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GAS FIELDS, FORMATION-FLUID FLOW AND HYDROCHEMISTRY IN EARLY CRETACEOUS FORMATIONS, PEACE RIVER REGION, N.W. ALBERTA, CANADA

by

Mary Joanne Thompson

A THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

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ABSTRACT

A hydrogeological study of Early Cretaceous formations was conducted in a 36,000 km^2 area of northwestern Alberta, in order to establish possible relations between gas fields, formation-fluid flow and hydrochemistry. Two dynamic systems of formation waters have been inferred from potentiometric surface analyses, water chemistry, vertical pressure gradients, stratigraphy and structure.

The upper hydrodynamic zone comprises the Paddy and Cadotte Members of the Peace River Formation. The potentiometric surface mirrors the present topographic surface indicating gravity-driven flow with recharge occurring cross-formationally under the highlands. Flow is generally towards the northeast, where outcrop of the Paddy and Cadotte Members causes a regional potentiometric low. Sulin-Palmer analyses indicate the presence of meteoric water. Total dissolved solid contents range from 20 000 to 25 000 mg/l, with fresher waters in recharge areas, tending towards higher salinities in discharge areas. The majority of gas fields are found in the potentiometric lows as predicted by the Hydraulic Theory of Petroleum Migration (Tóth, 1980).

The lower hydrodynamic zone has been mapped in the Cadomin, Gething and Bluesky Formations of the Bullhead Group. An influx of fresh (< 20 000 mg/l TDS) meteoric water from the west appears to displace more saline waters (> 75 000 mg/l). Similar salinity patterns are observed in the three formations due to a predominantly upward fluid flow direction. A control of the basin geometry on regional flow is most obvious in the northern half of the study area where higher fluid potentials correspond to western highlands and lower potentials result from formation subcrops to the east.

The influence of local geology is reflected by the flow preferentially following zones of higher permeability. Gas distribution is clearly affected by the groundwater flow regime. Gas trapping in local stratigraphic and structural traps is enhanced by the upward fluid movement. Gas pools are associated with potentiometric lows in the updip region.

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I would like to thank Canadian Hunter Exploration Limited for additional financial support through their grant-in-aid program, and for access to computer facilities, drafting services, etc. Special thanks to Bob Gies for inspiring the project and for his friendship and support, especially in the rather rough early days. I cannot list by name all the "Hunter's" that deserve thanks. Suffice it to say I enjoyed and appreciated everyone's time and assistance.

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CHAPTER 1

INTRODUCTION

The search for oil and gas has been traditionally based on the integration of data from three sciences, namely, geology, geophysics and geochemistry. The petroleum industry constantly looks for improved ways to find oil, and millions of dollars are spent in the search for new data, developing methods of analysis, computer programs, seismic techniques, etc. The intent is, of course, to better understand the subsurface environment and predict favourable areas for hydrocarbon accumulation.

Industry has, however, overlooked or simply not used to full advantage tremendous amounts of data that are economic, presently available, and provide much needed information about subsurface fluid movement. Specifically, these are formation fluid pressure and water chemistry data, tools commonly used in hydrogeological investigations. Unfortunately, hydrogeology is not commonly incorporated into hydrocarbon exploration strategies.

In 1980, Tóth advanced the generalized hydraulic theory of petroleum migration, in which gravity-induced cross-formational groundwater flow is the principal agent in the transport and accumulation of hydrocarbons. This theory has been applied in recent studies of oil-bearing areas (Tóth, 1980; Vugrinovich, 1988; Wells, 1988; Tóth and Otto, 1989) where understanding the hydrogeology has proven to be valuable in understanding the hydrocarbon distribution.

The intent of this thesis is to investigate the application of the generalized hydraulic theory of petroleum migration to a predominantly gas-bearing region. The area selected for this study was the Peace River area, north of the giant Deep Basin gas accumulation in northwest Alberta (Figure 1.1). This work will illustrate how a relatively simple and inexpensive hydrogeological study can add to, and aid in, the understanding of subsurface conditions provided by standard geological, geochemical and geophysical investigations. Industry can only benefit from the added information and should integrate hydrogeology into exploration and development programs.

1.1 HISTORY OF STUDY

A hydrogeological investigation of the Early Cretaceous Cadomin Formation was carried out as a summer-student project for Canadian Hunter Exploration Ltd. in Calgary, Alberta, 1987. The objective of the study was to regionally characterize Cadomin formation water chemistry throughout the Deep Basin area of Alberta. The study area was chosen on the basis of available data, and covered 36 000 square kilometres bounded by Townships 60 to 90 and Ranges 22 west of the 5th meridian to 13 west of the 6th meridian (Figure 1.1).

Mapping of water chemistry established the regional salinity patterns within the Cadomin Formation which appeared to indicate the presence of a hydrodynamic flow regime. Further investigation suggested a relationship between water salinity anomalies, groundwater flow patterns and gas accumulations. In an effort to define and understand this relationship, and to consider the three-dimensional effects of cross-formational flow, the study was expanded to include the Peace River Formation (Paddy, Cadotte and Harmon Members), the Spirit River Formation (Notikewin, Falher and Wilrich Members) and the Bullhead Group (Bluesky, Gething and Cadomin Formations) (Figure 1.2). Initial investigations found a distinct lack of formation pressure and water chemistry data for the Harmon, Notikewin and Wilrich Members. Production-disturbed pressure data and severe contamination of water samples limited the use of data from the Falher Member. Research,

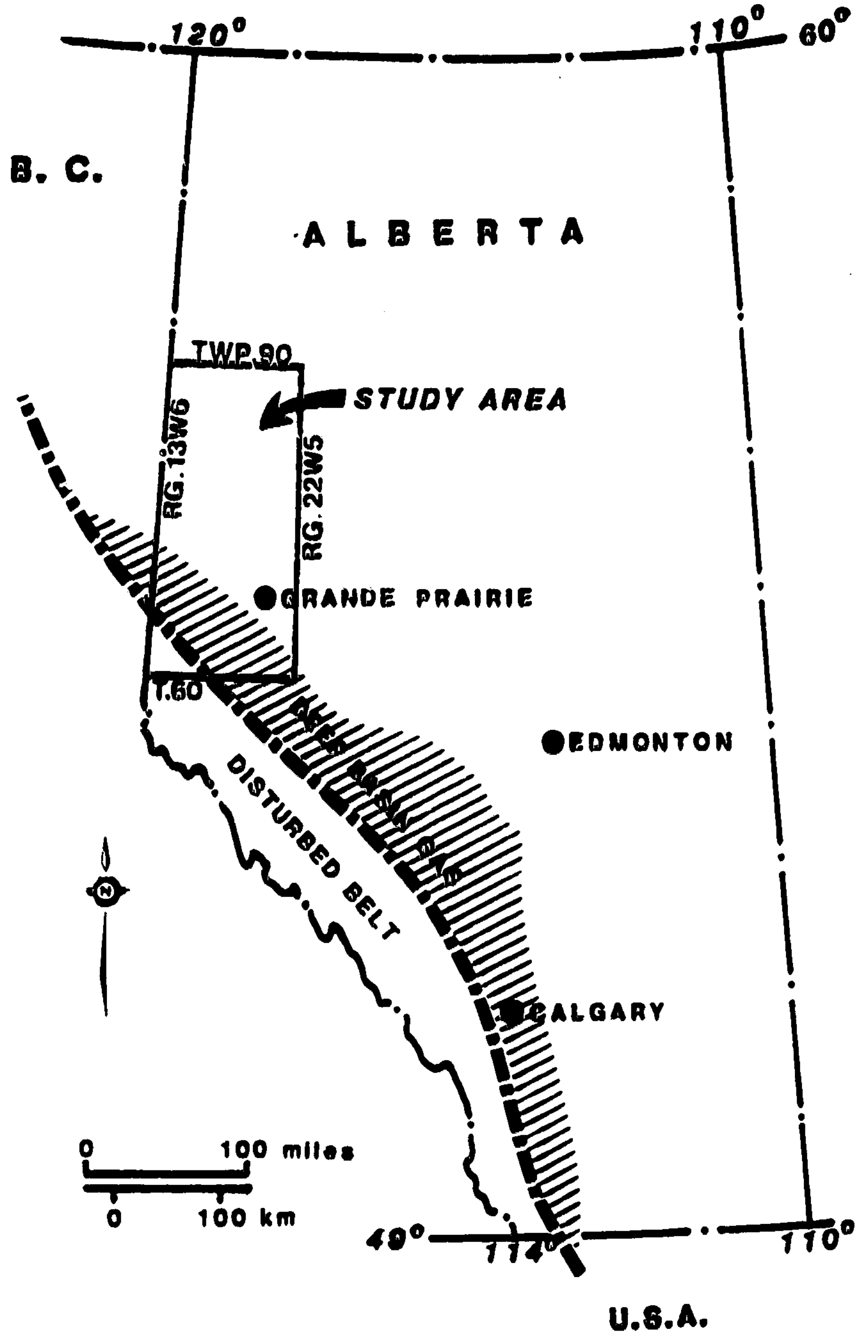

Figure 1.1 Location of study area

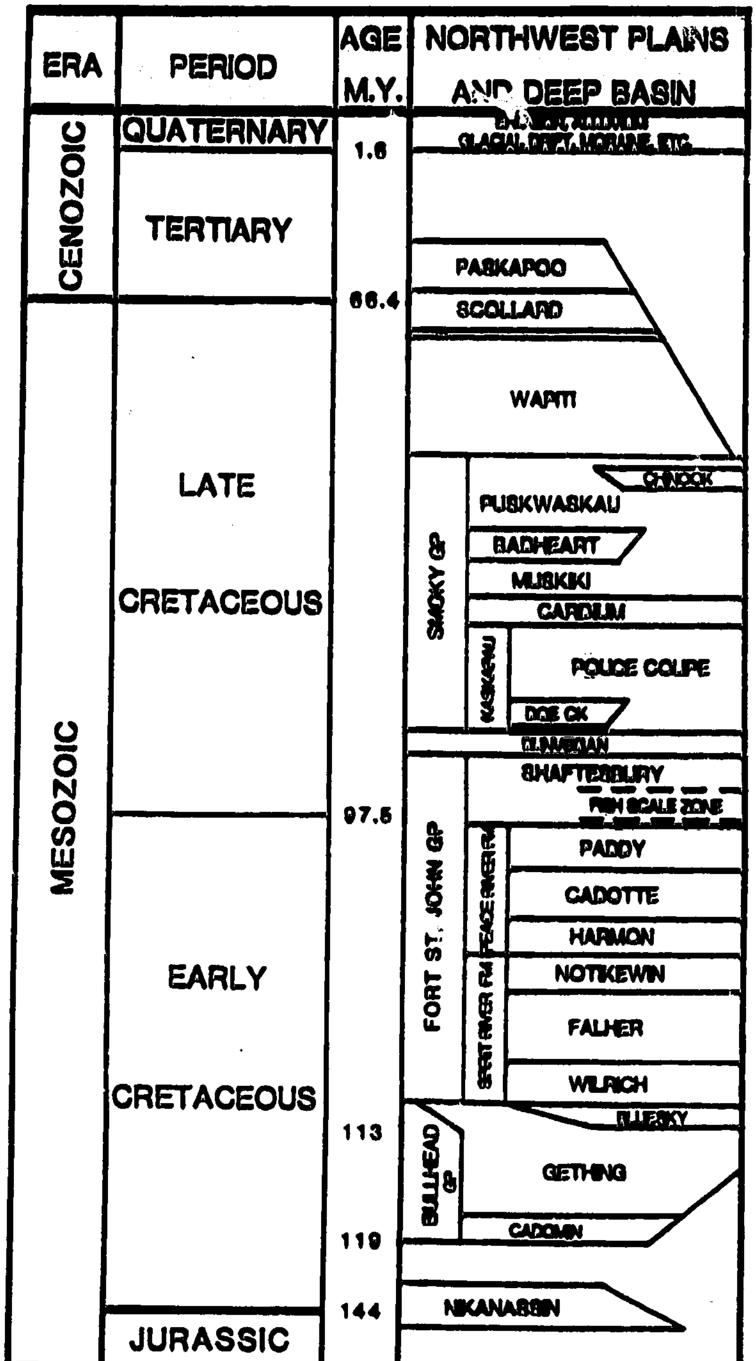

Figure 1.2 Stratigraphy

therefore, concentrated on the Peace River, Bluesky, Gething and Cadomin Formations (Figure 1.2).

