, Alberta
T2P 0X8
Fax: (403) 292-5503
Phone: (403) 299-3562
Internet: www.neb.gc.ca

For pick-up at the NEB office:
Library
Ground Floor

Printed in Canada

Nº de cat. NE23-82-1999F
ISBN 0-662-84006-2

Ce rapport est publié séparément dans les deux langues officielles.

Exemplaires disponibles sur demande auprès du:
Coordonnateur des publications
Office national de l'énergie
444, Septième Avenue S.-O.
Calgary (Alberta)
T2P 0X8
Télécopieur: (403) 292-5503
Téléphone: (403) 299-3562
Internet: www.neb.gc.ca

En personne, au bureau de l'Office:
Bibliothèque
Rez-de-chaussée

Imprimé au Canada

*This publication is printed on paper containing **20%** Total Recovered Fiber/All Post-Consumer Fiber*

TABLE OF CONTENTS

List of Figures and Tables ii

List of Acronyms and Units iii

Foreword iv

Chapter 1: Introduction 1

Chapter 2: Overview of Natural Gas Markets

2.1 Domestic Market 3
2.2 Export Market 4
2.3 Future Requirement for Natural Gas for the WCSB 4

Chapter 3: Factors Affecting Short Term Gas Supply

3.1 WCSB Gas Areas 7
3.2 Historical Production Rates and Reserves 8
3.3 Drilling Activity 10
3.4 Role of Storage 12
3.5 Producing Characteristics 13

Chapter 4: Deliverability Forecasts

4.1 Base Deliverability Forecast 17
4.2 Sensitivity to Input Parameters 19
4.3 Deliverability Trends to Date in 1999 20

Chapter 5: Summary and Conclusions 21

Glossary 23

Appendix I: Raw Gas Production by Region 25

Appendix II: Gas Well Completions by Region 31

Appendix III: Intra-WCSB Gas Sales and Ex-WCSB Pipeline Transportation 37

Figures

2.1	Major Gas Pipelines in Canada	3
3.1	Western Canada Gas Areas	7
3.2	WCSB Production & RR/P	8
3.3	WCSB Raw Gas Production by Connection Year	9
3.4	WCSB Gas Well Completion	11
3.5	WCSB Gas Well Investments	11
3.6	WCSB Produced and Marketed Gas Volumes	12
3.7	WCSB Gas Dispositions	13
4.1	WCSB Forecast of Connected Gas Wells	18
4.2	WCSB Deliverability Forecast	18
4.3	WCSB Deliverability Comparisons	19
4.4	Western Canada Storage Levels	20

Tables

2.1	Pipeline Design Capacities and Intra-WCSB Gas Demand	5
3.1	Percent Share of WCSB Raw Gas Production	10
3.2	Decline Rates for Connected Wells by Connection Year	14
3.3	Estimated Producing Characteristics of Recently Connected Gas Wells	15

Acronyms

ANG	**Alberta Natural Gas**
B.C.	**British Columbia**
EMA	**Energy Market Assessment**
Foothills	**Foothills Pipe Lines Ltd.**
The Board/NEB	**National Energy Board**
NGMA	**Natural Gas Market Assessment**
NW	**North West**
RR/P	**Remaining Reserves to Production ratio**
SE	**South East**
SW	**South West**
TCPL/TransCanada	**TransCanada PipeLines**
U.S.	**United States**
WCSB	**Western Canada Sedimentary Basin**
WEI	**Westcoast Energy Inc**

Units

Prefix	Multiple	Symbol
kilo-	10^3	k
mega-	10^6	M
giga-	10^9	G
tera-	10^{12}	T
peta-	10^{15}	P
exa-	10^{18}	E

m3/d	=	cubic metres per day
Mcf	=	thousand cubic feet
MMcf	=	million cubic feet
Bcf	=	billion cubic feet
Tcf	=	trillion cubic feet
Mcf/d	=	thousand cubic feet per day
MMcf/d	=	million cubic feet per day
Bcf/d	=	billion cubic feet per day
Gj	=	Gigajoules (10^9 joules)

FOREWORD

The National Energy Board ("the Board" or "NEB") continually monitors the overall energy situation in Canada by considering long and short-term developments in supply and demand.

As a result of the integration of the energy markets, the Board has implemented a program of Energy Market Assessments ("EMA") which cover near-term developments and long-term outlooks. The EMA program will provide analyses of the major energy commodities on an individual commodity basis, as well as, in specific cases, on an integrated commodity basis. Thus, the EMA program includes what were previously known as *Natural Gas Market Assessments ("NGMA")* and this present report, using the previous terminology, would have been considered to be an NGMA.

For the natural gas market in particular, specific developments are monitored, assessed and published periodically in the Board's EMA reports. EMAs are focussed on current issues specifically related to the functioning of the market and characteristics of the resource base.

This EMA report, titled *Short-term Natural Gas Deliverability from the Western Canada Sedimentary Basin, 1998 -2001*, examines the factors which affect gas supply in the short term and presents an outlook for deliverability to the year 2001. The main objective of this report is to advance the understanding of the short-term gas supply situation by examining recent trends in the production characteristics of the Western Canada Sedimentary Basin ("WCSB") and applying them to provide an outlook for short-term deliverability from the WCSB. An analysis of the long-term outlook for supply and demand of all energy commodities is published periodically in the Board's *Canadian Energy - Supply and Demand* reports[1] which is an integral part of the EMA program. With respect to natural gas, these reports provide long-term outlooks for natural gas supply and demand including perspectives on reserves, productive capacity, prices, demand and interfuel substitution, in the overall framework of Canadian energy commodities.

[1] Canadian Energy Supply and Demand to 2025, published in June 1999, is the most recent of these reports.

INTRODUCTION

From 1996 to 1998, natural gas producers faced a situation of constrained pipeline takeaway capacity from the WCSB. Average natural gas production was flat at about 15.4 Bcf/d (435 million m^3/d) during this period and exports of natural gas increased only marginally, slowing significantly from average double-digit growth over the previous five years. The constraint in pipeline takeaway capacity from the WCSB resulted in an oversupply situation in western Canada; consequently, natural gas prices in Canada dropped and remained low relative to other markets, such as the U.S. Midwest, until pipeline expansion projects were announced.

Producers were also adversely affected by lower crude oil prices over the past two years. Industry cash flow was substantially reduced and drilling activity plummeted from over 16,000 wells in 1997 to less than 10,000 in 1998. The reduction in activity was primarily experienced for oil well drilling as gas well completions were only slightly lower.

In late 1998, expansions on the systems of TransCanada PipeLines Limited ("TransCanada") and Foothills Pipe Lines Ltd. ("Foothills") resulted in 1.1 Bcf/d (31 million m^3/d) of additional takeaway capacity. The Board also approved an application by TransCanada for an additional 109 MMcf/d (3 million m^3/d) of capacity to be in service by November 1999 and an application by Alliance Pipeline Ltd. to construct a pipeline capable of delivering 1.3 Bcf/d (37 million m^3/d) from the WCSB by the second half of the year 2000.

There was a significant amount of speculation in the fall of 1998 as to whether producers would be able to increase gas production to fill the larger amount of available pipeline capacity, especially in an environment of sharply curtailed cash flow.

The recent and planned expansions in pipeline takeaway capacity are creating a better balance between gas supply from the WCSB and the ability to move it to markets, thereby further integrating the North American gas market. This transformation or new market condition provides the setting for this EMA report.

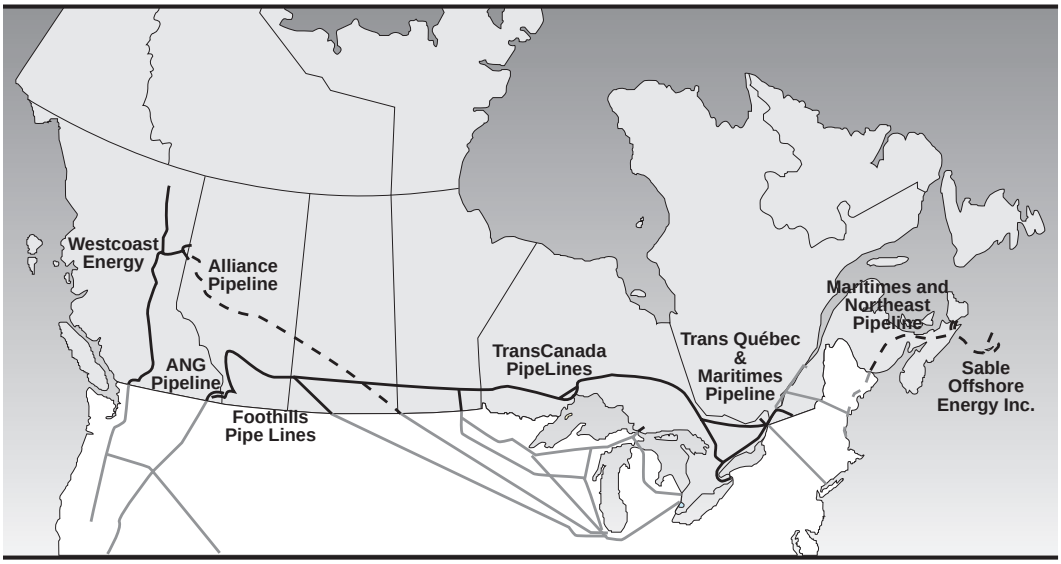
Chapter 2 contains a historical review of natural gas demand and an outline of assumptions for demand used in the preparation of deliverability outlooks. Chapter 3 identifies and discusses the key factors which affect short-term gas supply, Chapter 4 presents the Board's outlook for short-term deliverability and Chapter 5 summarizes the key conclusions.

OVERVIEW OF NATURAL GAS MARKETS

Canadian natural gas production is delivered to domestic and export markets through a number of pipeline systems (Figure 2.1). Since the deregulation of natural gas in 1985, exports have accounted for an increasing share of production. For the last five years, deliveries of Canadian natural gas to the export market have exceeded deliveries to Canadian customers. In 1998, an average of about 8.6 Bcf/d (244 million m^3/d) or 55 percent of Canadian gas production was exported. Domestic consumption averaged 6.8 Bcf/d (193 million m^3/d) last year.

FIGURE 2.1

Major Gas Pipelines in Canada



2.1 Domestic Market

Based on pipeline takeaway capacity, the domestic gas market can be simply categorized as intra-WCSB sales (including British Columbia, Alberta and Saskatchewan) and ex-WCSB sales (including Manitoba, Ontario and Québec). Overall, consumption of natural gas has tended to be slightly higher in the intra-WCSB market, which is dominated by industrial customers such as petrochemical processors and end-users associated with the energy industry such as enhanced oil recovery projects. Alberta is the largest consumer of natural gas in the intra-WCSB market and accounted for more than 30 percent of domestic demand in 1998. Ontario dominates the ex-WCSB market as it consumes about the same amount of natural gas as Alberta.

Domestic demand for gas supplies from the WCSB can experience seasonal swings of up to 3 Bcf/d (85 million m^3/d). Since pipelines leaving the WCSB are operating at the high load factors, only about 0.5 Bcf/d (14 million m^3/d) of seasonal swing can be attributed to the ex-WCSB market (the swing within the ex-WCSB market is actually about 2.5 Bcf/d (71 million m^3/d) and this is largely met by gas storage located in southwestern Ontario). The remaining 2.5 Bcf/d (71 million m^3/d) of seasonal swing can therefore be attributed to the intra-WCSB market. This additional demand is primarily mitigated by gas storage located in western Canada. A further discussion of gas storage is in section 3.4.

Recent low oil prices have resulted in a loss of market share for natural gas over the past two years in the ex-WCSB market. Market share for natural gas is, however, expected to recover with a rise in oil prices. Over the next few years to 2001, domestic demand for gas is expected to grow moderately, led by the electric generation sector. However, demand for electric generation, especially in Ontario, is uncertain and dependent on the amount of nuclear retirement.

2.2 Export Market

Canadian natural gas is exported to four primary markets in the United States - the Midwest, the Northeast (including New England and the mid-Atlantic states), California and the Pacific Northwest. The Midwest has historically been Canada's largest export market and in 1998 this market accounted for about 35 percent of Canadian exports. California and the Northeast each imported about 25 percent of Canadian exports with the remainder imported by the Pacific Northwest.

As mentioned is section 2.1, there can be a seasonal swing from domestic demand for gas supplies. To the extent that pipelines serving the export market are operating at high load factors year-round, the demand for gas supply for the export market tends to be stable throughout the year.

Expansions in 1998 and new construction will result in total additional export capacity of 2 Bcf/d (57 million m^3/d) to the Midwest and about 397 MMcf/d (11million m^3/d) of capacity to the Northeast market by the second half of the year 2000.