1.2 OBJECTIVES

There are three main objectives of this thesis:

1) to characterize the area's petroleum hydrogeological conditions, i.e., hydrostratigraphy, hydraulic head distribution, hydrochemistry and hydrocarbon occurrence
2) to determine the relationships between flow distribution, water chemistry, geology (lithology, permeability, structure) and gas accumulation
3) to formulate a hydrogeological model for the observed relationships.

The ultimate goal of the research is to use the model for the prediction of favourable locations for hydrocarbon accumulations, i.e., to use hydrogeology as an exploration tool.

1.3 FORMAT

A "paper-format" has been chosen for this thesis. This requires introductory (Chapter 1) and concluding chapters (Chapter 3) in addition to an introduction and conclusion of the paper itself (Chapter 2). There is some overlap of figures and text due to the repetitive nature of this format.

Chapter 2 presents the main results of the research and discusses formation water chemistry and gas distribution in relation to hydraulic head and groundwater flow in the study area. Details of theory, data aquisition, data qualification and methods of study have been included in appendix form.

Appendix I discusses formation pressure data, the necessary culling criteria, hydraulic head calculations and potentiometric surface maps. A complete list of pressure data and head values is provided for each formation. Appendix II contains the qualification procedures and culling criteria used in assembling the hydrochemistry data base and complete lists of water data by formation. Appendix III reviews the Sulin and Palmer water classification systems adopted for use in this study. Again, data lists are provided. These appendices are referred to in appropriate sections of the paper presented in Chapter 2.

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Vugrinovich, R., 1988: Relationships between regional hydrogeology and hydrocarbon occurrences in Michigan, U.S.A.; Journal of Petroleum Geology, Vol. 11, No. 4, pp. 429-442.

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CHAPTER 2

GAS FIELDS, FORMATION-FLUID FLOW AND HYDROCHEMISTRY IN EARLY CRETACEOUS FORMATIONS, PEACE RIVER REGION, N.W. ALBERTA, CANADA

2.1 INTRODUCTION

A hydrogeological investigation of the Cretaceous Cadomin Formation in N.W. Alberta suggested a relationship between water salinity anomalies, groundwater flow patterns and gas accumulations. In an effort to further define and understand this relationship, and to consider the effects of cross-formational fluid flow, the investigation was expanded to include other Early Cretaceous formations. The work was carried out as an M.Sc. thesis at the University of Alberta, supervised by Dr. József Tóth and sponsored by Canadian Hunter Exploration Ltd.

The objectives of the investigation were threefold: 1) to characterize the area's petroleum hydrogeological conditions, i.e., hydrostratigraphy, hydraulic head distribution, hydrochemistry and hydrocarbon occurrence, 2) to determine the relationships between flow distribution, water chemistry, geology, structure and gas accumulation, and 3) to formulate a hydrogeological model for the observed relationships and for the prediction of favourable locations for hydrocarbon accumulations.

2.1.1 *Study Area*

The study area comprises 36 000 square kilometres in northwestern Alberta covering townships 60 to 90 and ranges 22W5 to 13W6 (Figure 2.1). Rock units under consideration are Early Cretaceous in age and include the Peace River Formation (Paddy, Cadotte and Harmon Members), the Spirit River Formation (Notikewin, Falher and Wilrich

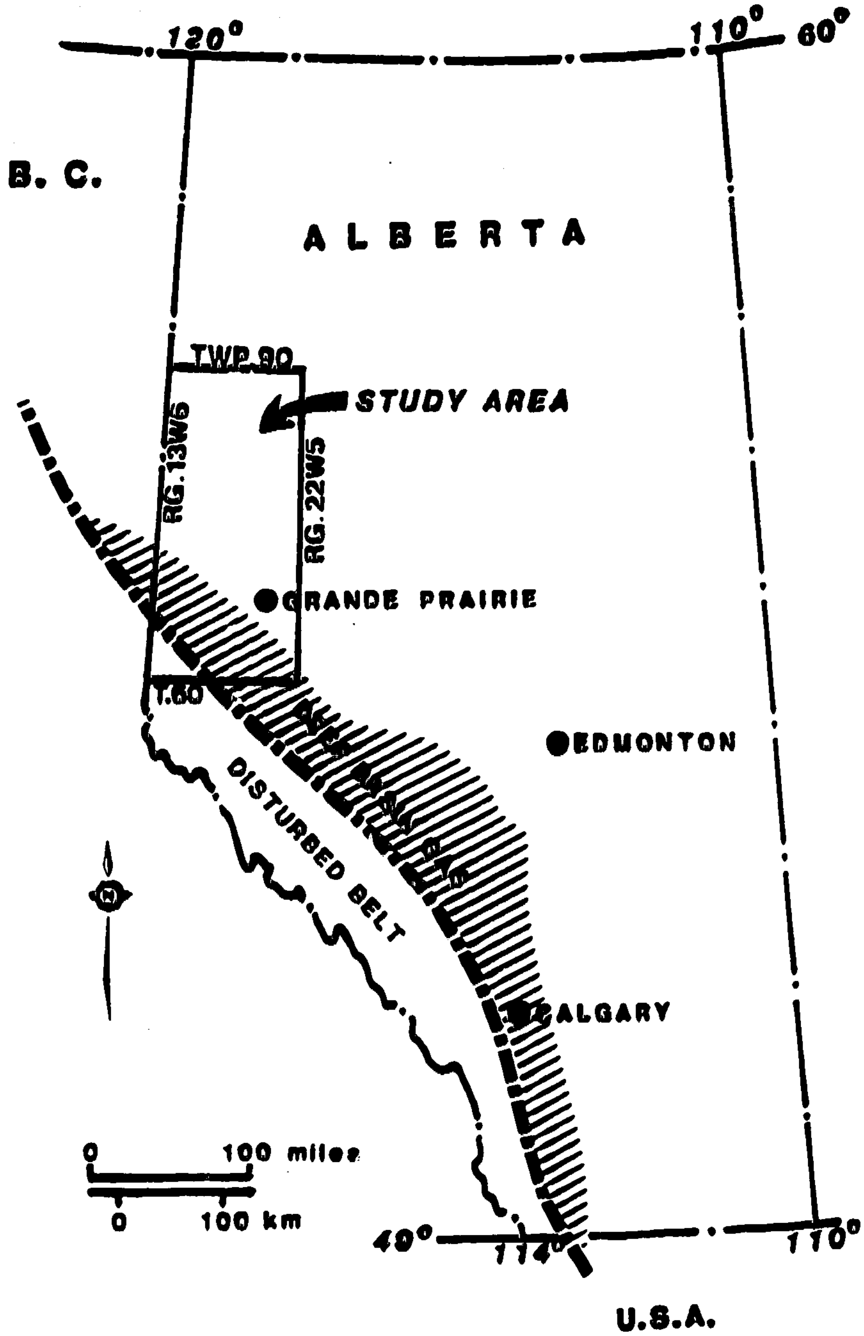


Figure 2.1 Location of study area

Members), and the Bullhead Group (Bluesky, Gething and Cadomin Formations) (Figure 2.2). Initial investigations found a distinct lack of both pressure and water chemistry data for the Harmon, Notikewin and Wilrich Members. Severe contamination problems and production-disturbed pressure values limited the use of data from the Falher Member. Investigation, therefore, focussed on the Paddy and Cadotte Members of the Peace River Formation and the Bluesky, Gething and Cadomin Formations.

2.1.2 *Topography*

The major features of topographic relief are illustrated in Figure 2.3. Elevations of less than 500 metres above mean sea level (a.m.s.l.) mark the valleys of the two main rivers, namely the Peace River and the Smoky River, the latter of which is fed by the Wapiti and Simonette Rivers. The Peace River Valley becomes deeper and wider from west to east cutting down to elevations of less than 335 metres a.m.s.l. where the valley turns towards the north. It is important for later synthesis to note that this deep incision causes outcrop of the Peace River Formation (Paddy and Cadotte Members) at an elevation of approximately 350 metres a.m.s.l.

Much of the study area is between 500 and 800 metres a.m.s.l., sloping towards the principal river valleys. The average altitude is approximately 750 metres a.m.s.l., although elevations of 1033 metres and 995 metres are reached in the central Saddle Hills area (Figure 2.3). The Clear Hills mark the highest elevations in the north half of the study area, reaching 1066 metres a.m.s.l.

In the south, elevations over 1000 metres a.m.s.l. characterize the area referred to as the Alberta High Plains. The Rocky Mountain Foothills are evident in the southwest corner where elevations reach over 2200 metres a.m.s.l. (Figure 2.3).

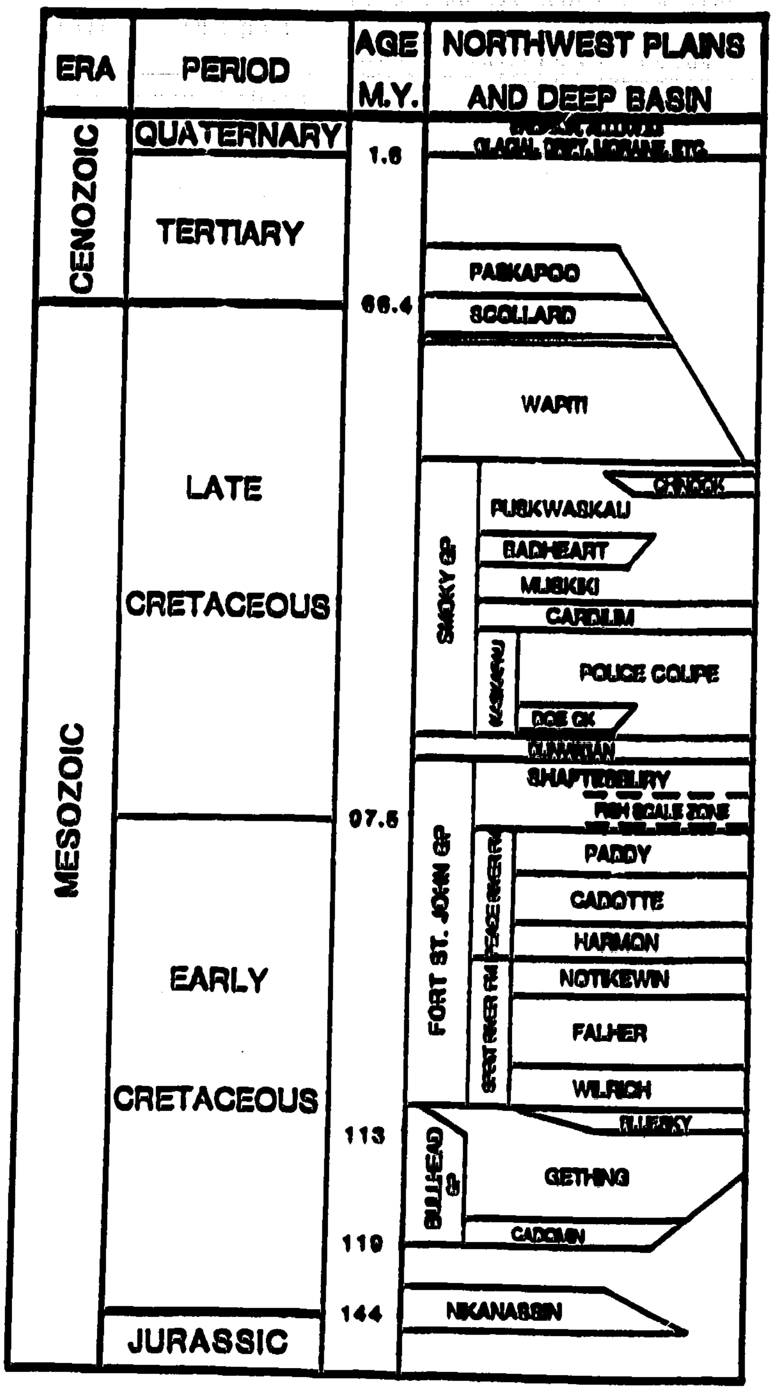


Figure 2.2 Stratigraphy

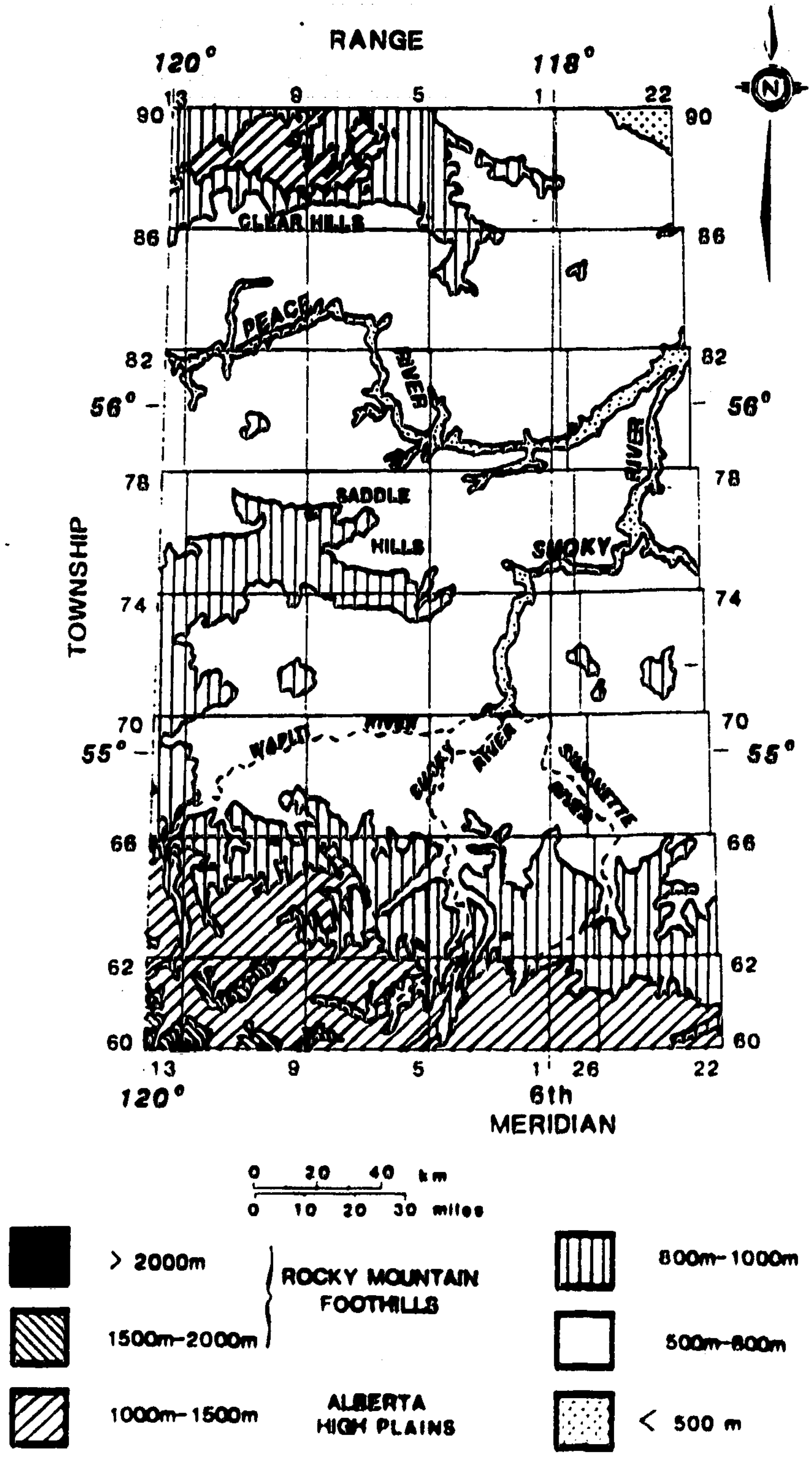


Figure 2.3 Generalized topography of study area

2.2 DATA BASE

Fundamental to a complete hydrogeological study is the acquisition, evaluation and interpretation of hydraulic, hydrochemical and stratigraphic data. These data must be carefully screened to insure accurate results. Briefly outlined below are the sources and qualification criteria for the data used in this study. (Details are provided in Appendices I-II).

Formation-fluid pressure data were obtained from a drill stem test (DST) microfiche file purchased from the Canadian Institute of Formation Evaluation (CIFE). The file provides summary reports of all available DST information for the study area as well as extrapolated formation fluid pressures. CIFE qualified each test on the basis of mechanical soundness, data quality and accuracy, using a quality code rating system A through G, with "A" representing the highest quality DST's. In this study, only A and B quality tests were considered and, of these, 25% were removed due to questionable validity of extrapolation methods, disturbance by production, or multiple test intervals on a single report. The final data base includes over 1000 DST's for which extrapolated formation pressures are trusted (Appendix I).

The basic hydrochemistry data came from the Alberta Energy Resources Conservation Board (ERCB) standard water analyses files, which commonly report concentrations of sodium, calcium, magnesium, bicarbonate, sulphate, chloride, total dissolved solids (TDS), and occasionally a few other ions such as potassium, iodide or carbonate. Other information includes water density, resistivity and pH.

Drilling muds, acid washes, cement filtrates, or waters from other than the zone of interest, commonly cause contamination of formation water samples. Variable sampling methods, locations of samples and analytical techniques also affect the reliability of the results, and care must be taken in selecting analyses for an accurate data base. Strict culling criteria as described by Hitchon et al. (1987) were utilized (Appendix II). Use of such criteria resulted in the rejection of approximately 90% of more than 6900 standard analyses initially considered, as they did not appear to be representative of true formation waters.

The regional geology was synthesized from available ERCB data and published literature, which included age, lithology, depth, thickness, porosity and permeability information.

2.3 METHODS OF ANALYSIS

2.3.1 *Theory of Regional Groundwater Flow*

Assuming a hydraulically continuous rock framework, Tóth (1963) mathematically modelled regional gravity-flow of groundwater in a simple homogeneous drainage basin. Three important conclusions were reached: 1) three types of flow systems occur: local, intermediate and regional (Figure 2.4a); 2) systems are defined by recharge, midline and discharge regions (Figure 2.4b); 3) quasi-stagnant conditions will occur where flow systems meet or part. System development is controlled by the relief of the water table, which may be approximated by the topographic relief. Recharge areas occur under highlands with flow towards the valleys or discharge areas.

Complex topographic and geologic settings have a profound effect on the development of these flow systems. Where there is pronounced topographic relief, many local systems may develop. If local relief is negligible, regional systems will dominate. Lithology and the resultant subsurface variations in hydraulic continuity affect the relationships between local and regional systems and directly influence the direction of subsurface fluid movement. A detailed discussion of these effects on flow patterns is beyond the scope of this paper, and is well documented elsewhere (e.g., Tóth, 1963; Freeze and Witherspoon, 1967; Tóth, 1980). Regional groundwater flow theory is,

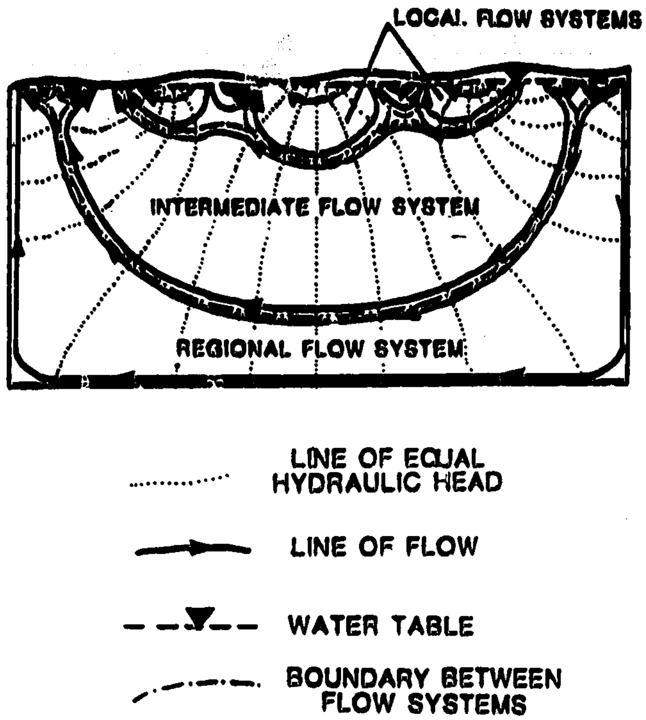


Figure
2.4 a Illustration of the three orders of flow systems: local, intermediate and regional (modified from Tóth, 1963)

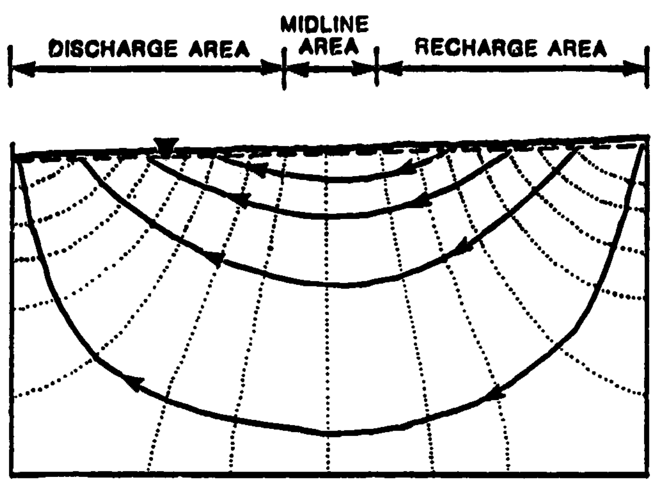


Figure
2.4 b Illustration of the downward movement of groundwater flow under highlands, lateral flow, and upward flow in lowlands, defining recharge, midline and discharge areas of a flow system respectively (modified from Tóth, 1980)

however, used in the interpretation of potentiometric surface maps, and the effects of topography and geology must be considered.

2.3.2 *Potentiometric Surface*

A potentiometric surface is an imaginary surface representing the lateral distribution of fluid potential in a confined aquifer. Hubbert (1940) defined fluid potential as the energy contained by a unit mass of fluid. This energy is commonly expressed in terms of fresh water head, where head, h, is the height above datum of a column of fresh water that is in equilibrium with the pore pressure at the point of measurement

$$h = z + p/\gamma \qquad (1)$$

where, h=hydraulic head

z=recorder elevation with respect to datum, commonly sea level

p=undisturbed formation-fluid pressure

γ=specific weight of the fluid (vertical pressure gradient)=ρg (fluid density x gravity)

Potentiometric surface maps are made by contouring hydraulic head values and may be used to determine fluid flow directions (fluid flows from areas of high potential, or head, to areas of low potential). The interpretation of potentiometric surface maps is theoretically valid only for formation fluids of constant density. Davies (1987) modelled variable density groundwater flow using equivalent freshwater head and analysed the potentially significant errors in this method. Using his error-analysis technique, it has been determined that density differences in the present study are not large enough for density related gravity effects to become significant. Hitchon (1969a) and Tóth (1978), working with similar water salinities, also found that density effects do not invalidate general flow conclusions. It has, therefore, been considered justified to calculate hydraulic heads using the extrapolated pressure data obtained from CIFE, the subsea recorder elevation, and a fresh water pressure gradient.

Although potentiometric surface maps were constructed for individual formations, they are not meant to imply that flow is restricted within these units. Cross-formational flow is an important aspect of fluid-flow patterns. Construction of vertical hydraulic cross-sections aided interpretation of the three-dimensional flow systems occurring within the study area.

2.3.3 *Pressure-Depth Relations*

Analysis of pressure versus depth relations is useful in the determination of dynamic conditions of subsurface fluids. Pressure-depth data can indicate overpressured or underpressured conditions and whether flow within and between aquifers has an upward or downward vertical component (Tóth, 1978).

The pore pressure at any point of a hydraulically continuous body of regionally unconfined rock saturated by a static fluid is,

$$p = \rho \times g \times d = \gamma \times d \qquad (2)$$

where p is the pore pressure, ρ is the fluid density, g is the acceleration of gravity, d is the depth below surface and γ is the specific weight of the fluid. Pressure versus depth (p-d) curves are simply a graphical representation of Equation (2), and a pressure computed by (2) for any depth is termed normal or hydrostatic pressure (Tóth, 1978). If the formation fluid has a vertical component of movement, the pressures will differ from hydrostatic causing a change in slope (rate of change of pressure with depth) of the p-d curve. Upward flow is indicated when the slope is greater than hydrostatic and flow is downward when the slope is less than hydrostatic. Hydrostatic slope may indicate a "no flow" situation or horizontal flow conditions.