2.3 Future Requirement for Natural Gas from the WCSB

For the purpose of this report, the upper limit for natural gas requirements is defined as the sum of intra-WCSB sales and total ex-WCSB pipeline capacity expected by 2001. Assuming that intra-WCSB consumption remains at the current level for the next two years and that there are no other significant pipeline expansions, the upper limit of natural gas requirements would be 18.8 Bcf/d (530 million m^3/d) by 2001 (Table 2.1). Clearly though, the pipelines will not be operating at a 100 percent load factor; in other words, the upper limit for requirements. In practice, pipelines are considered to be fully utilized when the annual average load factor is greater than 90 percent.

TABLE 2.1

Estimated Future Pipeline Capacity and Intra-WCSB Demand in 2001 (Bcf/d)

Pipeline	Market	Average of Winter and Summer Design Capacity (Bcf/d)
ANG	California	2.5
Foothills	Midwest	2.4
TransCanada	E. Canada, Midwest, Northeast	7.6
Westcoast[2]	Pacific Northwest	1.3
Sub-total: pipeline capacity		**13.8**
	Intra-WCSB sales[3]	3.6
Sub-total: current demand		**17.4**
TransCanada (Nov. 1999)	E. Canada, Northeast	0.1
Alliance (Nov. 2000)	Midwest	1.3
Upper limit for demand in 2001		**18.8**

This report adopts a demand projection from the NEB's 1999 report *Canadian Energy Supply and Demand to 2025*, specifically, the accelerated efficiency demand case. Natural gas requirements under this scenario would be 17.1 Bcf/d (485 million m^3/d) by 2001. This level of demand equates to about a 91 percent load factor based on the previously defined upper limit for natural gas requirements.

[2] The capacity at Huntingdon, B.C. consists of 1.18 Bcf/d of receipt capacity by Northwest Pipeline Company (the major transmission system in the Pacific Northwest) plus 0.1 Bcf/d for other exports not utilizing that system.

[3] Average annual demand in 1998.

FACTORS AFFECTING SHORT-TERM GAS SUPPLY

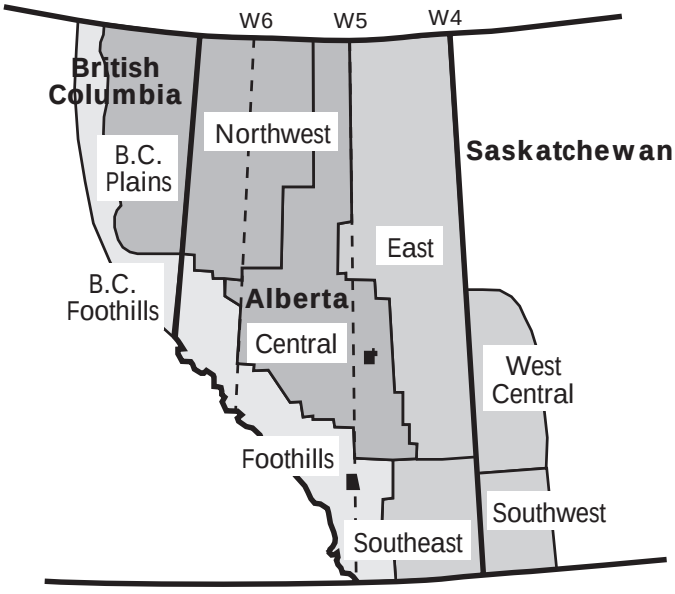
There are several factors which will influence the level of deliverability from the WCSB over the next three years. Some factors are related to the ability to produce gas over an entire year while others affect the ability to meet the additional demand during winter heating seasons. This chapter describes these factors and provides historical information to demonstrate the effects on deliverability.

3.1 WCSB Gas Areas

The topography and geology of the WCSB varies regionally and this influences the exploration and development strategies of the gas industry. Based on these topographic and geologic variations, the WCSB can be subdivided into nine geographic areas (Figure 3.1).

FIGURE 3.1

Western Canada Gas Areas



These nine areas have been used for the purposes of preparing detailed analyses of the production characteristics in order to derive a typical well. However, only three groupings are necessary to represent wells of similar drilling costs.

The *low cost* grouping includes the four areas in the eastern portion of the WCSB: Saskatchewan Southwest, Saskatchewan West Central, Alberta Southeast and Alberta East. Gas wells in these areas are shallow and surface locations are easily accessible; consequently, exploration and development costs tend to be low. This grouping contains many of the wells drilled in the last decade. An average cost of a well in these areas ranges from $75,000 to 1,000,000.

Alberta Central, Alberta NW and B.C. Plains form the *medium cost* grouping. Although the central portion of Alberta is easily accessible, well costs are higher due to increased well depths. On the other hand, wells in northwest Alberta and the B.C. plains tend to be fairly shallow but costs are higher due to the difficulty of access. Costs for this grouping range from $500,000 to 2,000,000 per well.

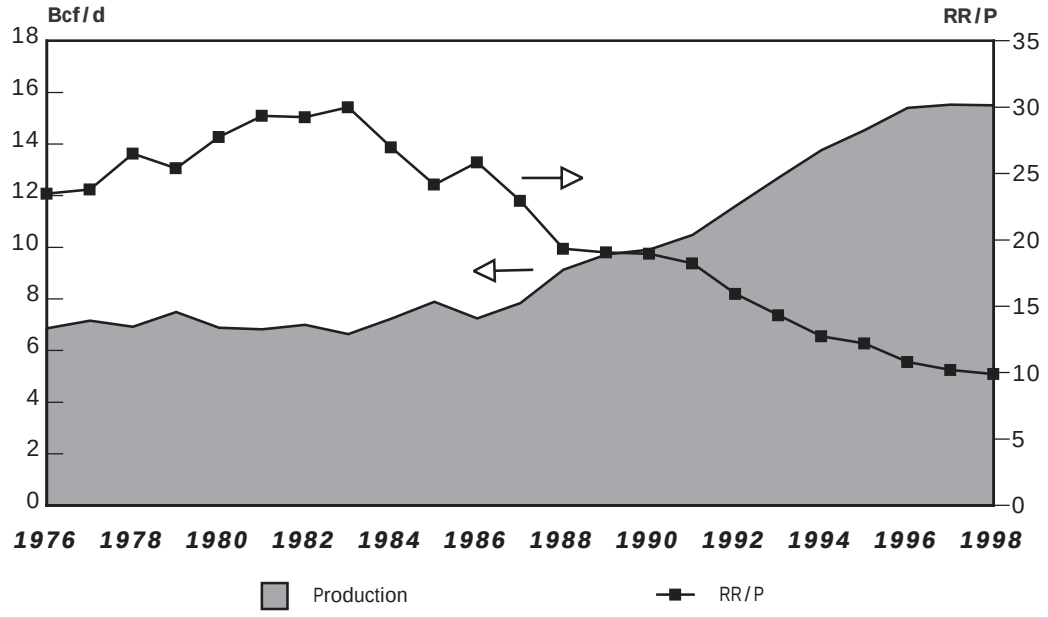
The Foothills areas of Alberta and B.C. constitute the *high cost* grouping. Exploration and development costs in the Foothills areas are high due to: restricted access, less infrastructure, environmental restrictions, and high sour gas content which requires additional processing. Costs of gas wells in this grouping range from 1,000,000 to 10,000,000.

3.2 Historical Production Rates and Reserves

Marketable production from WCSB has increased from approximately 7 Bcf/d (198 million m^3/d) in 1985 to the current rate of over 15 Bcf/d (425 million m^3/d). The combination of increased production rates with less than 100 percent reserves replacement has resulted in decreasing remaining reserves to production ratios ("RR/P") (Figure 3.2). These lower RR/P ratios indicate that industry is now producing from lower inventories and suggests that new wells and reserves will be required to maintain future deliverability.

FIGURE 3.2

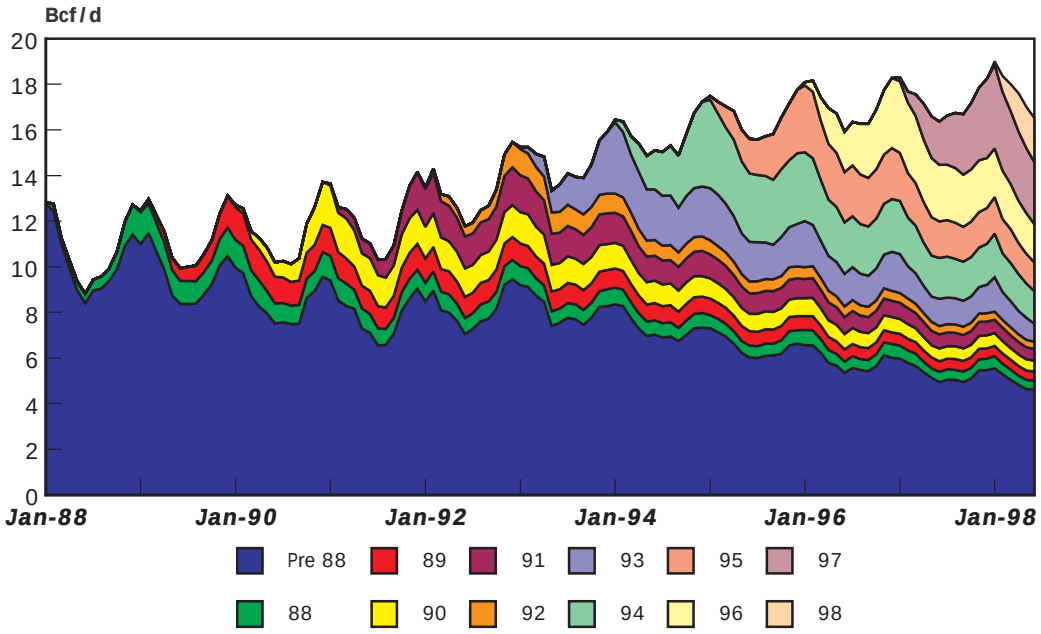
WCSB Production & RR/P



Additional information can also be obtained from historical production data by plotting it on a monthly basis and by grouping the production data according to the year wells were placed on production (Figure 3.3). The raw gas production, for non-associated wells only, shows the same overall production increases as the marketable production in the previous figure but also shows the seasonal variations. The summer rates from 1988 to about 1991 were about 21 percent less than winter production rates in the same period. Storage capacity was subsequently increased and this has allowed producers to maintain higher production rates in summer, resulting in a difference of about 13 percent between recent summer and winter production rates.

FIGURE 3.3

WCSB Raw Gas Production by Connection Year



The monthly data also shows that 50 percent of production for January 1998 was provided from wells connected in 1994 or later, demonstrating the importance of recent drilling activity to current deliverability. The trend of increasingly higher slopes indicate that production rates for recently connected wells are decreasing rapidly and that these wells will be depleted quickly.

Charts of raw gas production grouped by region indicate that all regions are dependent on recently connected wells to maintain deliverability (Appendix I). These charts also indicate that seasonal variations in production have decreased over the last decade in all regions except for the Alberta SE and the B.C. Plains regions.

Production has increased in all regions with the Alberta NW and B.C. Foothills showing the highest growth. However, these regions only contribute 14 percent of overall WCSB production; other regions such as Alberta Central and Alberta Foothills have a larger impact on overall production levels (Table 3.1). Of note, while still a large contributor to WCSB production, the Alberta Foothills region has experienced a declining share of production, decreasing from 25 percent in 1988 to 19 percent in 1998. At the same time, low and medium cost regions have experienced 28 and 50 percent increases, respectively, of raw gas production reflecting the large amount of wells drilled in these areas.