2.3.4 *Water Chemistry*

The nature of formation waters in an oil- or gas- bearing region is of vital concern to both exploration and development. Fluid composition and distribution are related to reservoir rock type, porosity, permeability and age. Consequently, water analyses can provide the exploration geologist with useful information regarding the geologic framework on both local and regional scales (Collins, 1975). Proper characterization of formation water chemistry is also critical for accurate E-log interpretation and formation evaluation.

Isoconcentration maps showing regional variations in total dissolved solids content of waters within a given stratigraphic unit are important. As well, individual ion concentration/distribution maps and ion-ratio maps are useful for characterizing the type and relative amount of dissolved solids (Collins, 1975). Explaining patterns in major ion chemistry and understanding the processes responsible for water chemistry patterns aids interpretation of regional flow systems (Hendry and Schwartz, 1988). Tóth (1984) discussed the relationship of groundwater chemistry to flow systems and indicated that, in general, TDS contents increase along flow paths.

Chebotarev's sequence (1955) describes the sequential change of the dominant anions in subsurface waters from bicarbonate to sulphate to chloride with increased depth and residence time. It is possible to correlate the empirically established chemical evolutionary sequence of Chebotarev with groundwater flow distribution (Tóth, 1984). By mapping the distribution of these components it is possible, therefore, to delineate probable flow directions.

Changes in salinity patterns may also be effected by permeability variations within a rock unit. Water will preferentially follow the path of least resistance to flow, i.e., the zones of highest permeability or fluid conductivity. This is illustrated by groundwater flow models of the gradual displacement of resident formation waters by infiltrating meteoric waters (Domenico and Robbins, 1985; Hendry and Schwartz, 1988), where dilution patterns correspond to high conductivity pathways in hydraulic communication with recharge areas. Permeability changes in the lithologic framework resulting from facies changes, reservoir discontinuities, structures, faults, etc., cause changes in hydraulic continuity which may limit the infiltration and mixing of the recharge waters. This results in steep lateral concentration gradients on salinity maps oriented approximately normal to the flow direction. High salinity regions, therefore, may be interpreted as areas of poor circulation or areas bypassed by the regional flow of fresher meteoric waters. Domenico and Robbins (1985) concluded that macroscopic heterogeneities at the formation scale control the mixing zones for meteoric and original formation water. Salinity variations, therefore, may be used to infer permeability contrasts, reservoir discontinuities, structures, etc. Such features are of fundamental importance in hydrocarbon exploration.

2.3.5 *Sulin-Palmer Water Classification*

In an effort to facilitate comparison of water analyses, formation waters may be classified according to the dominant ions present in solution. Many systems have been suggested for classifying waters (Palmer, 1911; Sulin, 1946; Schoeller, 1955; Chebotarev, 1955), without any one system receiving universal acceptance (Ostroff, 1967). The Palmer classification system depends on general properties of salinity and alkalinity of waters (Palmer, 1911). The Sulin classification system (Sulin, 1946) categorizes water into four types according to the distribution of three cations (sodium, calcium, magnesium) and three anions (bicarbonate, sulphate, chloride):

Type 1) sulphate-sodium waters

Type 2) bicarbonate-sodium waters

Type 3) chloride-magnesium waters

Type 4) chloride-calcium waters

These water types are considered to infer genetic origin of formation waters; Types 1 and 2 characterize near surface or meteoric waters whereas Types 3 and 4 tend to indicate deeper subsurface brines or evolved waters. The Sulin classification scheme incorporates Palmer's system and is, therefore, commonly referred to as the Sulin-Palmer system. Details of these classification systems are discussed in Ostroff (1967) or Collins (1975) (Appendix III). In this study, distribution maps of the Sulin-Palmer water types were made which, together with the TDS maps, provide useful insight into the origin, distribution and flowpaths of subsurface waters.

2.4 GEOLOGY

The Early Cretaceous strata within the study area consist of approximately 360 to 780 metres of conformably deposited, alternating fine and coarse clastics, which lie unconformably over Paleozoic strata. A pre-Cretaceous erosional event leveled the Paleozoic strata, truncating progressively older strata to the east. Within the bounds of this study area the Early Cretaceous sediments overlie Jurassic and Triassic units (Figure 2.5). The strata dip gently (approximately 4m/km) southwestward into the Deep Basin, where both porosity and permeability of the units decrease significantly due to greater compaction, higher clay content and more intense diagenesis (Welte et al., 1985).

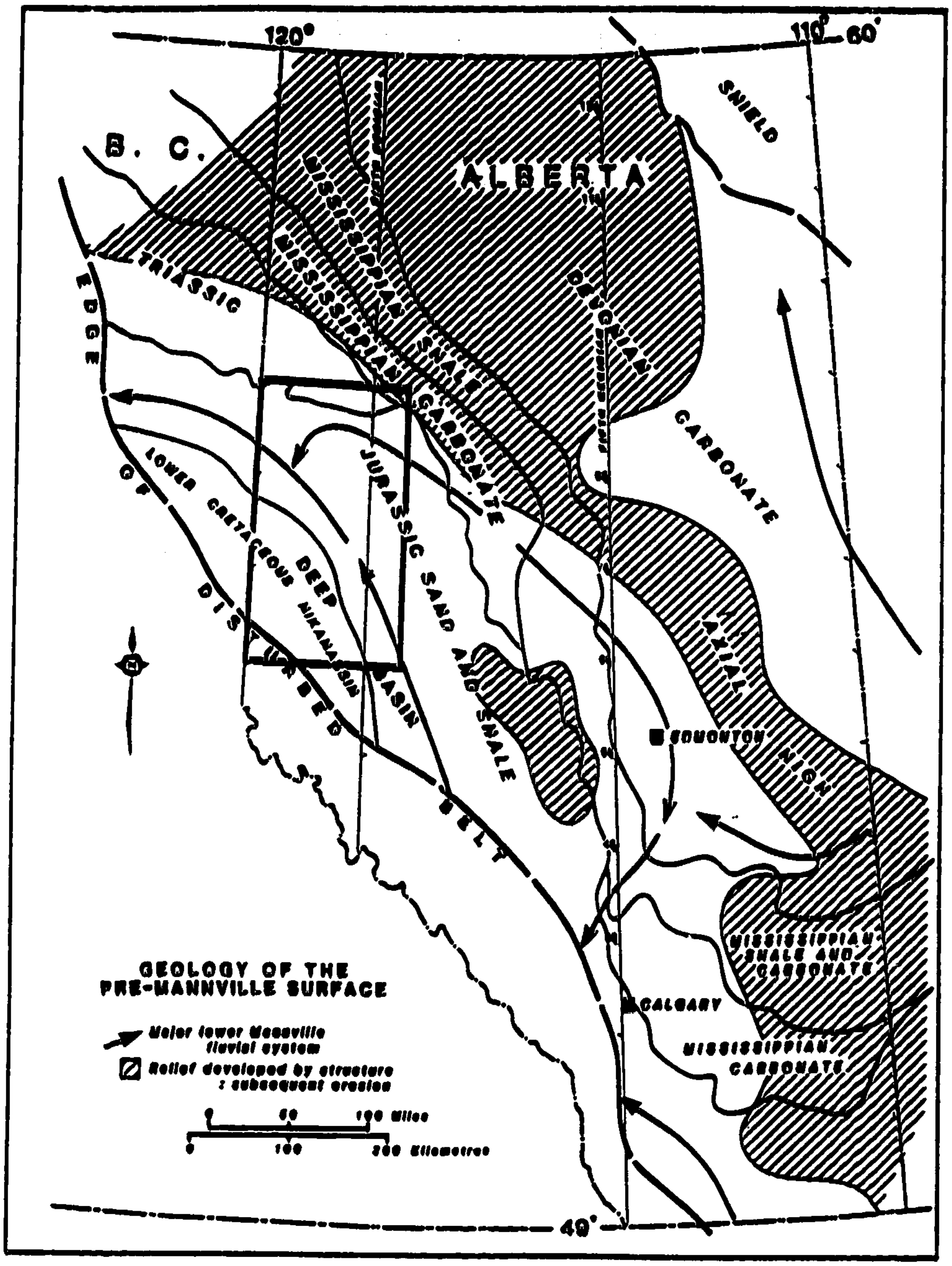


Figure 2.5 Pre-Cretaceous erosional surface. Outlined study area overlies Triassic and Jurassic sediments (modified from Jackson, 1984).

2.4.1 *Bullhead Group*

2.4.1.1 *Cadomin Formation*

The Cadomin Formation is the basal unit of the Early Cretaceous Bullhead Group (Figure 2.2) and lies unconformably on the Nikanassin Formation. Within the study area, the formation occurs as a relatively thin sheet deposit with thickness ranging from 1.2 metres to 18.8 metres, and mean thickness of 7.7 metres (Varley, 1984).

The Cadomin was deposited in an alluvial plain environment (McLean, 1976; Gies, 1984). The alluvial plain sediments are poorly-sorted sandy conglomerates composed mainly of chert with some quartzite pebbles. A major braided river channel known as the Spirit River Braid Plain, is mapped over most of the study area (Figure 2.6). The eastern edge of this channel is a gently rising erosional feature known as the Fox Creek Escarpment (McLean, 1976). The braid plain sediments are also dominantly chert although the pebbles tend to be smaller and better sorted (Gies, 1984).

An important difference in permeability exists between the alluvial plain and braid plain sediments. The fine matrix of the alluvial plain sediments causes very low permeabilities (< 1 millidarcy) whereas the well-sorted, coarser-grained braided river sediments have permeabilities ranging up to several hundred millidarcys (Gies, 1984).

2.4.1.2 *Gething Formation*

The Gething sediments were deposited in a low relief, interior drainage plain which produced a thick succession of terrestrial sediments. The drainage pattern is illustrated by a net sand isopach and paleogeography map (Figure 2.7). The formation primarily consists of interbedded, fine to medium grained, poorly-sorted sandstones, siltstones, mudstones and discontinuous carbonaceous shales and coal beds (Rudkin, 1964).

Thickness of the Gething ranges from 400 metres down to 60 metres, as the

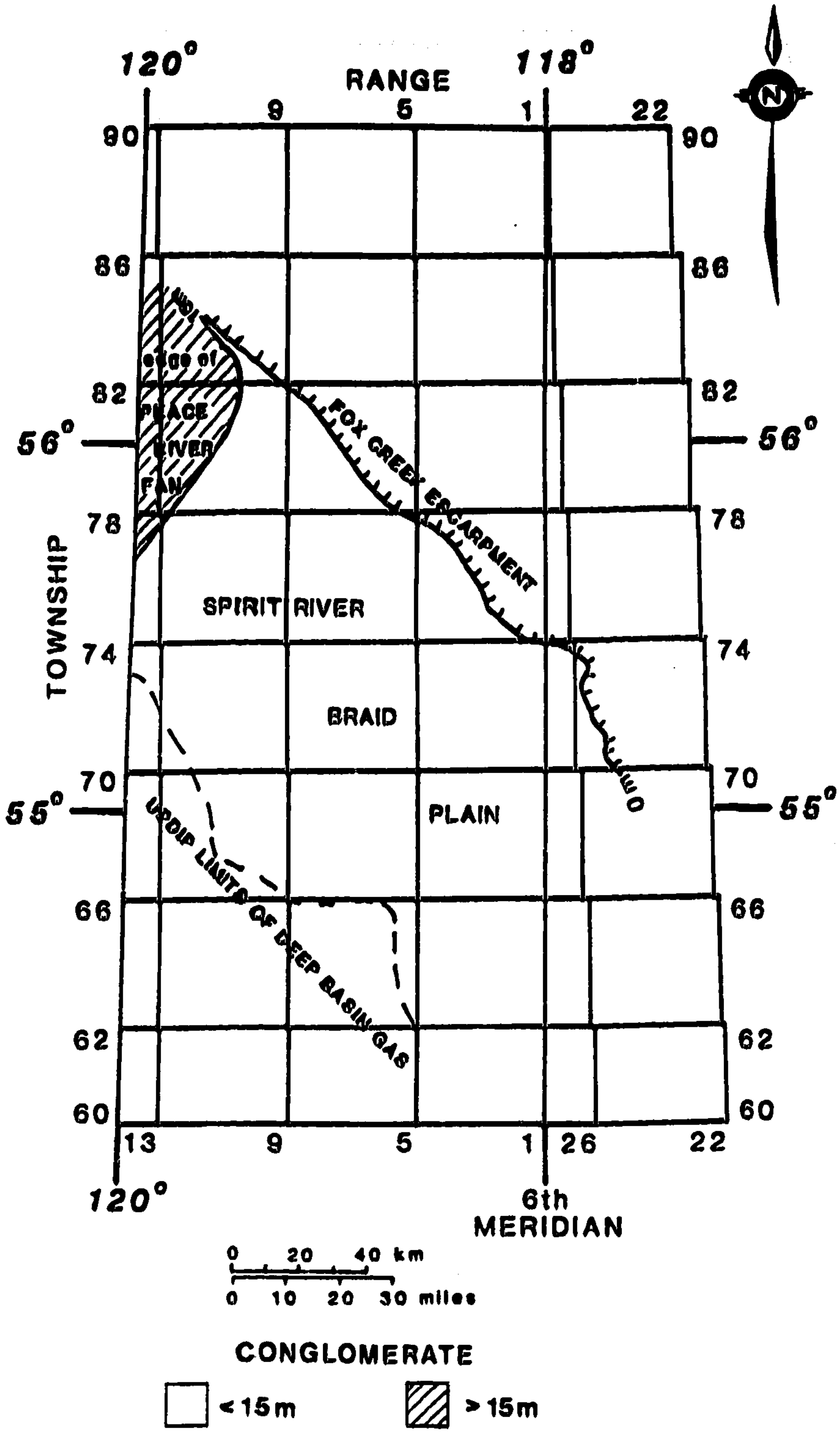


Figure
2.6 Cadomin Formation paleogeography and conglomerate isopach map (modified from Smith, et al., 1984).