TABLE 3.1

Percent Share of WCSB Raw Gas Production

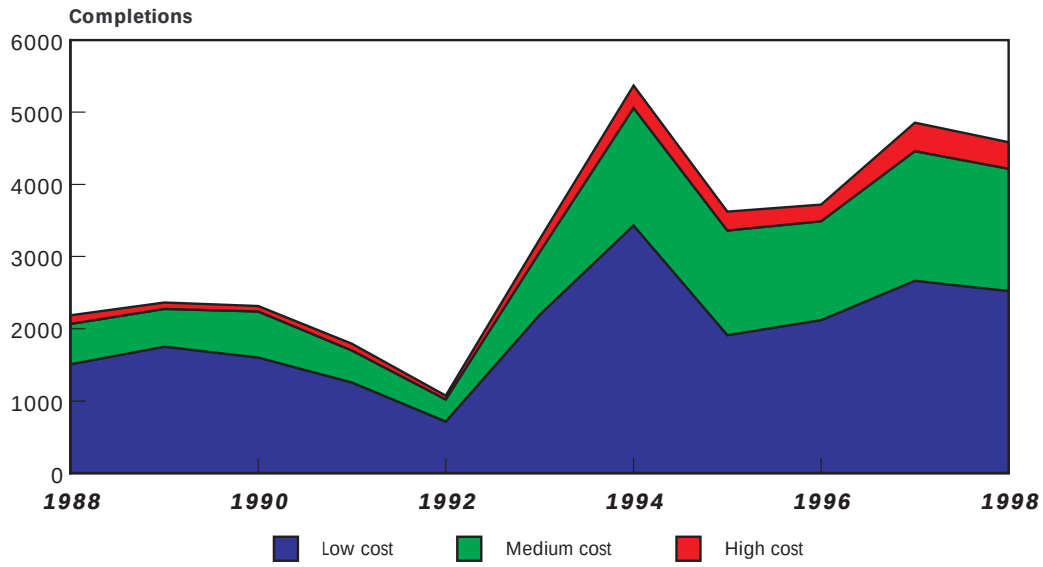
Region	January 1988	January 1993	January 1998
Saskatchewan SW	2.2	2.4	1.7
Saskatchewan WC	0.5	1.8	1.5
Alberta SE	10.9	9.6	11.5
Alberta East	12.4	14.6	13.6
Low Cost Group	26	28.4	28.3
Alberta Central	32.3	31.1	29.5
Alberta NW	5.7	7.9	10.9
B.C. Plains	9.8	10.2	9.4
Medium Cost Group	47.8	49.2	49.8
Alberta Foothills	24.5	19.2	18.6
B.C. Foothills	1.7	3.2	3.3
High Cost Group	26.2	22.4	21.9

3.3 Drilling Activity

The number of gas wells drilled is often used as an indicator of ability to produce. Some analysts have stated that up to 8,000 wells per year will have to be drilled to meet deliverability requirements over the next five years. This is a significant increase from the current rate of completions and from the record level of 5,400 accomplished in 1994. However, the forecast presented in a later section suggests that under 5,000 connections per year or levels closer to current drilling activity will be required. Well productivity varies significantly by region and a shift from one region to another will affect the number of wells required. Over the last five years, about half of the wells drilled were located in the low cost areas of eastern Alberta and western Saskatchewan and less than 10 percent were drilled in the deep Foothills areas of Alberta and B.C. (Figure 3.4). The deeper wells are more costly but generally have higher productivity and recover more reserves per well.

FIGURE 3.4

WCSB Gas Well Completions

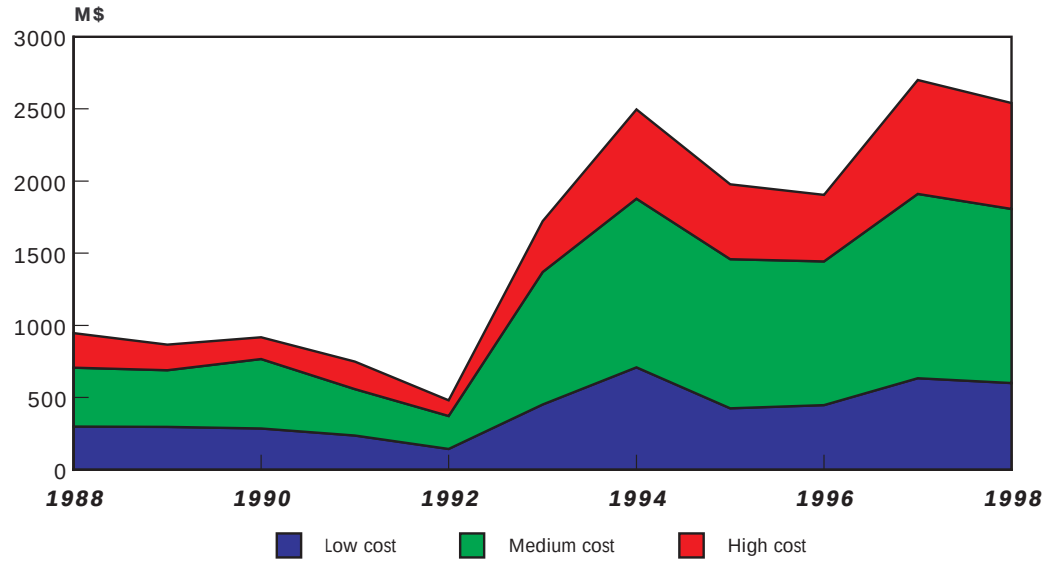


Examining the well counts for each region also shows that the majority of wells were development wells (Appendix II). Many development wells are step outs from existing pools and add both deliverability and reserves; however, some development wells are infill wells which add only deliverability.

Converting well counts to capital invested in drilling shows that more money was spent in the medium cost areas and this more closely corresponds to areas where deliverability was added (Figure 3.5).

FIGURE 3.5

WCSB Gas Well Investments



3.4 Role of Storage

Average gas deliveries from the WCSB during the winters of 1997 and 1998 have been more than 30 percent higher than the average summer gas deliveries of the corresponding years. However, because of the use of gas storage within the WCSB, marketable production from producing wells has only varied by approximately 13 percent from summer to winter.

The impact of storage can be shown by comparing produced gas volumes with marketed volumes (Figure 3.6). Storage withdrawals tend to occur over a five-month period, from November to March, and peak in January at about 2 Bcf/d (56.7 million m^3/d). Injection is spread over the remaining seven months and peaks in July at about 1.25 Bcf/d (35.4 million m^3/d). Generally, total withdrawals from storage in a year are equal to total injections.

FIGURE 3.6

Produced and Marketed Natural Gas from the WCSB

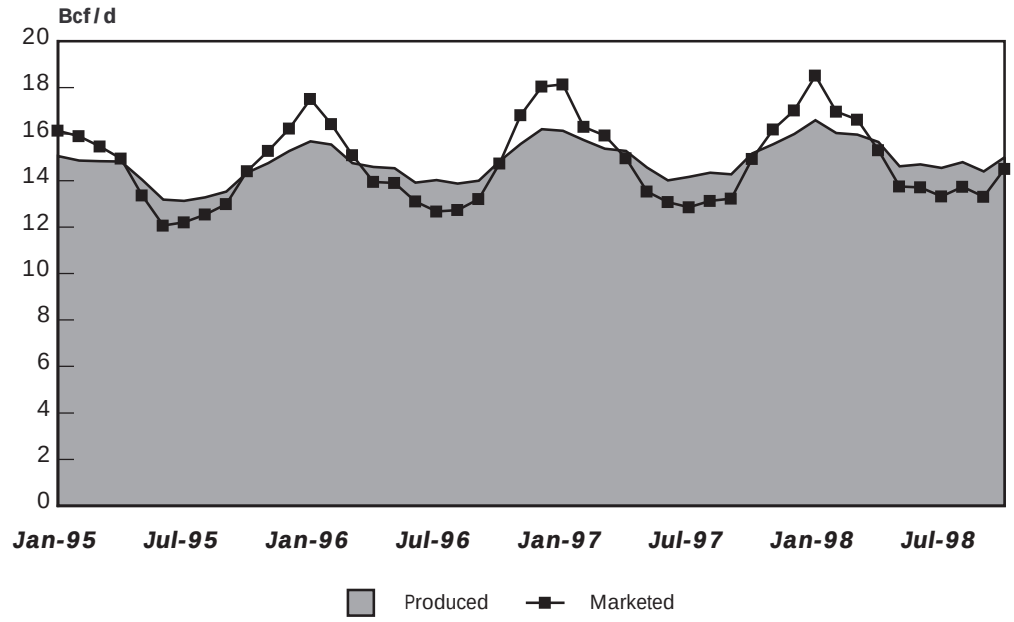
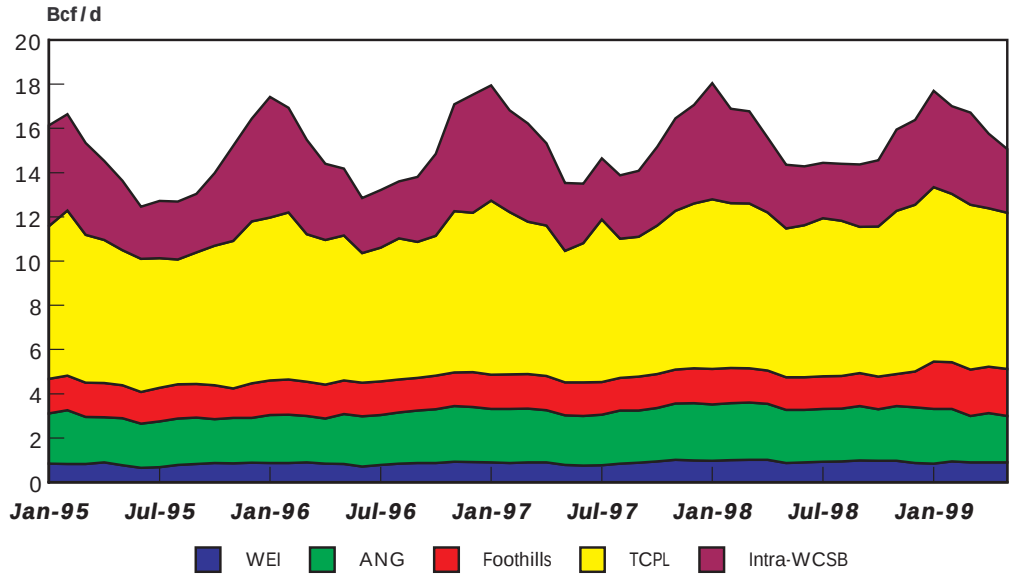


Figure 3.6 shows the seasonal variation in marketed gas but it does not provide any insight on the causes for these variations. This is better understood by examining each component of gas demand for the WCSB.

About 20 percent of WCSB production is consumed within the WCSB and the remaining 80 percent is transported from the WCSB to eastern Canadian and U.S. markets by four major pipeline systems (Figure 3.7). The ex-WCSB pipelines have been operating near capacity over the summer periods as well as the winter periods; the seasonal swing is small and is nearly equivalent to the swing in physical capacity caused by changes in ambient temperature. Although the intra-WCSB sales are a small portion of overall requirements, their influence on overall seasonal variability is significant. A portion of gas consumption in the intra-WCSB market is for heating in the residential and commercial sectors and this consumption varies according to temperature.

FIGURE 3.7

WCSB Gas Disposition



Most of the growth in gas requirements from the WCSB is expected to result from expansions of major transmission lines exiting the WCSB or from growth in the industrial sector within the basin. These new requirements have low seasonal variation and will tend to reduce the variation in overall gas demand from the WCSB.

3.5 Producing Characteristics

Figure 3.3 showed that wells connected since 1994 contribute about 50 percent of current WCSB production. Further, it also indicated that production from recently connected wells declines more quickly over time than older wells. More quantitative information regarding the producing characteristics of wells of varying age was determined by analyzing production plots of rate versus time and rate versus cumulative production (not included in report) for wells grouped according to the year they were connected and placed on production. The contribution of each group to Alberta's and B.C.'s December 1997 production is shown in Table 3.2. Also shown for each connection year, is the rate at which production has declined over time, from their connection year until the end of 1997. This decline rate is the nominal value used in exponential decline analysis and is expressed as percent decrease per year.

TABLE 3.2

Decline Rates for Connected Wells

Year on Production	Alberta Annual Decline Rate Percent	Share of 1997 Production Percent	B.C. Annual Decline Rate Percent	Share of 1997 Production Percent
Pre 1986	6.3	27.0	8.5	24.8
1986	6.0	3.1	13.0	1.0
1987	13.9	1.8	12.4	2.9
1988	9.4	2.7	9.2	2.7
1989	13.9	2.6	16.8	2.8
1990	18.6	3.1	15.2	4.3
1991	22.3	3.5	21.5	4.9
1992	24.3	2.1	14.5	3.3
1993	21.1	7.0	28.8	6.3
1994	33.8	10.0	18.5	14.7
1995	43.3	10.2	5.9	9.1
1996	30*	15.4	20*	13.7
1997	30*	11.5	20*	9.4

* Estimated

Table 3.2 shows that producing characteristics have changed over time but it does not provide any information of any changes due to geographical locations described in section 3.1. It is expected that wells drilled in the near future will have characteristics similar to wells drilled in the last five years rather than those drilled prior to that time. Therefore, a more detailed analysis of producing characteristics, which emphasizes recent performance and takes regional variations into account, was performed.

TABLE 3.3

Estimated Producing Characteristics of Recently Connected Gas Wells

Category	Initial Productivity MMcf/d	Reserves per well Bcf	Nominal Annual Decline Rate Percent
Low Cost Group			
Sask Shallow (SW)	0.5	0.5	35
Alberta Shallow (Eastern)	0.5	0.5	33
Medium Cost Group			
Alberta Central&NW	1.2	1.2	35
B.C. Plains	2	4	18
High Cost Group			
Alberta Deep (Foothills)	2.5	3.9	23
B.C. Deep (Foothills)	5	7.3	25

Wells which were connected after 1988 were grouped according to their connection year and according to the nine geographical areas described in section 3.1. Initial production rates per well and the annual production decline rate were determined from the production rate versus cumulative production plots for each group (not included in this report). The results can be summarized according to the three different cost groups, also described in section 3.1 (Table 3.3). As expected, initial production rates per well vary substantially across regions with the deeper wells in the western area of the WCSB producing at ten times the rates of shallow wells in the eastern regions. The production decline rates are, however, more consistent regionally and production from most wells tends to decline at about 35 percent per year.

DELIVERABILITY FORECASTS

This chapter contains a forecast to 2001 along with estimates of the number of wells required to be drilled in order to meet expected annual gas demand from the WCSB. This forecast shows deliverability trends and does not attempt to match seasonal swings which are normally mitigated by gas storage. A range of deliverability scenarios, based on changes to input parameters of the forecast, is also provided.

4.1 Base Deliverability Forecast

The basic premise for the deliverability forecast presented in this report is that currently connected wells will continue to produce in a similar manner as they have in the past. It was also assumed that wells drilled from now until 2001 would have the same producing characteristics as recently connected wells. Using these production characteristics, the number of new wells required to satisfy an overall demand increasing from the current rate of 15.3 Bcf/d (430 million m^3/d) to a rate of 17.1 Bcf/d (485 million m^3/d) is determined. Following these assumptions, future deliverability for the 45,000 currently connected wells was estimated by extrapolating the current decline trends for each group from their 1997 production rates (Table 3.2).

There are over 7,000 wells in Alberta and about 380 wells in B.C. which have been assigned reserves but have not yet been placed on production. For this reason, these wells are classified as unconnected. With increased demand and with the development of more infrastructure, it was assumed that the economics of placing these wells on production would improve and, therefore, these wells would be connected gradually. For this forecast, it was assumed that one percent of these wells would be connected in 2000 and that two percent would be connected in 2001. Unconnected wells in Alberta were assigned an initial rate of 1 MMcf/d (28.3 thousand m^3/d) and a 33 percent annual decline rate while unconnected wells in B.C. were assigned an initial rate of 1.9 MMcf/d (53.8 thousand m^3/d) and a 17 percent annual decline rate.

Production from existing gas wells is expected to decline at rates of about 19 percent per year and this declining production will have to be replaced by drilling new wells. In addition to replacing declining production, more wells will be required to meet expected increases in demand. In this forecast, WCSB deliverability and demand are balanced by varying the number of wells added in each year to 2001. The producing characteristics of the new wells are those provided in table 3.3.

The number of wells required and deliverability provided by each category are shown in Figure 4.1 and Figure 4.2, respectively. Based on this forecast, approximately 4,000 wells needed to be connected in 1998 to maintain average annual production at 15.3 Bcf/d (430 million m^3/d). In actual fact, approximately 4,600 wells were drilled in 1998 and, while it is not known for certain at this time, the number of connected wells is expected to be near the forecasted value. To increase deliverability to 17.1 Bcf/d (485 million m^3/d), connections will have to increase by about eight percent per year, or to about 5,000 wells, by 2001. Based on drilling to the end of May 1999, it

would appear as though the number of gas wells drilled in 1999 will be similar to the past two years. This is also consistent with the views expressed by the Canadian Association of Oilwell Drilling Contractors and Petroleum Services Association of Canada which forecast that about 5,000 gas wells will be drilled in 1999. However, the increase in the number of wells required to meet demand will depend on the extent to which producers shift from drilling low-cost and low-productivity wells in eastern Alberta to drilling in more prolific areas located in the higher cost western regions.

FIGURE 4.1

WCSB Forecast of Connected Gas Wells

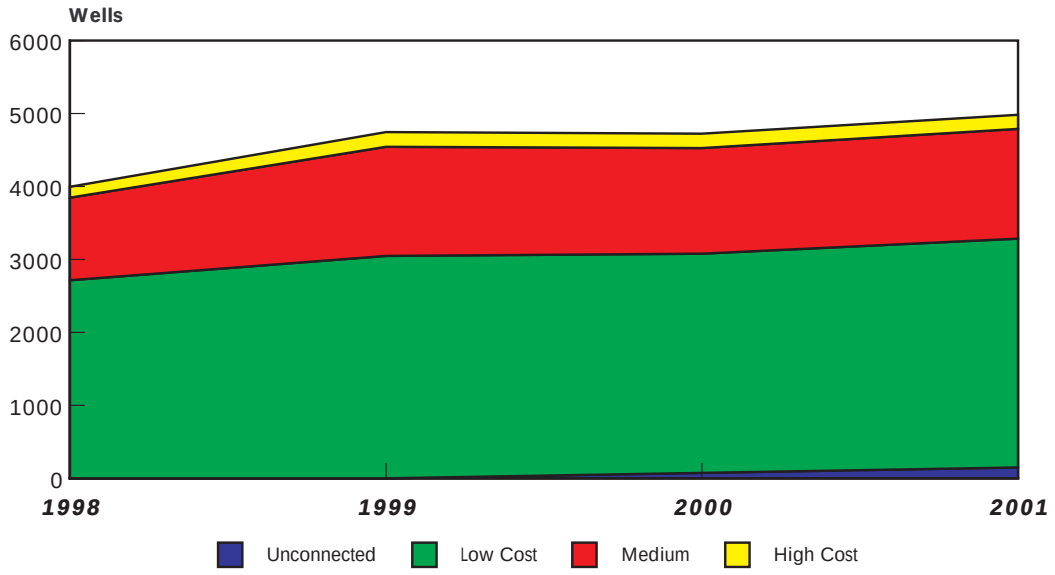
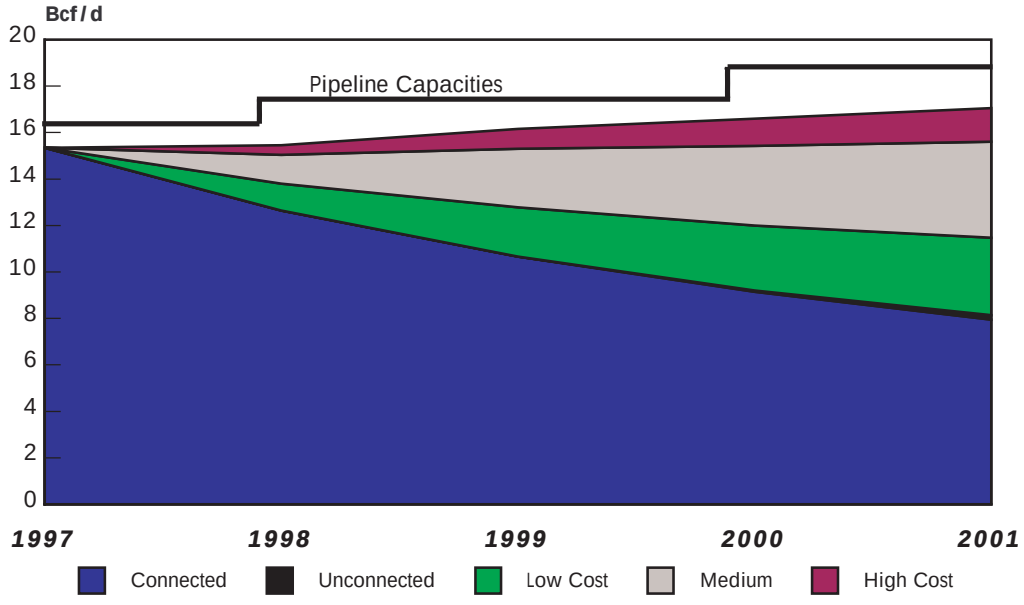


FIGURE 4.2

WCSB Deliverability Forecast



This forecast indicates that production rates from currently connected wells will decline from 15.3 Bcf/d (430 million m^3/d) in 1997 to approximately 8.0 Bcf/d (225 million m^3/d) in 2001 and will contribute less than half of total deliverability in 2001. In other words, future wells will have a large impact on overall deliverability and any deliverability forecast is very dependent on the characteristics assigned to these new wells.

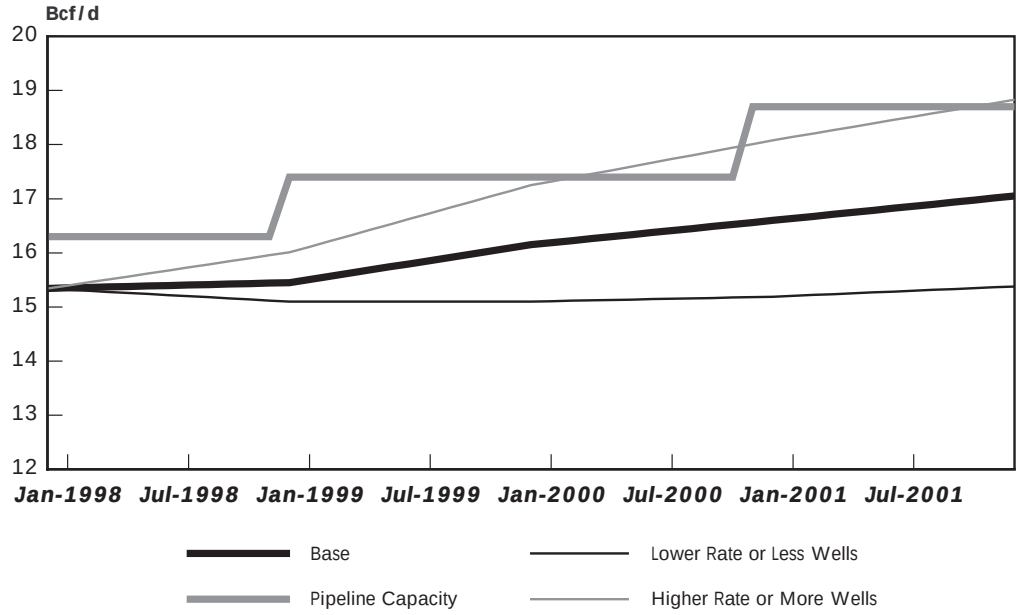
4.2 Sensitivity to Input Parameters

The sensitivity of the deliverability forecast, to changes in input parameters, was examined by varying a single input parameter and noting its changes on overall short term deliverability. The results show, as expected, that short term deliverability is most sensitive to the initial well productivity and to the number of wells connected (Figure 4.3).

Reducing the number of new wells connected by 20 percent, or from an average of 4,600 wells per year to 3,700 wells per year, results in deliverability that remains flat at current rates rather than increases as shown in the base case. Reducing the initial productivity of the typical new wells by 20 percent results in the same forecast as reducing well counts. Increasing the number of wells connected by 20 percent, or from an average of 4,600 wells per year to an average of 5,400 wells per year, results in deliverability that exceeds projected pipeline capacity. Again, increasing initial productivity of the typical well has the same impact as increasing well counts. The assumed changes in activity result in large changes in deliverability by 2001, but these assumptions are within the range of industry activity levels. For example, industry completed 5,400 gas wells in 1994, 3,700 wells in 1995 and 1996, 4,800 in 1997 and 4,600 in 1998. Average initial production rates per well have varied according to year connected, but in most areas the variation has been less than 20 percent.

FIGURE 4.3

WCSB Deliverability Comparisons



Although not included in this report, the effects of comparable changes to other input parameters, such as decline rates, have been analysed. Results indicate that these other parameters tend to impact long-term deliverability more than short-term deliverability. So, while some analysts would suggest different values for decline rates than those utilized in the deliverability forecast, this parameter seems to have a minimal impact on a short-term deliverability.

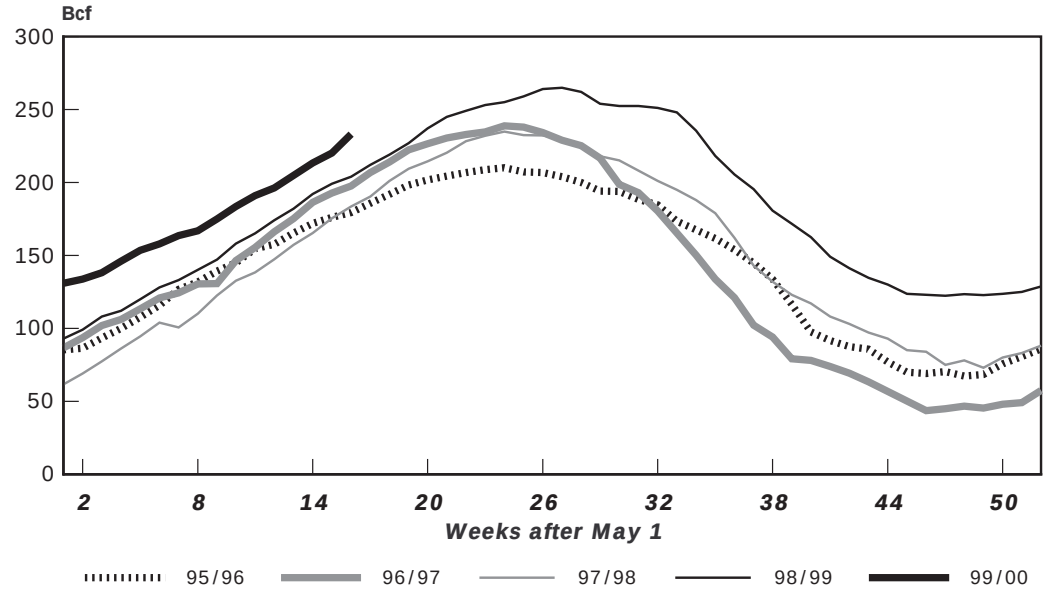
4.3 Deliverability Trends to Date in 1999

Another 1.1 Bcf/d (31 million m^3/d) of ex-WCSB pipeline capacity was added in December 1998 and has been fully utilized since that time, as shown by the charts of pipeline throughputs (Appendix III). This suggests that deliverability during 1999 would be 1.1 Bcf/d (31 million m^3/d) higher than in the corresponding period in 1998, if intra-WCSB gas sales were at normal levels. However, mild weather in early 1999 has reduced intra-WCSB gas sales and, therefore, total deliveries may not have increased by an amount corresponding to the additional capacity.