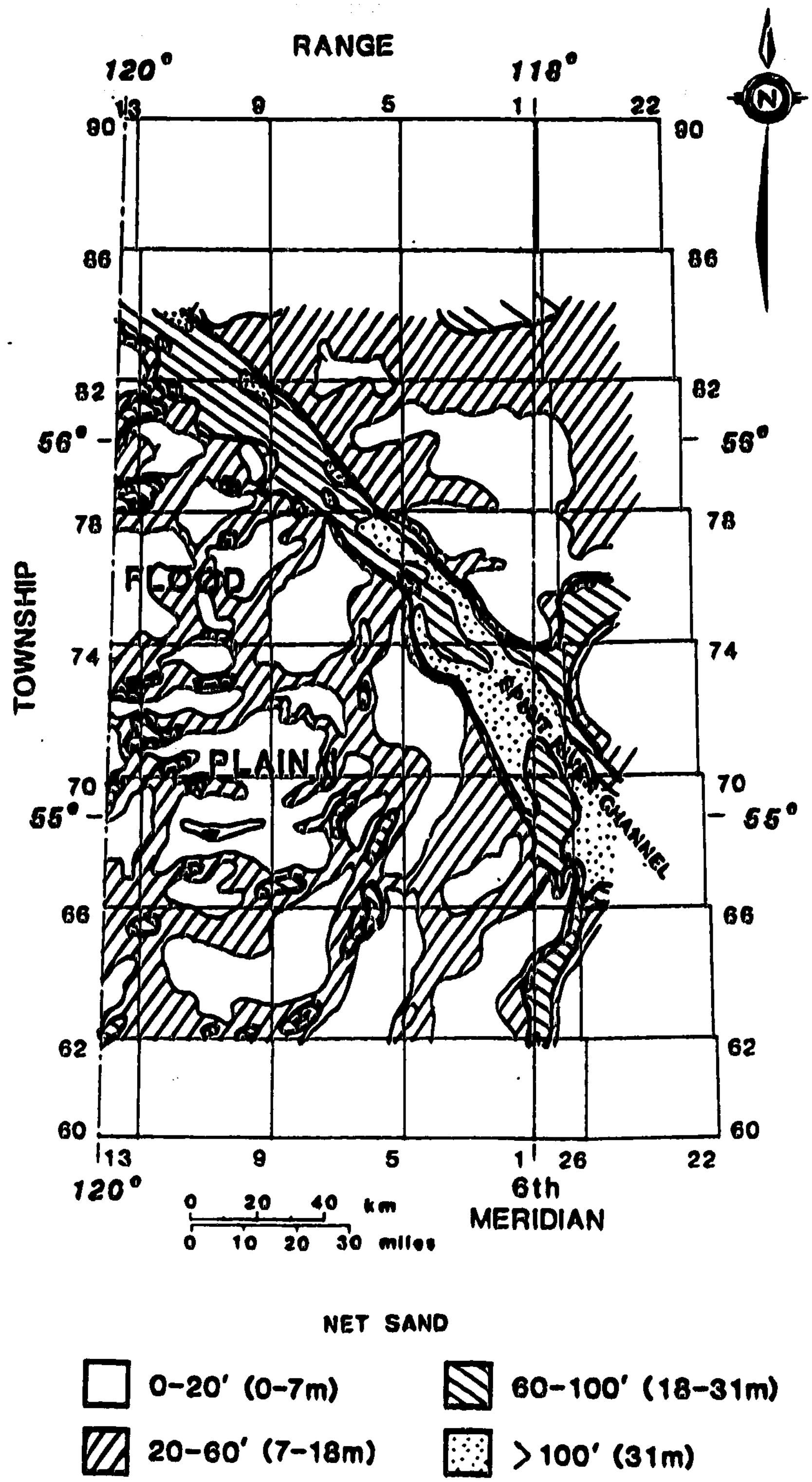


Figure 2.7 Gething Formation paleogeography and net sand isopach map (modified from Smith et al., 1984).

Formation thins over the Fox Creek Escarpment to the east. Greatest thicknesses occur in areas of channeling. Within the bounds of the study area the average thickness is about 100 metres. Permeability values range from about 3 millidarcys to 10 millidarcys, increasing north and east from the Deep Basin, with highest values in the fluvial channels.

2.4.1.3 *Bluesky Formation*

The Bluesky Formation is generally considered to be a reworked and winnowed part of the Gething sandstones (Rudkin, 1964). A paleogeography map (Figure 2.8) illustrates the apparent depositional trends in the Bluesky Formation as mapped by Smith et al. (1984).

Across the study area, the average thickness of Bluesky sediments is about 20 metres. Permeability values vary greatly; in the Deep Basin the average permeability is about 8 millidarcys compared to the northeastern Peace River area where permeabilities range from 20 millidarcys to over 1 darcy with an average of about 200 millidarcys (Smith et al., 1984).

2.4.2 *Peace River Formation*

2.4.2.1 *Cadotte Member*

The Cadotte Member of the Peace River Formation is a fine grained to conglomeratic sequence, coarsening upward. In the northern part of the study area, however, it grades into offshore silts and thin sands (Figure 2.9). The average Cadotte grain size increases towards the west, as does the unit thickness which varies from 10 to 40 metres. Smith et al. (1984) estimate a porosity of 5-10% and an average permeability of 25 millidarcys in the Deep Basin area, increasing in the Peace River area to 15-30% porosity and 250 millidarcys permeability.

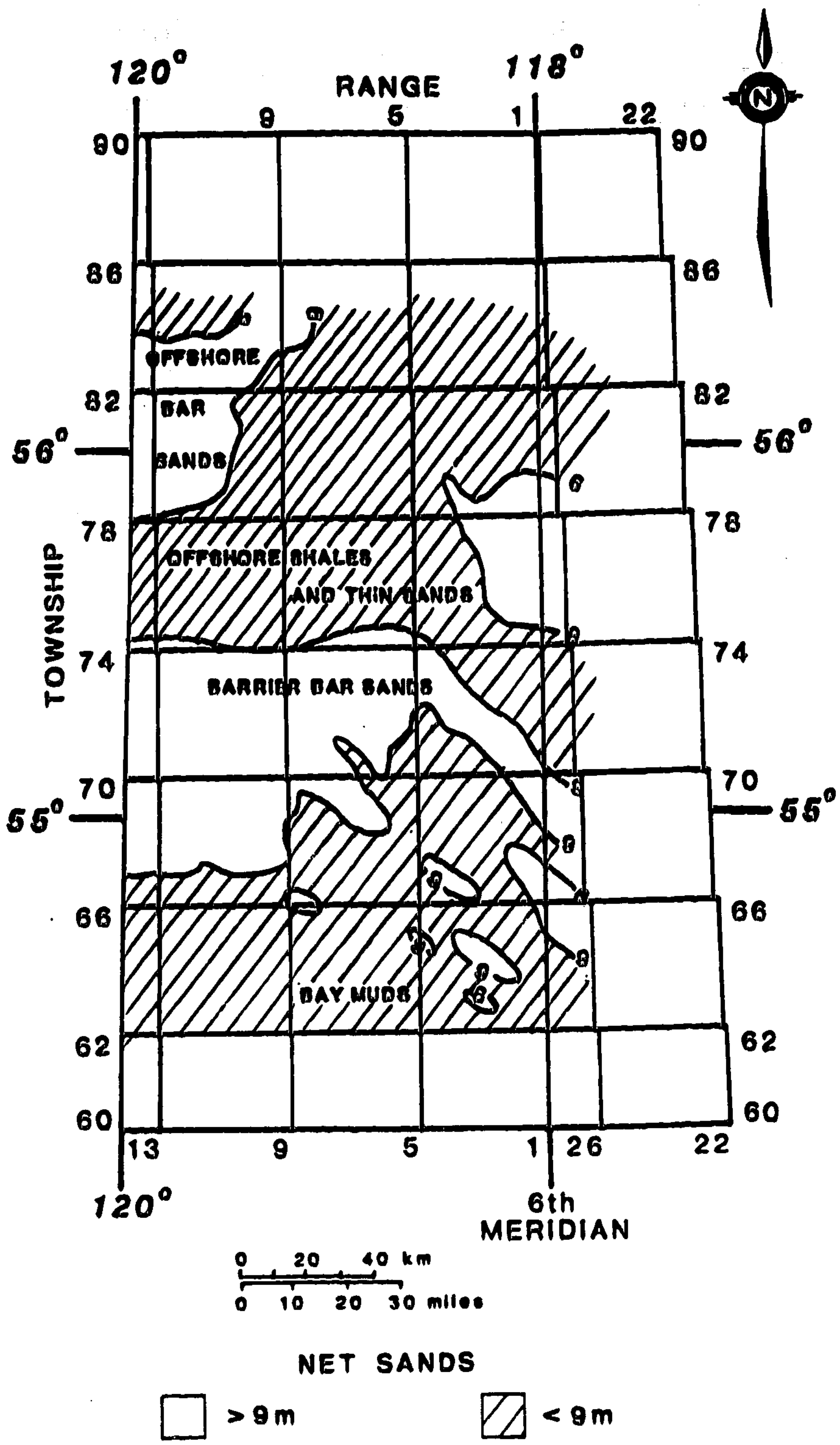


Figure 2.8 Bluesky Formation paleogeography and net sand isopach map (modified from Smith et al., 1984).