The most accurate method of analyzing short term deliverability is by summing production and storage withdrawals as shown in Figure 3.6. However, production data for early 1999 is not available so this analysis cannot be performed. Another indicator is to examine storage levels independently of production. The most recent storage information available for the WCSB shows that current injection rates are the same as in previous years indicating that the new pipeline capacity is being supplied from wells rather than from drawing on storage (Figure 4.4). A continuation of injection into storage at the current rates will likely result in higher than normal storage levels and this will provide additional winter deliverability for meeting higher intra-WCSB sales resulting from a possible return to normal winter weather.

FIGURE 4.4

Western Canada Storage Levels



Source: Energy ERA Corporation

SUMMARY AND CONCLUSIONS

Over the short-term, the upper limit of requirements for gas from the WCSB will be the sum of ex-WCSB pipeline capacity and intra-WCSB demand. By 2001, the upper limit, based on 100 percent pipeline utilization, could reach an average of 18.8 Bcf/d (530 million m^3/d) but demand is expected to be about 17.1 Bcf/d (485 million m^3/d). Seasonal swings in intra-WCSB sales are expected to continue to account for the majority of seasonal swings in total demand.

Trends in the characteristics of production from the WCSB, such as RR/P levels, decline rates and the productivity of new wells indicate that about one-half of production in 2001 would be provided from wells drilled or connected since January 1998. Consequently, current rates of drilling must be increased in order to meet future demand. However, the amount of increase will depend on the extent to which producers shift from drilling low-cost and low-productivity wells in eastern Alberta to drilling in more prolific areas located in the higher cost western regions. Connecting about 5,000 of such gas wells per year should be sufficient to meet expected demand to 2001.

Clearly, natural gas producers will be challenged to meet intra-WCSB demand and fill ex-WCSB pipeline capacity to a level where it is considered fully utilized. This challenge will be exacerbated, to some extent, by the recent climate of reduced cash flow. Notwithstanding this, the challenge is expected to be met by producers. Moreover, an extraordinary drilling effort, as predicted by some industry analysts, will not likely be necessary; rather, a gradually increasing drilling effort from current levels, will result in sufficient deliverability to meet expected average demand. Of course, spikes in demand will continue to occur primarily due to weather conditions. These spikes are expected to be met by gas storage and/or by the drilling of gas wells in addition to those required to meet average demand.

Connected Gas Well A gas well which has been connected to a gathering and processing system and thus is producing or ready to produce.

Completed Gas Well A well which has normally tested gas, has casing in its well bore, is nearly ready to produce but has not been connected to a gathering and processing system.

Connection Year The year in which a well is connected to a gas gathering and processing system and begins to produce.

Decline Rate A term used to describe the decrease in production rate over time usually expressed as a percentage per year. Most common forms are the nominal decline which is the slope of an exponential plot of production rate versus cumulative production or the effective decline which is one less the ratio of the production rate at end of a given year to the production rate at the beginning of the same year

Deliverability The amount of natural gas a well, reservoir, storage reservoir, field or producing system can supply in a given amount of time.

Ex-WCSB Outside of the Western Canada Sedimentary Basin.

Injection Process of forcing natural gas into a storage reservoir.

Industrial Market The portion of the natural gas market consisting of manufacturing, forestry and mining operations. This portion of market normally has a fairly uniform demand for gas.

Integrated Market A region with sufficient pipeline capacity to allow price signals in consuming areas to be passed on to producing areas.

Intra-WCSB Within the Western Canada Sedimentary Basin area.

Long Term Forecast Forecast beyond the year 2001.

Marketable Gas Natural gas which has been processed to remove impurities and liquids and which is ready for market use.

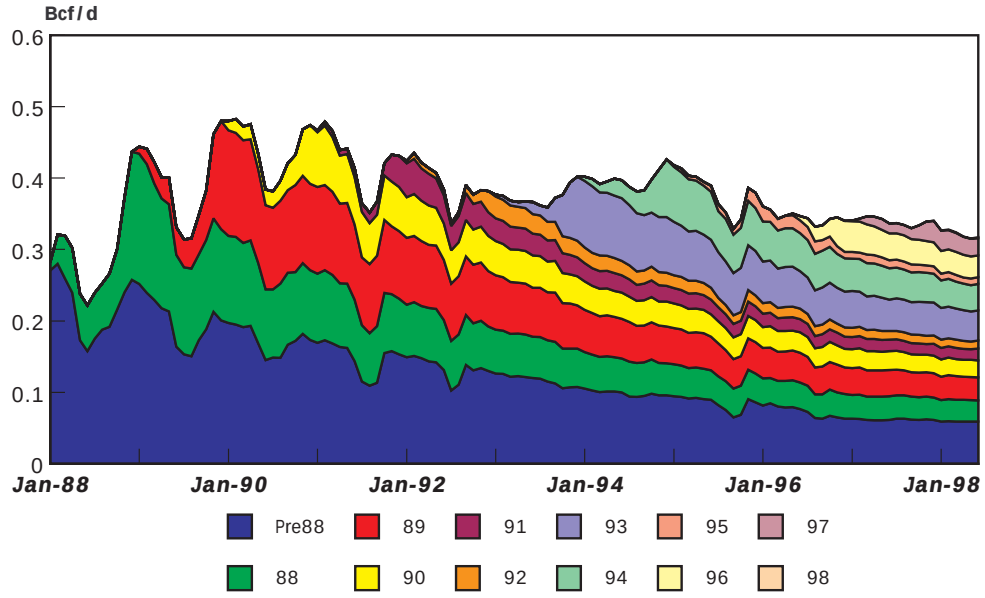
Pipeline Design Capacity Planned capacity of pipeline to transport gas under given set of operating conditions. Ambient temperature affects a pipeline's ability to transport gas resulting in different summer and winter capacities. Average pipeline capacity is the numerical average of the winter and summer designs.

Pipeline Take Away Capacity	Ability of a pipeline system to transport gas from producing basin to market.
Raw Gas	Natural gas as produced from a reservoir.
Remaining Reserves	Natural gas to be recovered from a reservoir or group of reservoirs taken into account the amount of reserves recovered to date.
Remaining Reserves to Production Ratio	Remaining reserves divided by annual production.
Reservoir	A porous and permeable underground rock containing accumulations of crude oil, natural gas and related substances that is confined by impermeable rock or water barriers.
Residential and Commercial Markets	The portion of natural gas market consisting of houses, offices and warehouses. The market normally uses natural gas for heating purposes and demand tends to fluctuate and coincide with ambient temperatures.
Rig Utilization	The portion of rigs drilling expressed as a percentage of the total number of rigs capable of drilling.
Short Term Forecasts	Forecast to and including the year 2001.
Storage	Facility or reservoir used to accumulate natural gas during periods of low demand and used to deliver natural gas during periods of high demand.
Storage Level	The amount of natural gas in a storage reservoir of facility.
Well Productivity	The amount of natural gas produced by a gas well, under normal producing conditions, over a given period of time. The rate is normally expressed as mcf or MMcf per day.
Withdrawals	Rate at which natural gas is taken out of a storage reservoir. A positive value indicates that gas is removed and a negative value indicates gas was injected into the reservoir.

Raw Gas Production by Region

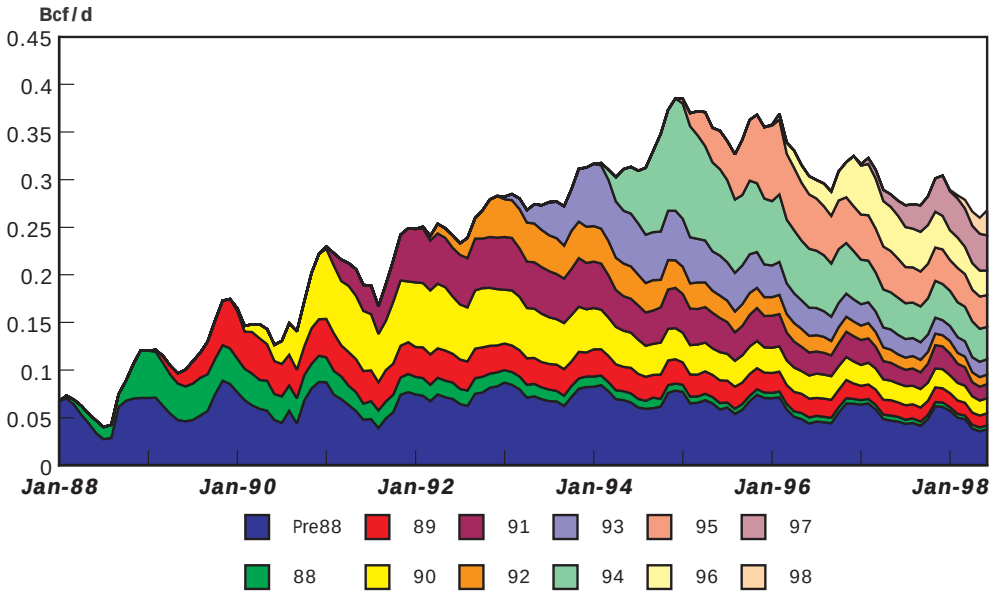
S A S K S W R A W G A S P R O D U C T I O N

Grouped by Connection Year



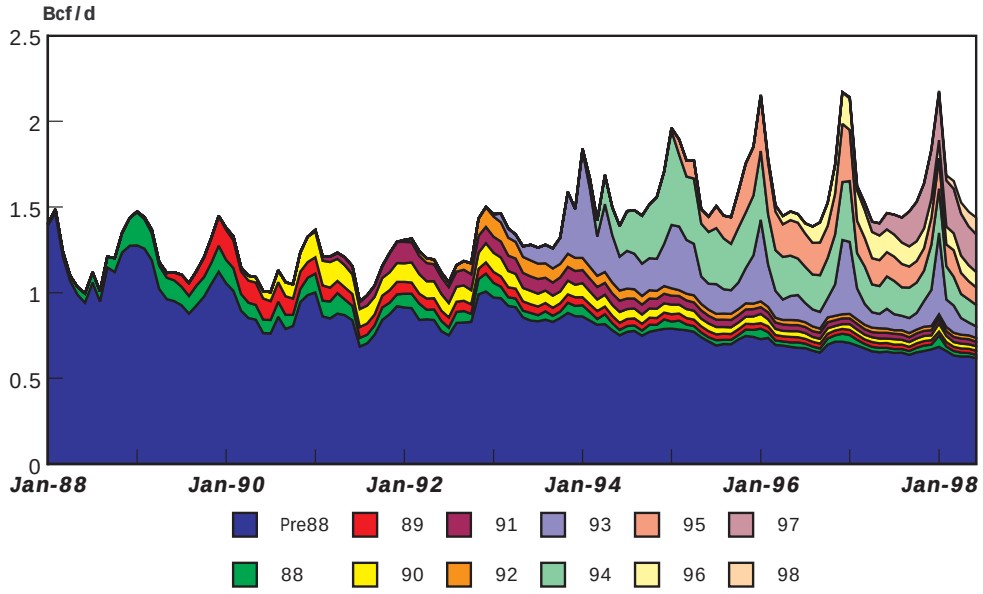
S A S K W C R A W G A S P R O D U C T I O N

Grouped by Connection Year



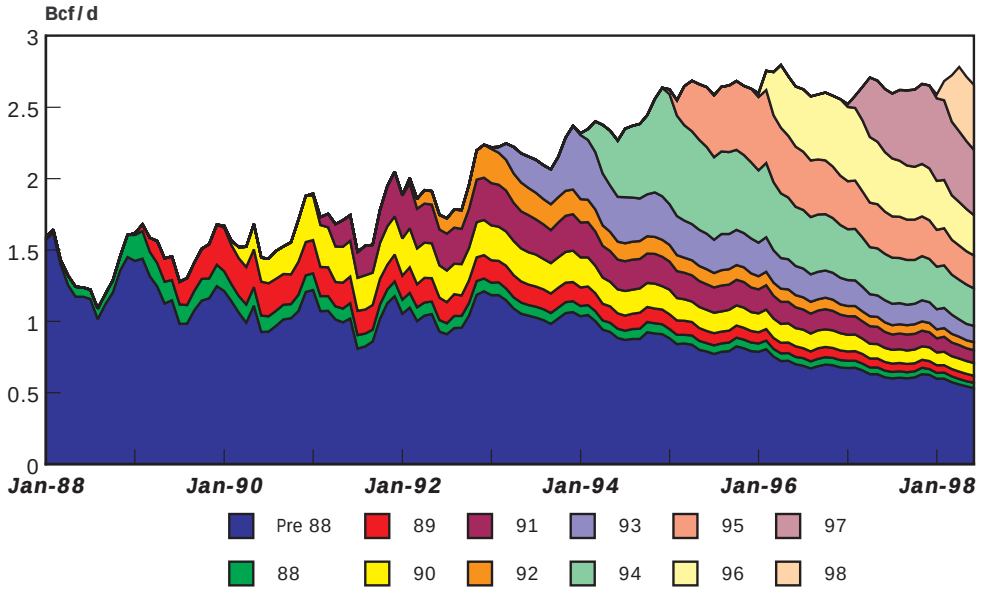
ALBERTA SE RAW GAS PRODUCTION

Grouped by Connection Year



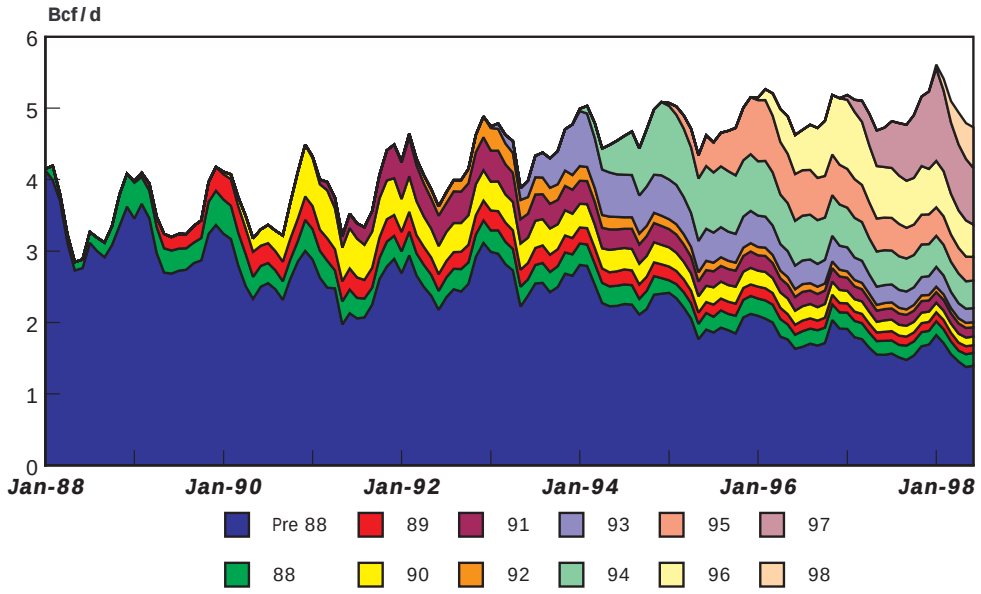
ALBERTA EAST RAW GAS PRODUCTION

Grouped by Connection Year



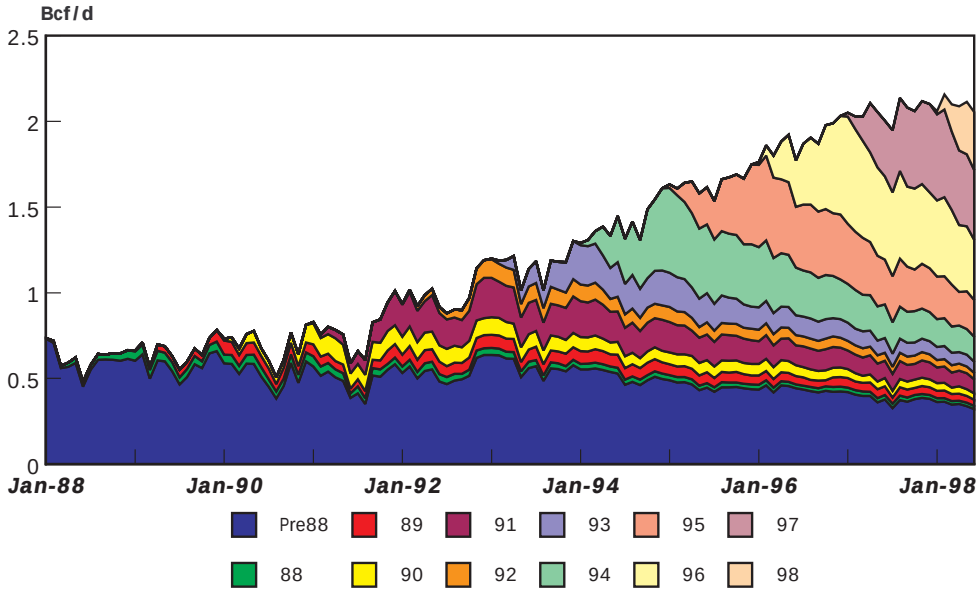
ALBERTA CENTRAL RAW GAS PRODUCTION

Grouped by Connection Year



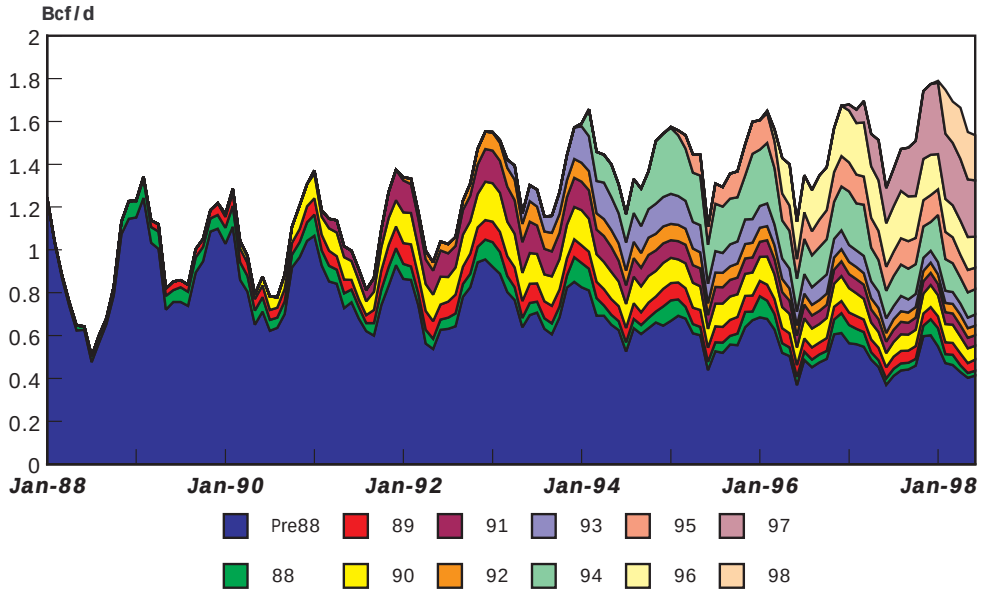
ALBERTA NW RAW GAS PRODUCTION

Grouped by Connection Year



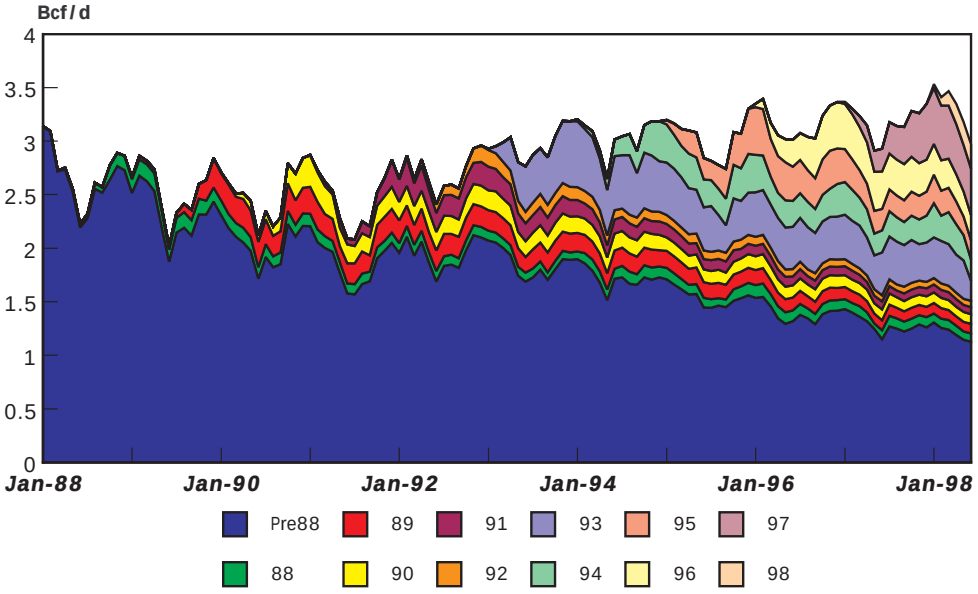
BC PLAINS RAW GAS PRODUCTION

Grouped by Connection Year



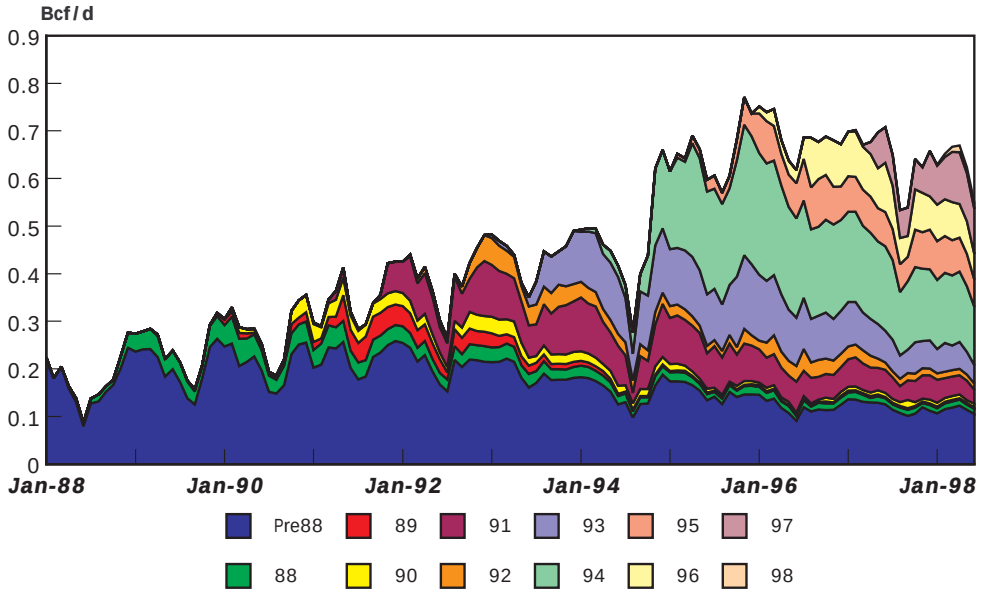
ALBERTA FOOTHILLS RAW GAS PRODUCTION