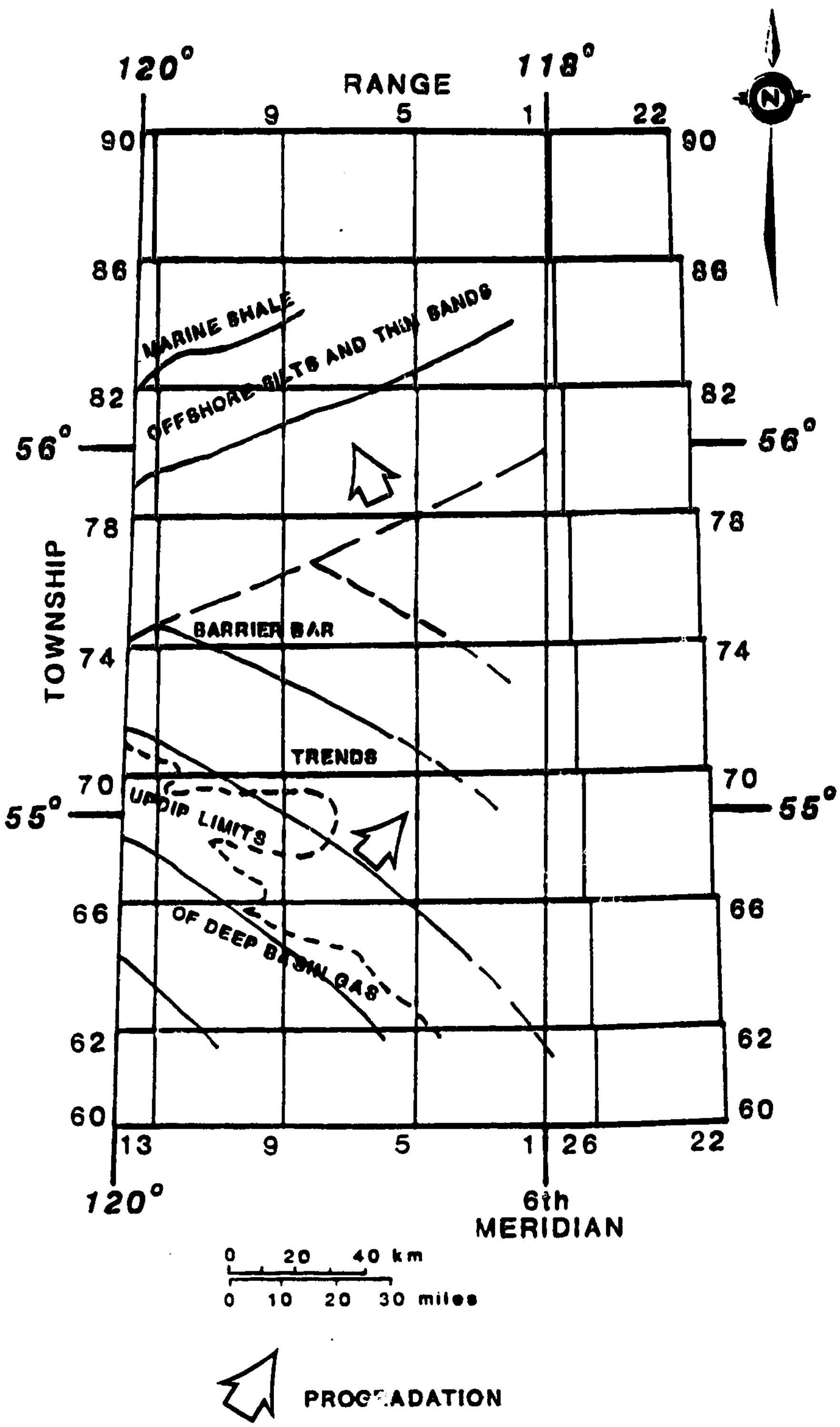


Figure 2.9 Cadotte Member (Peace River Formation) paleogeography map (modified from Smith et al., 1984).

2.4.2.2 *Paddy Member*

The Paddy is the upper member of the Peace River Formation (Figure 2.2) and in most areas lies conformably on the Cadotte Member. Figure 2.10 represents the paleogeographic conditions close to the end of the Paddy deposition.

In the southwest, the Paddy Member is interpreted as an intertidal facies of thin laminated siltstones, mudstones, thin carbonaceous shales, coals and occasional fine sandstones. To the north and east, the facies changes to subtidal sediments characterized by stacked, thin (6-9 metres), coarsening-upward sequences of interbedded sandstones and shales (Smith et al., 1984). A major west-east trending barrier bar is mapped across the northwest corner of the study area (Figure 2.10) consisting of coarsening upwards sandstones. The Paddy varies in thickness from approximately 10 to 30 metres. Porosity and permeability estimates vary greatly with facies and tend to be low in the intertidal facies and high in the barrier bar system (Smith et al., 1984).

2.4.3 *Structure*

Apart from the Cordilleran uplift, the only tectonic feature to affect Early Cretaceous sediments within the study area was the Peace River Arch. The Arch had subsided during the Early Cretaceous and apart from a gentle thickening of strata along the arch axis, had little effect on sedimentation (Williams, 1958). Towards the end of the Early Cretaceous epoch, however, the Peace River Arch once again became active as a positive feature, probably due to uplift during the Laramide orogeny (Williams, 1958). The Laramide uplift, along with subsequent erosion, resulted in exposure of Early Cretaceous rocks at surface, where they currently outcrop almost continuously along the B.C.-Alberta Foothills belt (Rudkin, 1964).

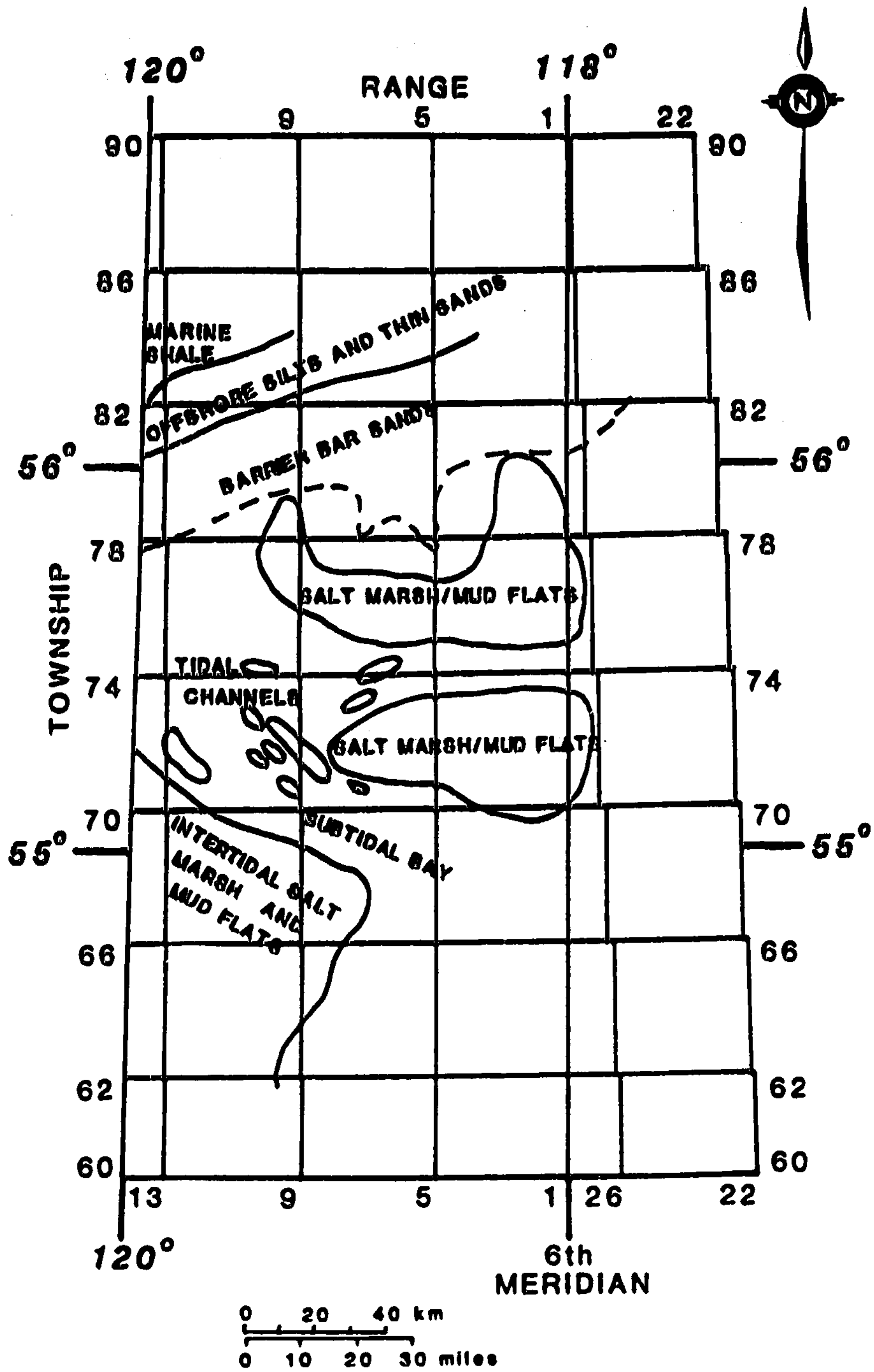


Figure 2.10 Paddy Member (Peace River Formation) paleogeography map (modified from Smith et al., 1984).

Recent work by Cant (1988) mapped small-scale faults cutting the top of the Bluesky Formation within the study area, and concluded that local, Arch-related, minor structural movements do affect Cretaceous sediments.

2.5 FORMATION FLUID FLOW

Patterns of formation fluid flow in the subsurface are influenced by variations in rock permeability and hydraulic conductivity. A permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients is defined as an aquifer (Freeze and Cherry, 1979). Aquitards are less permeable geologic units which may transmit enough water to be significant for regional groundwater flow, but the permeability is too low to allow the completion of production wells within them (Freeze and Cherry, 1979). Aquifers and aquitards are hydrogeologic units; the combination of two or more similar hydrogeologic units constitutes a hydrogeologic group. The identification of the hydrogeologic nature of stratigraphic units is an important step in the characterization of subsurface formation fluid flow.

Similarities in lithologies, water chemistries and hydraulic head patterns in the Paddy and Cadotte hydrogeologic units warrant the combination of these units into the Peace River hydrogeologic group. The same is true for the Bluesky, Gething and Cadomin hydrogeologic units, which are combined to form the Bullhead hydrogeologic group (Figure 2.11). Over a large study area the character of a group may change from aquifer to aquitard with variations in geology. An example is the Spirit River Formation -- an aquifer consisting of permeable sands in the Deep Basin region which shales out in the northern half of the study area to become an extensive aquitard.

Sufficient information was available to develop reasonably detailed potentiometric surface maps for the Paddy, Cadotte, Bluesky, Gething and Cadomin hydrogeologic units,

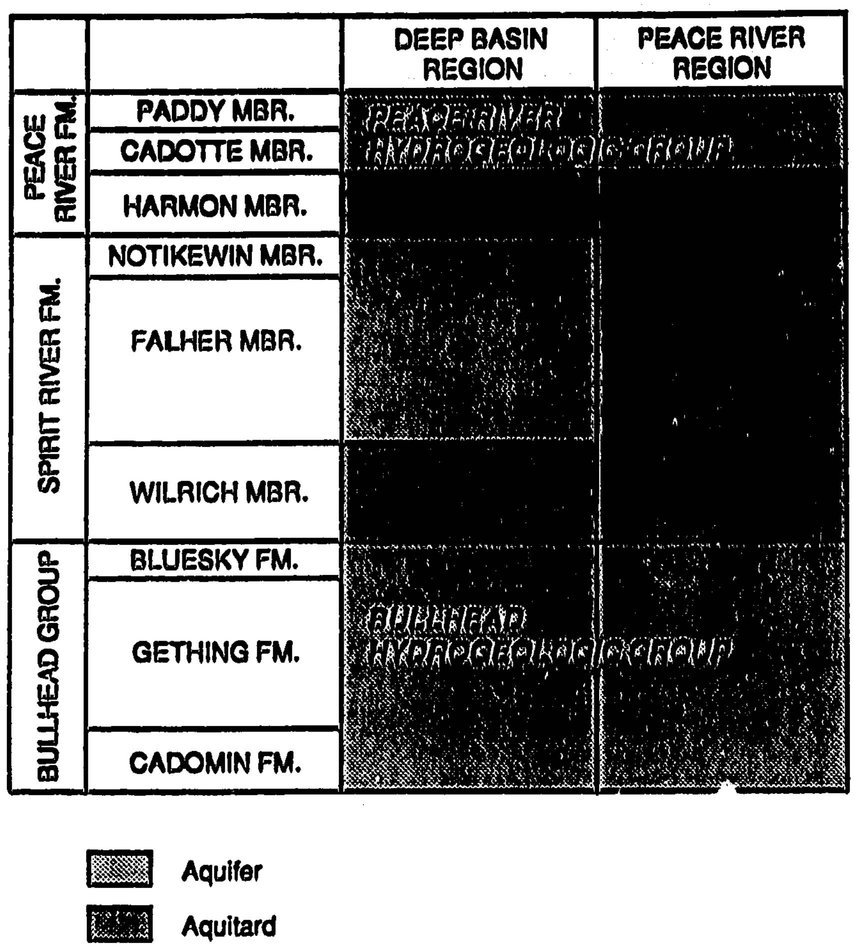


Figure 2.11 Hydrogeologic groups as defined by this study

from which flow directions were determined.