Grouped by Connection Year



BC FOOTHILLS RAW GAS PRODUCTION

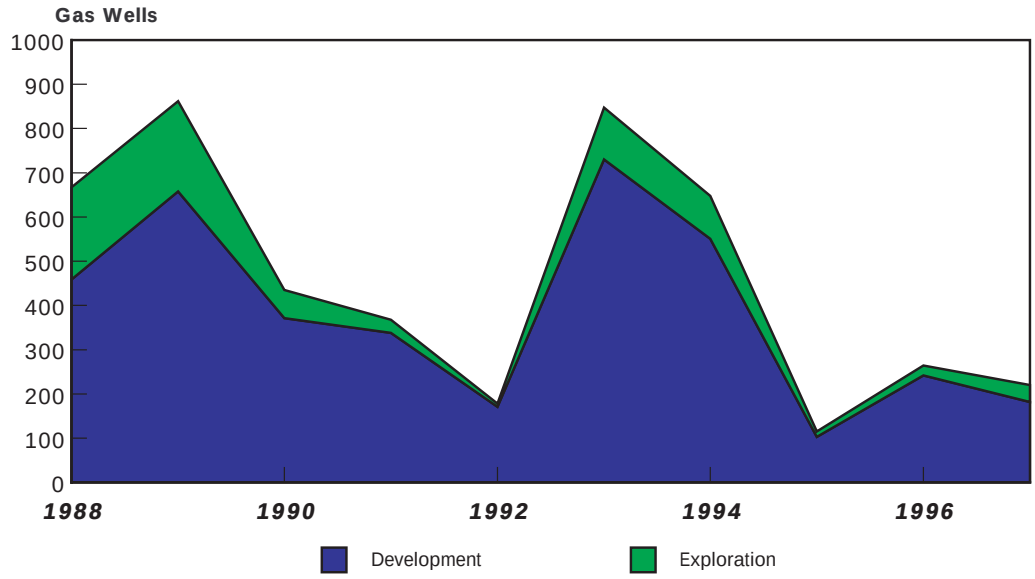
Grouped by Connection Year



Well Completions by Region

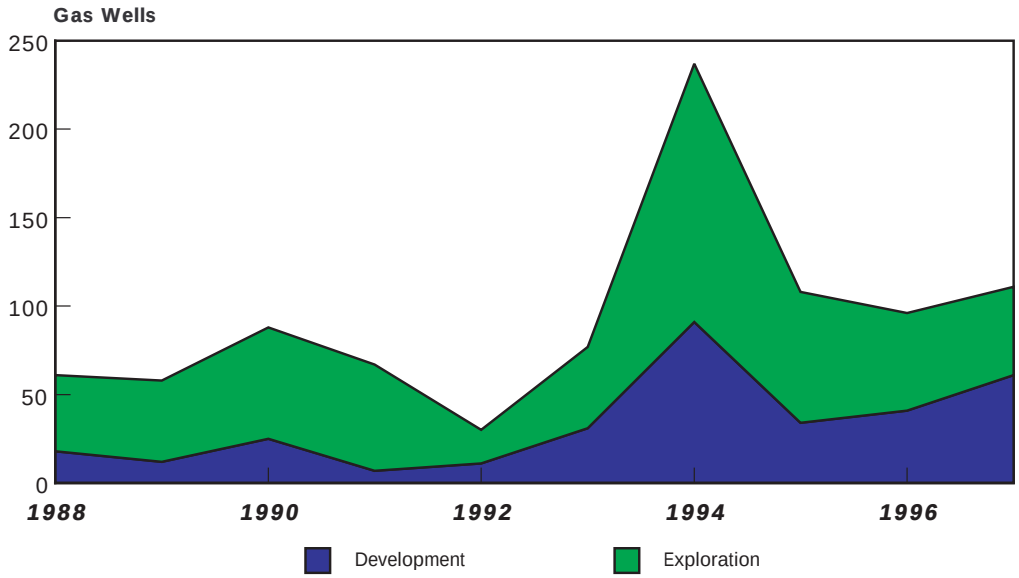
S A S K S W

Gas Well Completions



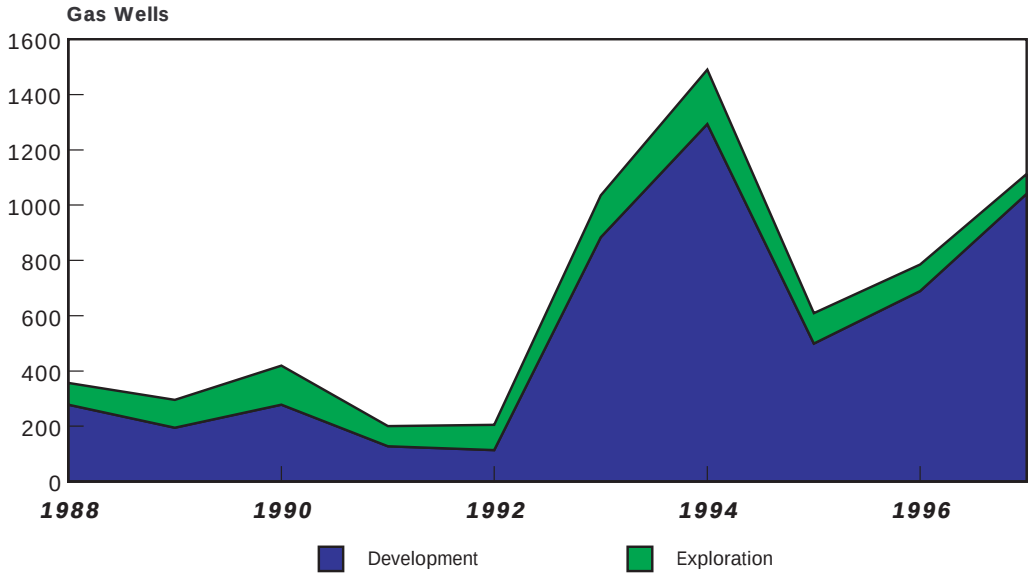
S A S K W C

Gas Well Completions



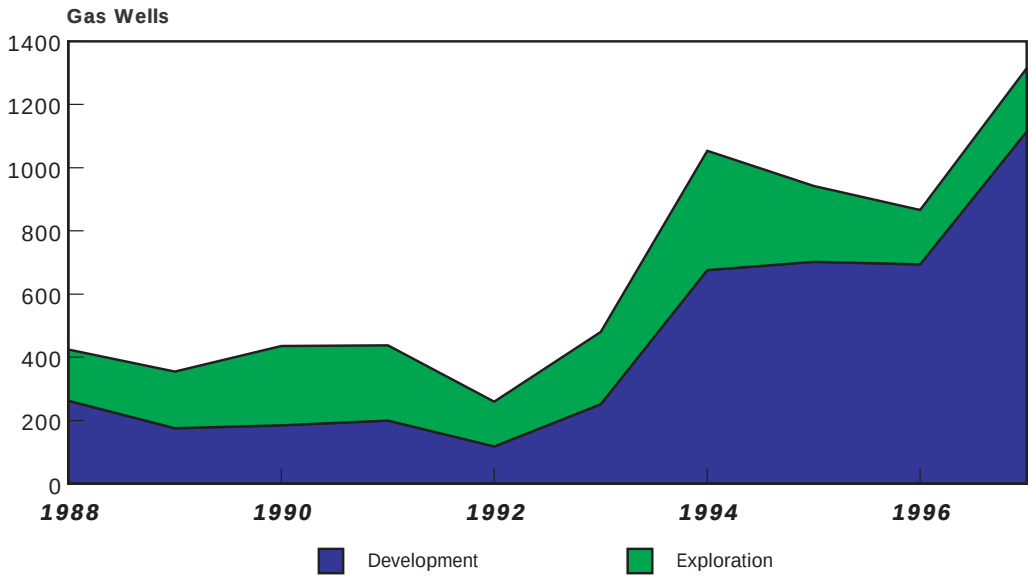
ALBERTA SE

Gas Well Completions



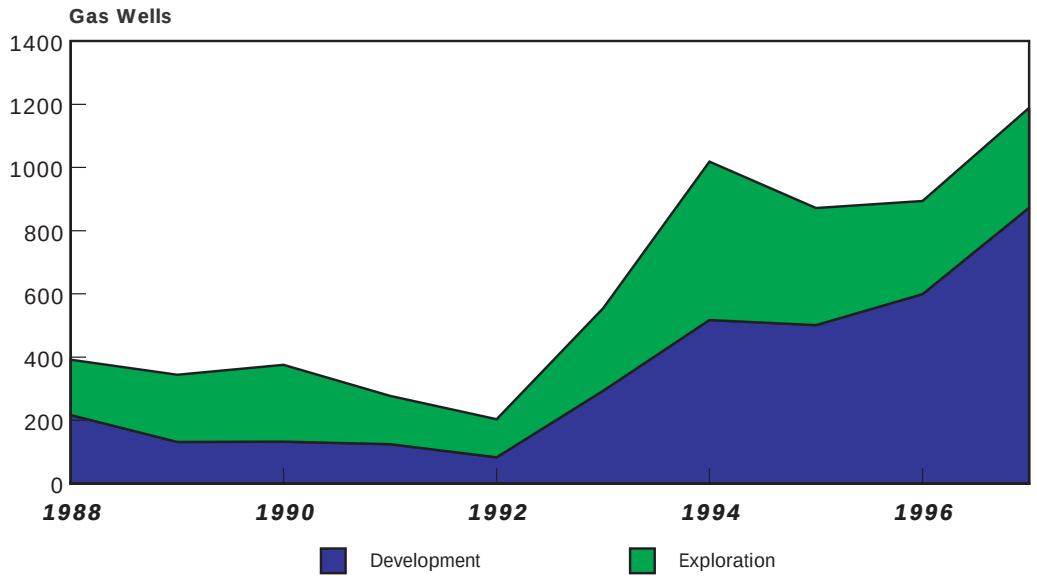
ALBERTA EAST

Gas Well Completions



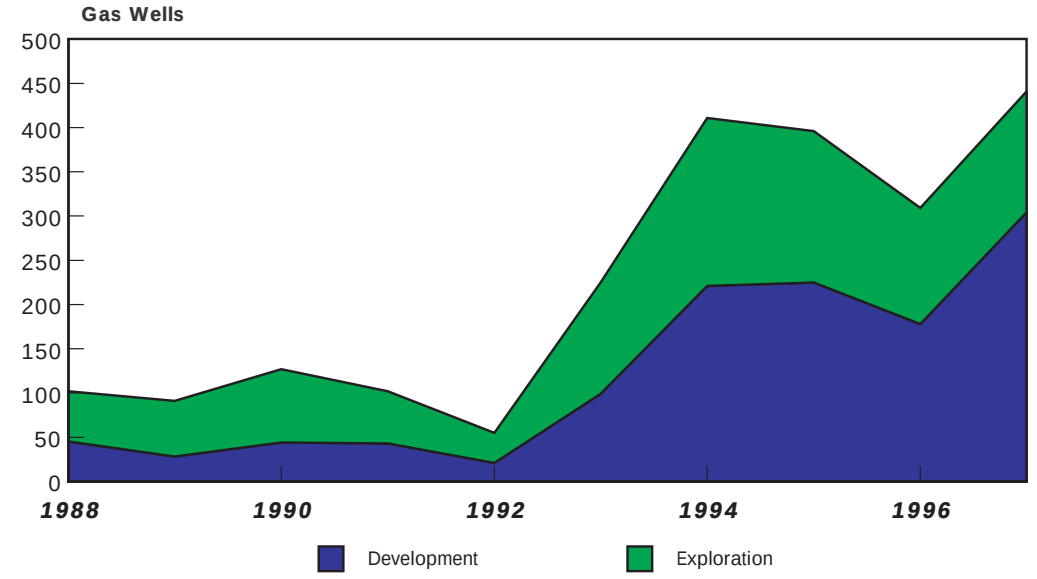
ALBERTA CENTRAL

Gas Well Completions



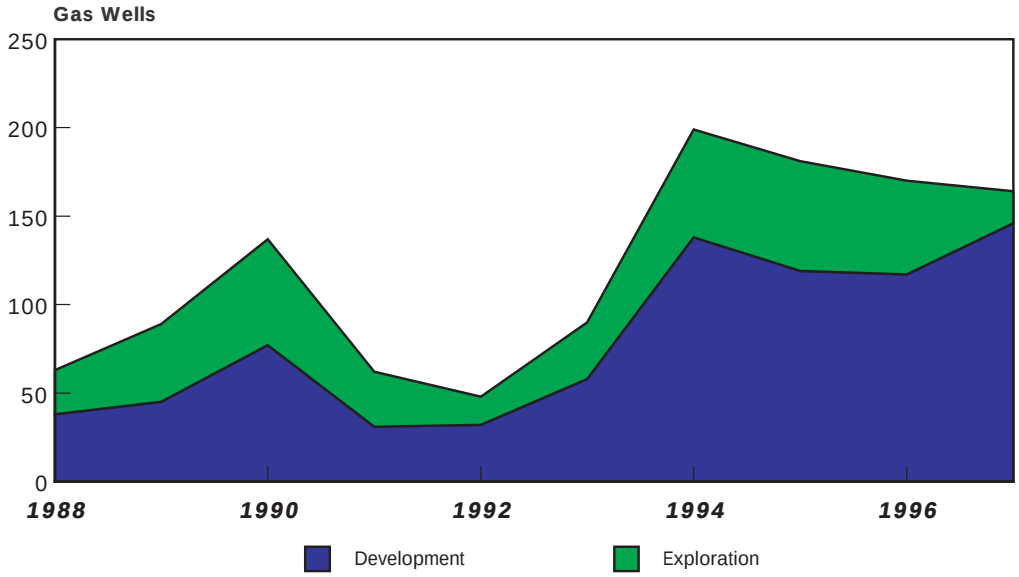
ALBERTA NW

Gas Well Completions



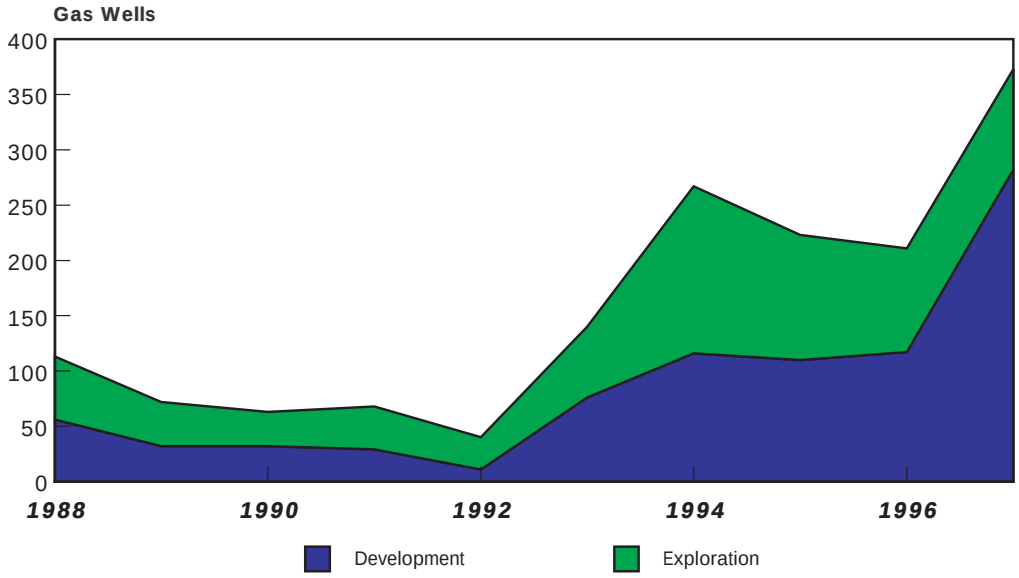
B C P L A I N S

Gas Well Completions

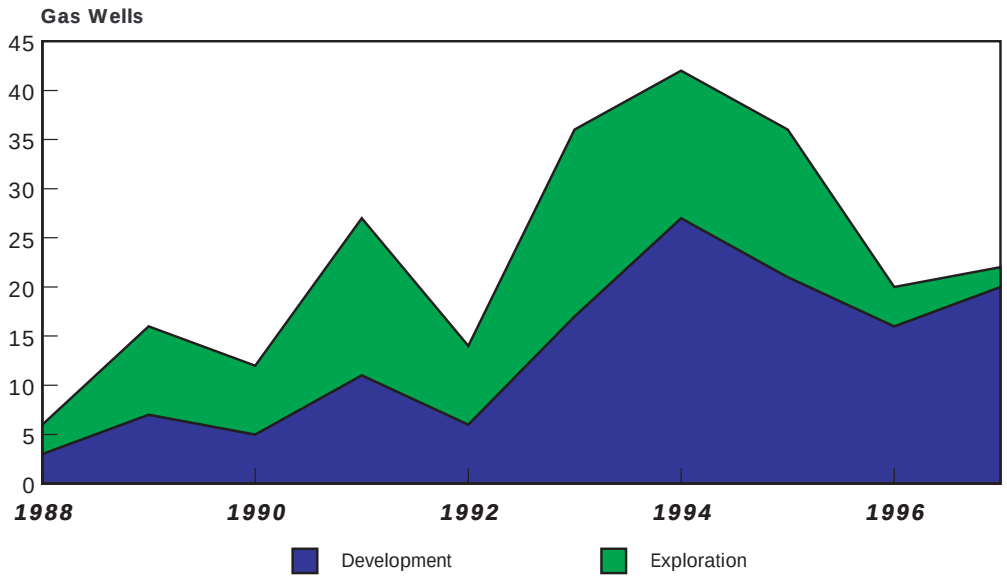


A L B E R T A F O O T H I L L S

Gas Well Completions

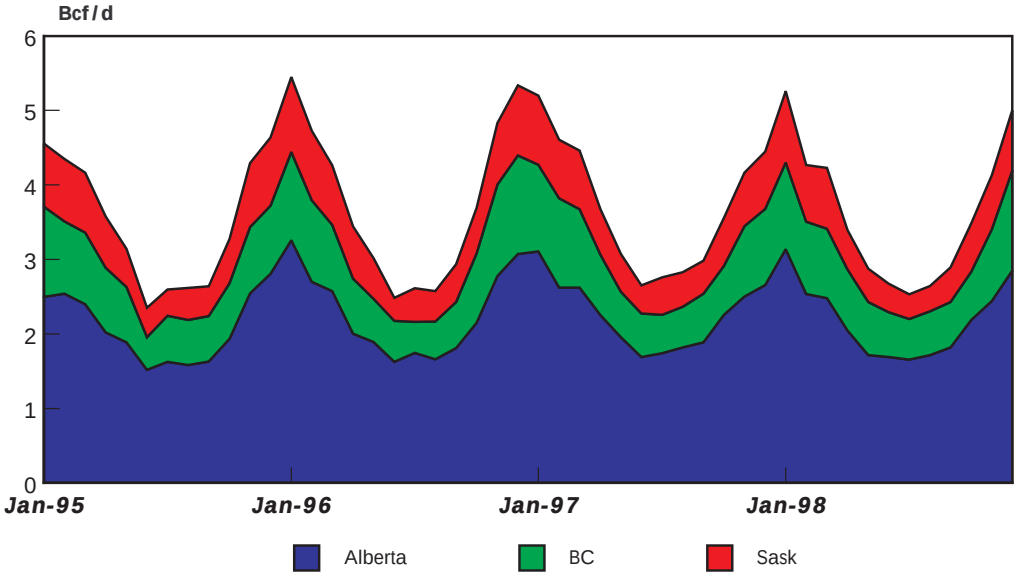


Gas Well Completions

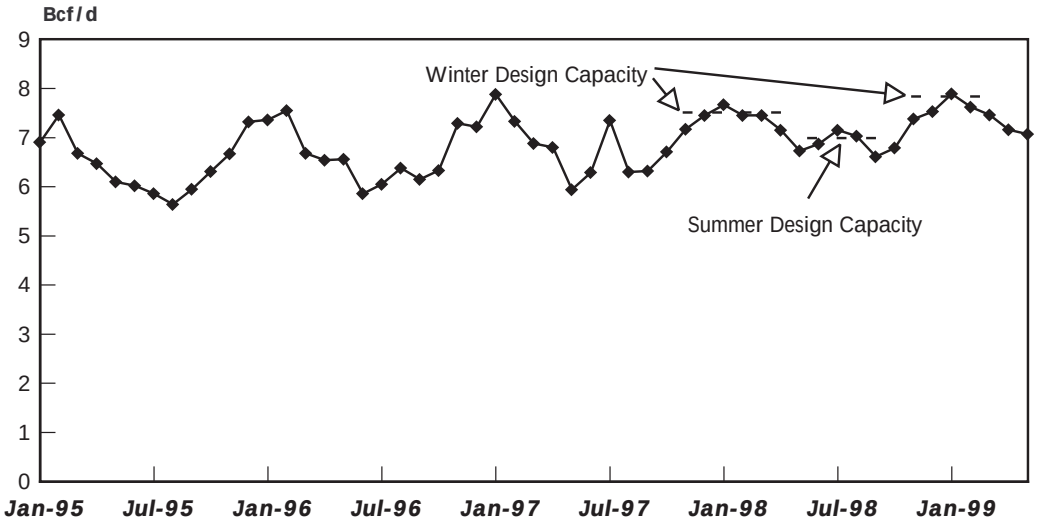


Intra-WCSB Gas Sales and Pipeline Volumes

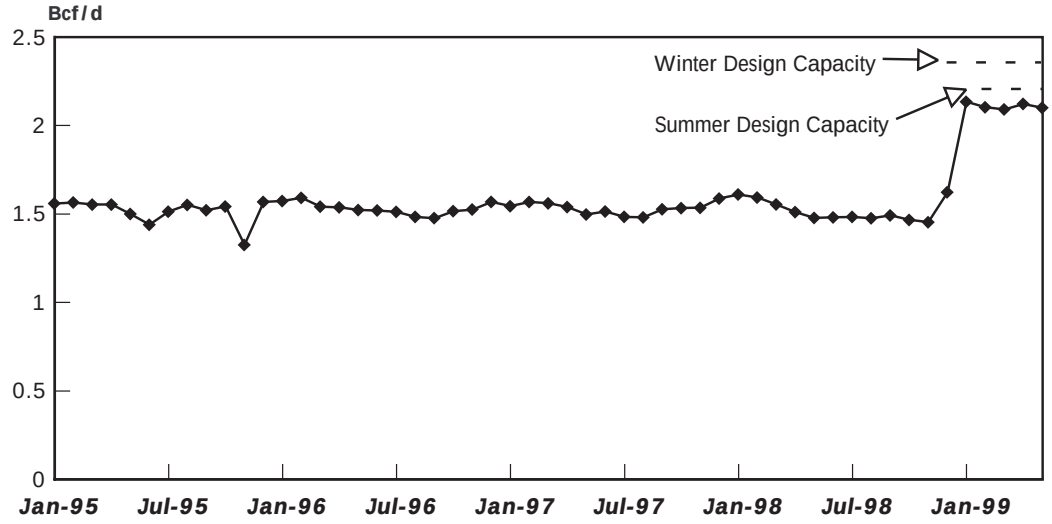
INTRA-WCSB GAS SALES



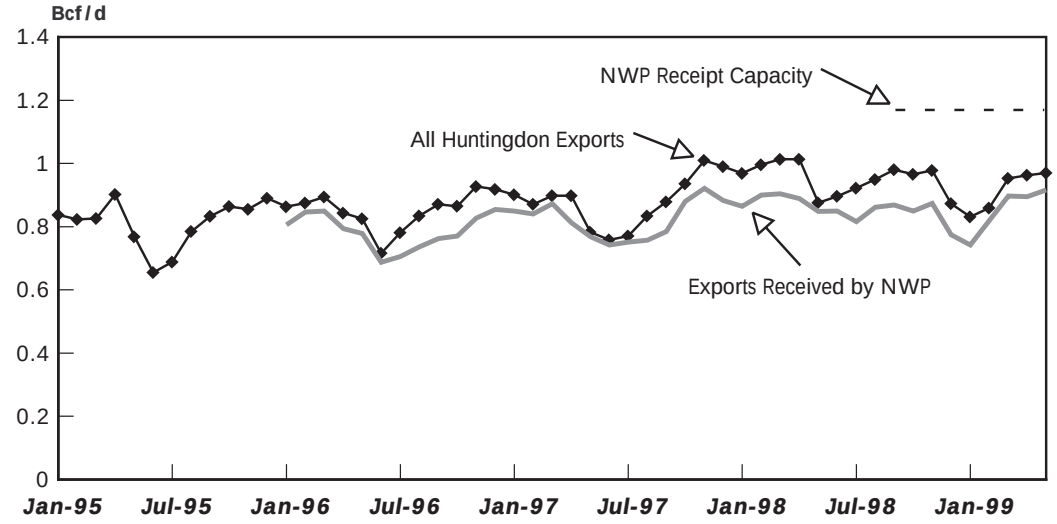
NATURAL GAS TRANSPORTED BY TCPL WESTERN SECTION



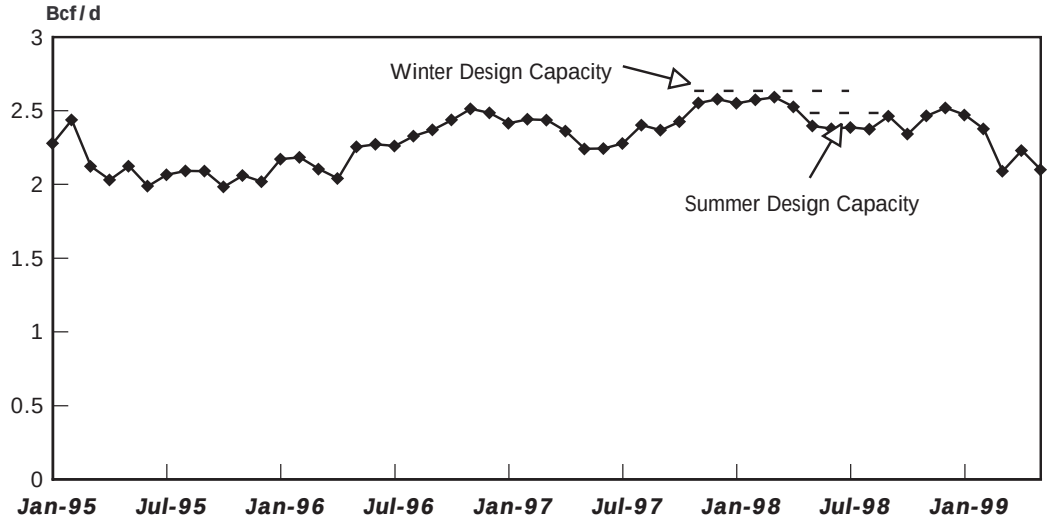
NATURAL GAS TRANSPORTED BY FOOTHILLS EAST



NATURAL GAS TRANSPORTED BY WEI AT HUNTINGDON



NATURAL GAS TRANSPORTED BY ANG



Canada