2.5.1 *Peace River Hydrogeologic Group*

As discussed above [Section 2.3.1], regional groundwater flow theory states that gravity-driven flow system development is controlled by the relief of the water table, which is approximated by the topographic relief. Recharge occurs in the highland regions and flow is towards lowland discharge areas.

Consider the topography of the study area (Figure 2.3) and the potentiometric surface map of the Paddy Member (Figure 2.12). The highest values of hydraulic head occur along the south and southwest edges of the area (Figure 2.12) and correspond to the topographically high Alberta High Plains region (Figure 2.3). Local highs on the Paddy potentiometric surface map occur in the west (Twps. 73-75, Rgs. 10-12) and central regions (Twps. 76-77, Rgs. 5-10) (Figure 2.12). These highs are the result of recharge under a local topographic ridge known as the Saddle Hills (Figure 2.3). The potentiometric surface generally slopes northward to a potentiometric trough where head values drop below 360 metres a.m.s.l. This mimics the topographic slope towards the deeply incised Peace River Valley. The trough feature does not, however, precisely correspond to the location of the Peace River Valley as expected. An explanation for this is found when the effects of subsurface geology and permeability are considered.

The potentiometric trough corresponds to the location of a high permeability sand body in the Paddy (Figure 2.10). Although the entire Peace River Valley attracts groundwater flow, the main discharge area occurs where the Peace River Formation outcrops at an elevation of 350 metres a.m.s.l. in the Peace River Valley, approximately 15 km northeast of the study area. The sand bar acts as a high permeability conduit, providing north flowing fluids with an easy route to the northeast outcrop area. The potentiometric

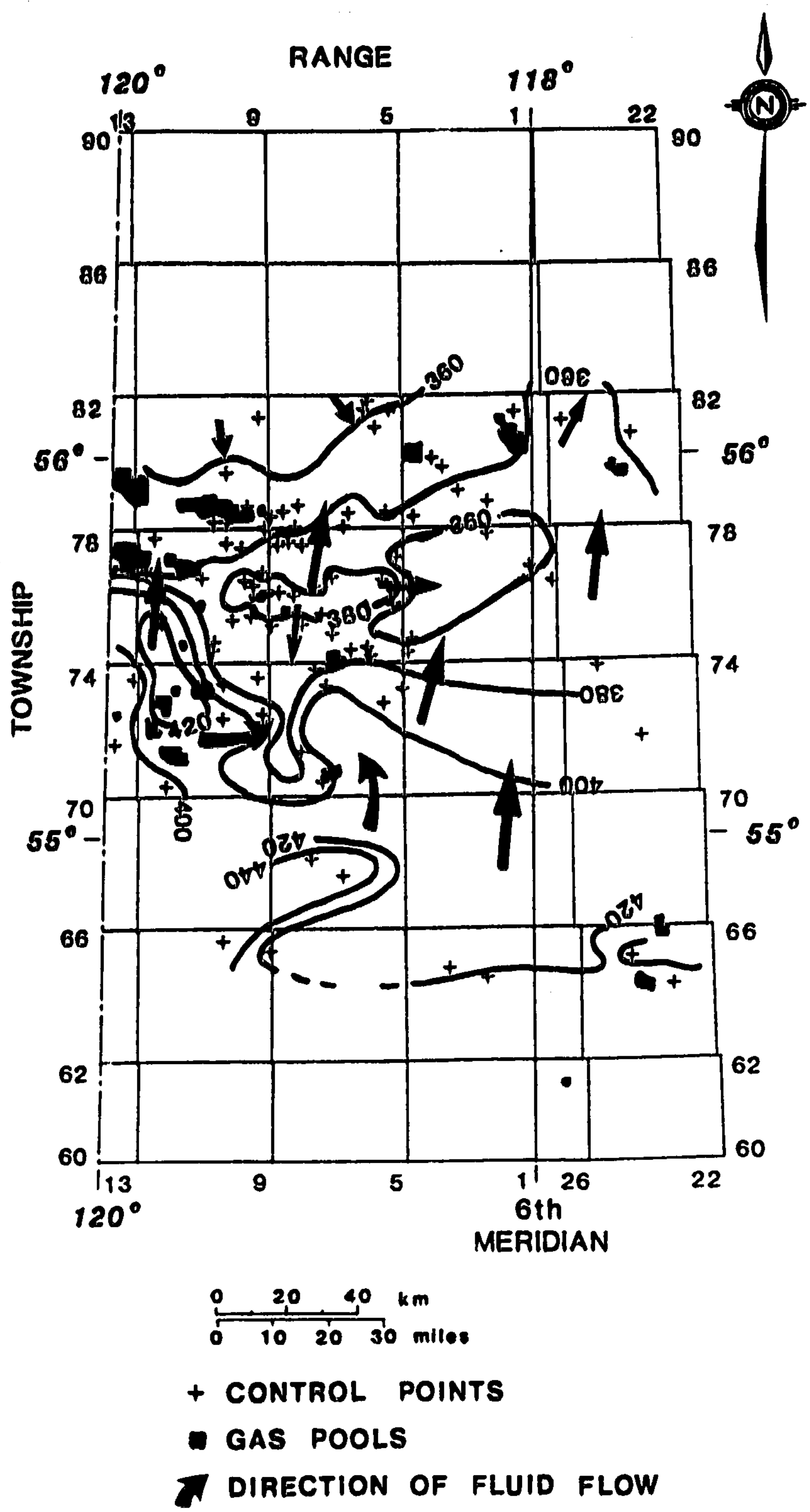


Figure 2.12 Paddy Member, Peace River Formation, potentiometric surface map (hydraulic head contours in metres a.s.l.)

depression in the central region (Twps. 75-78, Rg. 1-5) corresponds to the topographically low area between the Peace and Smoky River Valleys (Figure 2.3).

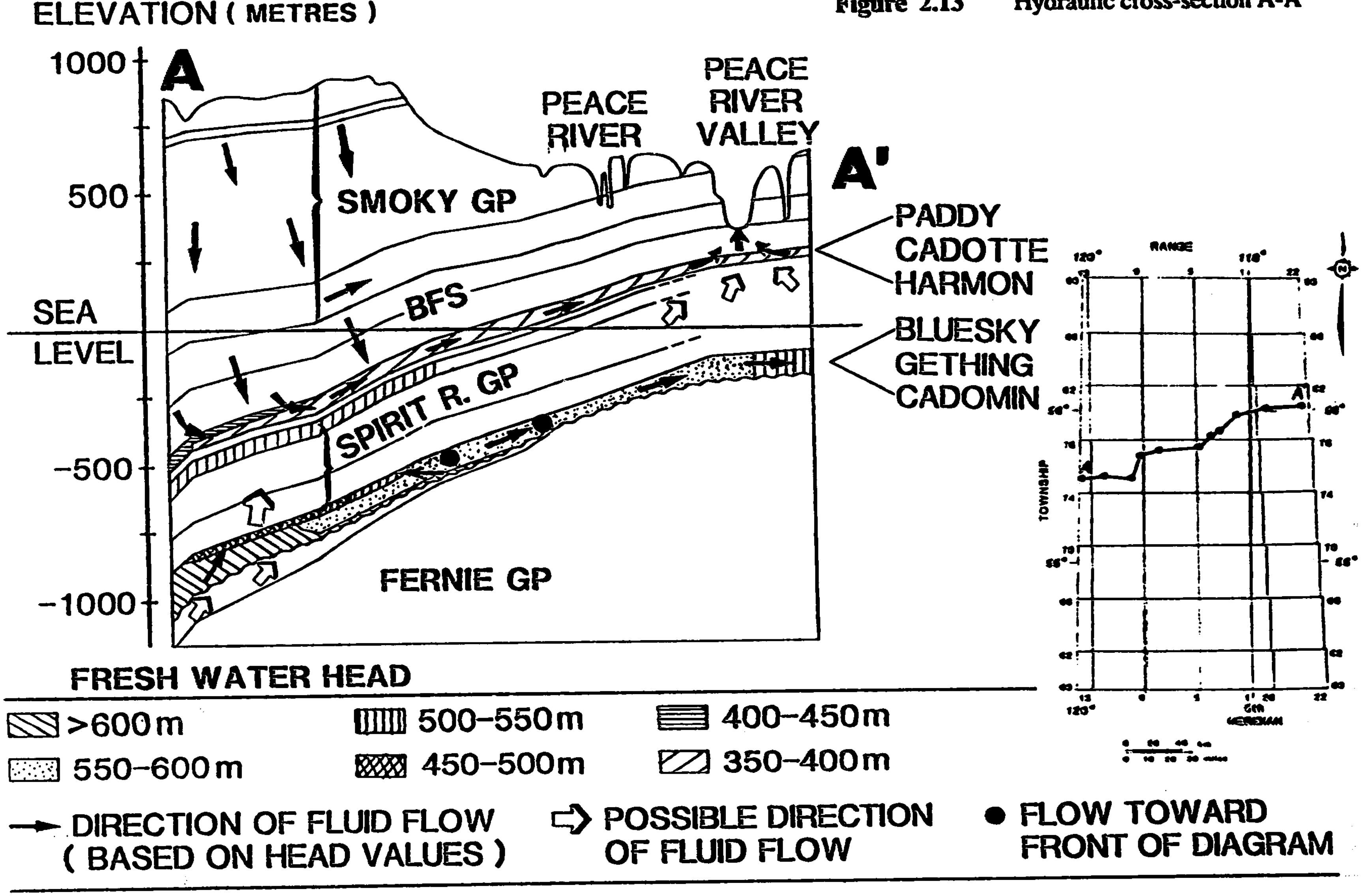
A steep fluid potential gradient is observed surrounding the closed potentiometric high in the west (Twps. 73-75, Rgs. 10-12) (Figure 2.12). This may indicate a sharp change in lateral permeability as "tight" zones produce higher gradients than more permeable areas. Vertical fluid movement may also account for this steep potential gradient. Hydraulic head values in the area are > 400 metres a.m.s.l. In the underlying Cadotte unit, head values are 10 to 25 metres lower. This suggests a downward flow direction in this area, as illustrated in Figure 2.13.

Pressure data from the area of Twps. 73-75, Rgs. 10-12, for the Paddy and Cadotte units were plotted versus depth (Figure 2.14). A sub-hydrostatic gradient is observed which supports the interpretation of downward fluid movement (Tóth, 1978).

The p-d plot (Figure 2.14) also indicates the fluid energy in the Peace River hydrogeologic group to be deficient with respect to hydrostatic, i.e., the formation is underpressured. The fluid energy is low due to the low vertical permeability of the overlying units restricting recharge, and to the relatively high transmissivity and low outcrop elevations of the Peace River Formation resulting in its effective drainage. This phenomenon was described by Tóth (1978) for Lower Cretaceous hydrogeologic units in the Red Earth region and more recently, Belitz and Bredehoeft (1988) invoked such a mechanism to explain subhydrostatic pressures in the Denver Basin.

The Cadotte potentiometric surface trends are similar to those in the Paddy, although its surface is slightly smoother (Figure 2.15). Again, the relationship to topography is evident with highest head values underlying the highlands to the south and west, and lowest head values corresponding to the Peace River Valley area. The flexure of the 390 and 400 metre contours in the south-central area is considered to be a response to the

Figure 2.13 Hydraulic cross-section A-A'



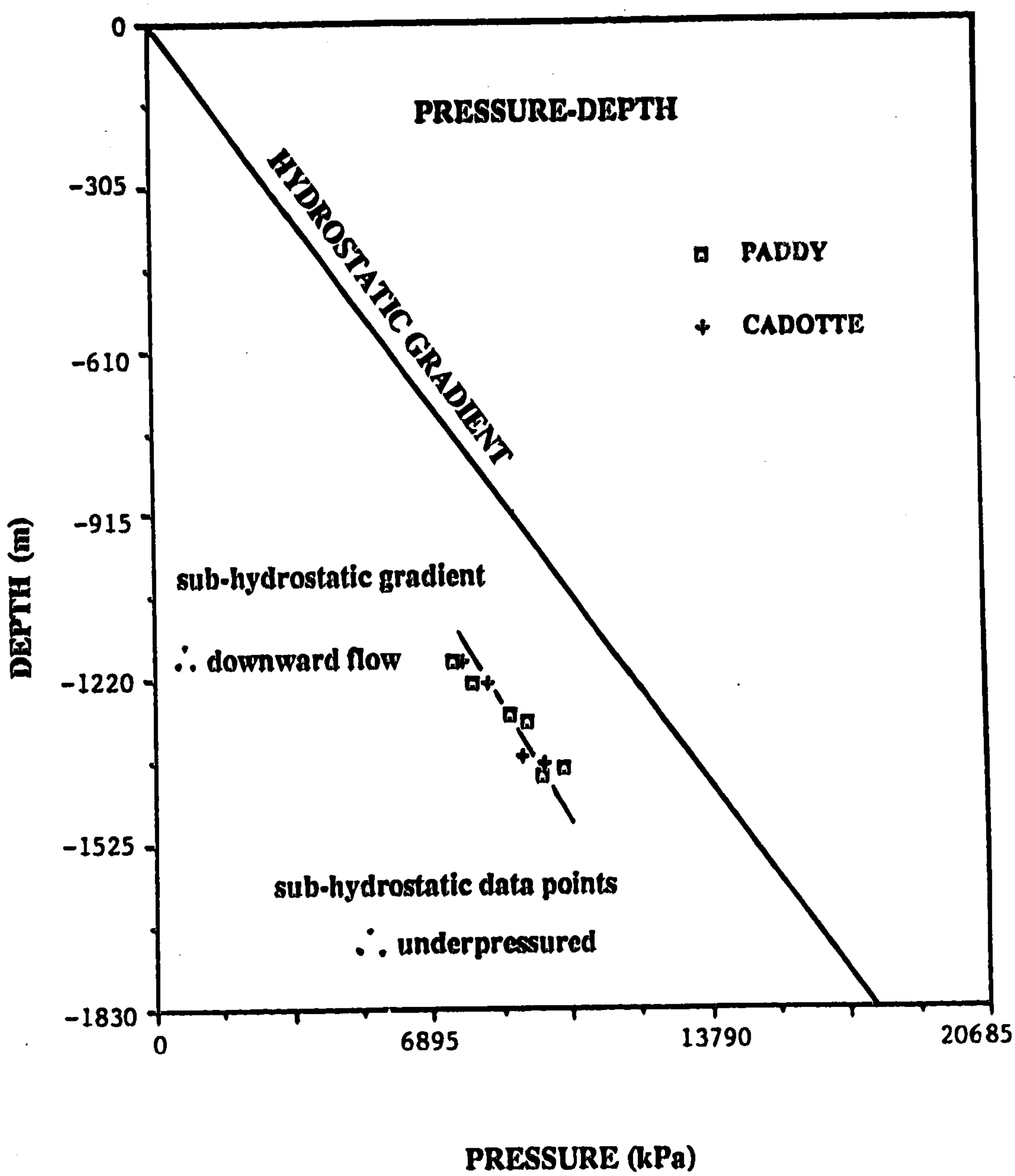


Figure 2.14 Pressure vs depth diagram (pressures taken from Paddy and Cadotte wells in the area of Twps. 73-75, Rgs. 10-12)

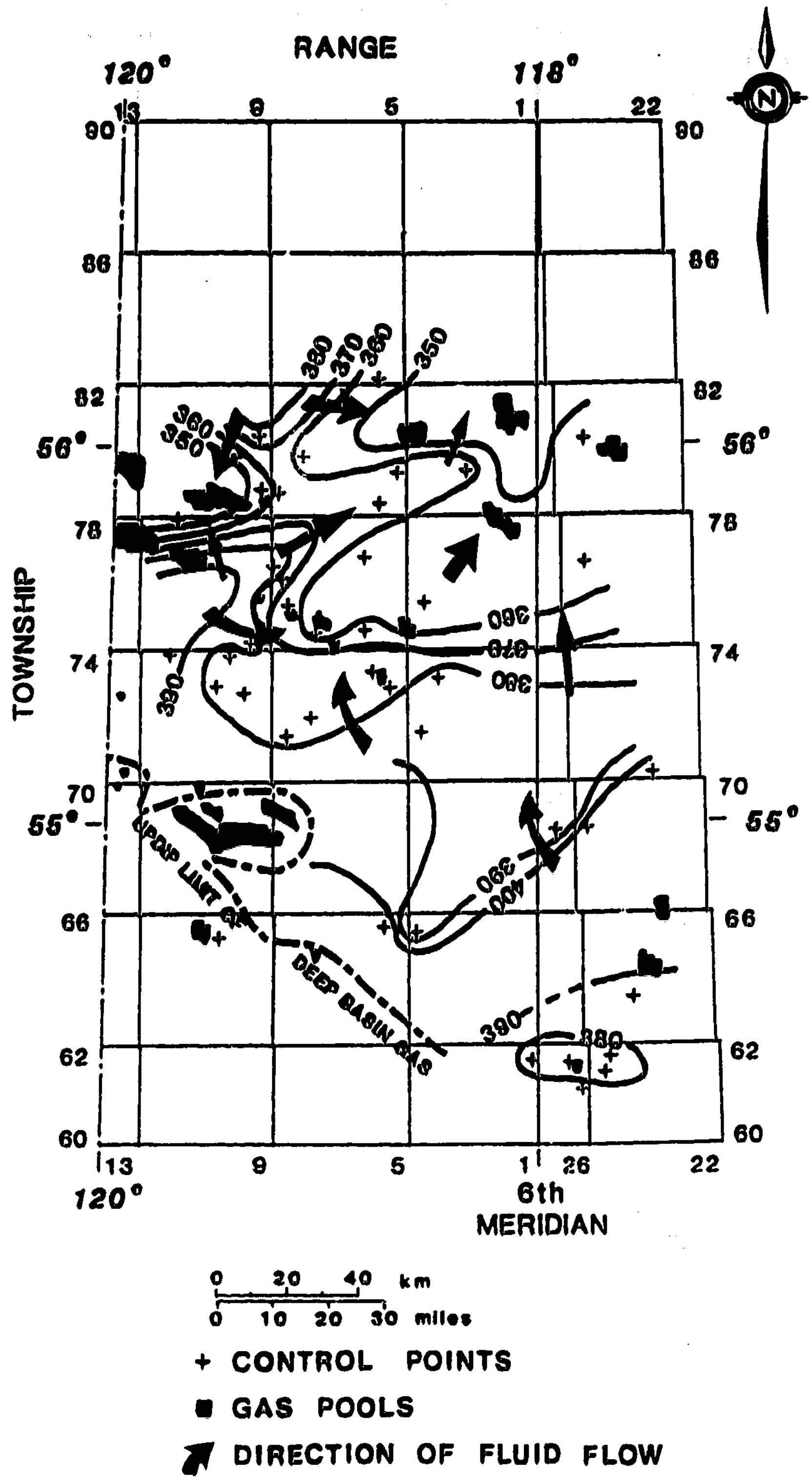


Figure 2.15 Cadotte Member (Peace River Formation) potentiometric surface map (hydraulic head contours in metres a.s.l.)

Smoky River Valley (Figure 2.3) which is not observed in the overlying Paddy due to lack of data. There is a minor depression in the potentiometric surface in the southeast corner, where head values drop below 380 metres a.m.s.l. (Figure 2.15). This may be a response to a local topographic low which occurs where a creek cuts through the foothills to join the Simonette River (Figure 2.3).

Gravity-driven, topographically-controlled flow systems have been mapped in the shallow (0-200 metres) surficial sediments of the Peace River area (Hackbarth, 1977; Barnes, 1977). The results of the present study confirm the influence of topography on groundwater flow to much greater depths (over 1200 metres in the Peace River Formation).

2.5.2 *Bullhead Hydrogeologic Group*

Potentiometric data for the Bluesky Formation is concentrated in the north half of the study area (Figure 2.16). In the eastern region, head values systematically decrease from > 590 metres a.m.s.l. to < 500 metres a.m.s.l. in the northeast corner, indicating a predominant flow direction to the north. A potentiometric depression occurs to the west where head values drop steeply to < 460 metres a.m.s.l. As discussed for the Peace River Formation, such a sharp change in gradient may represent permeability changes and/or vertical fluid movement. The general geology map by Smith et al. (1984) (Figure 2.8) indicates a change from permeable bar sands to shales and thin sands in this area, and vertically upward fluid flow also appears to occur in this region.

Figure 2.17 is the potentiometric surface map of the Gething Formation. A ridge of high head values (> 600 metres a.m.s.l.) trends southeast along the western side of the study area. A steady decrease in head occurs towards the northeast corner where head values are less than 500 metres a.m.s.l. This suggests a lateral component of flow towards the northeast.

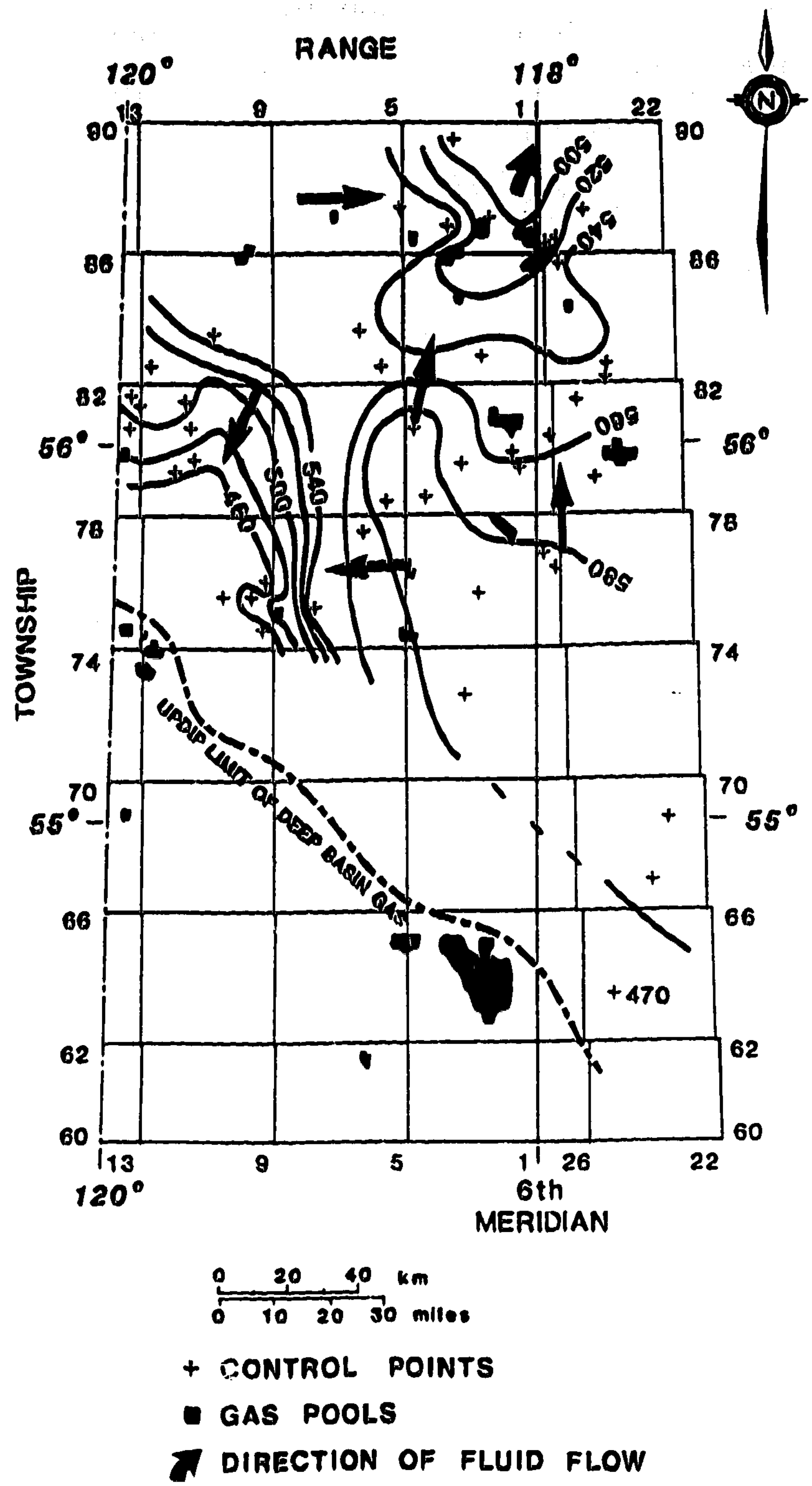


Figure 2.16 Bluesky Formation potentiometric surface map (hydraulic head contours in metres a.s.l.)

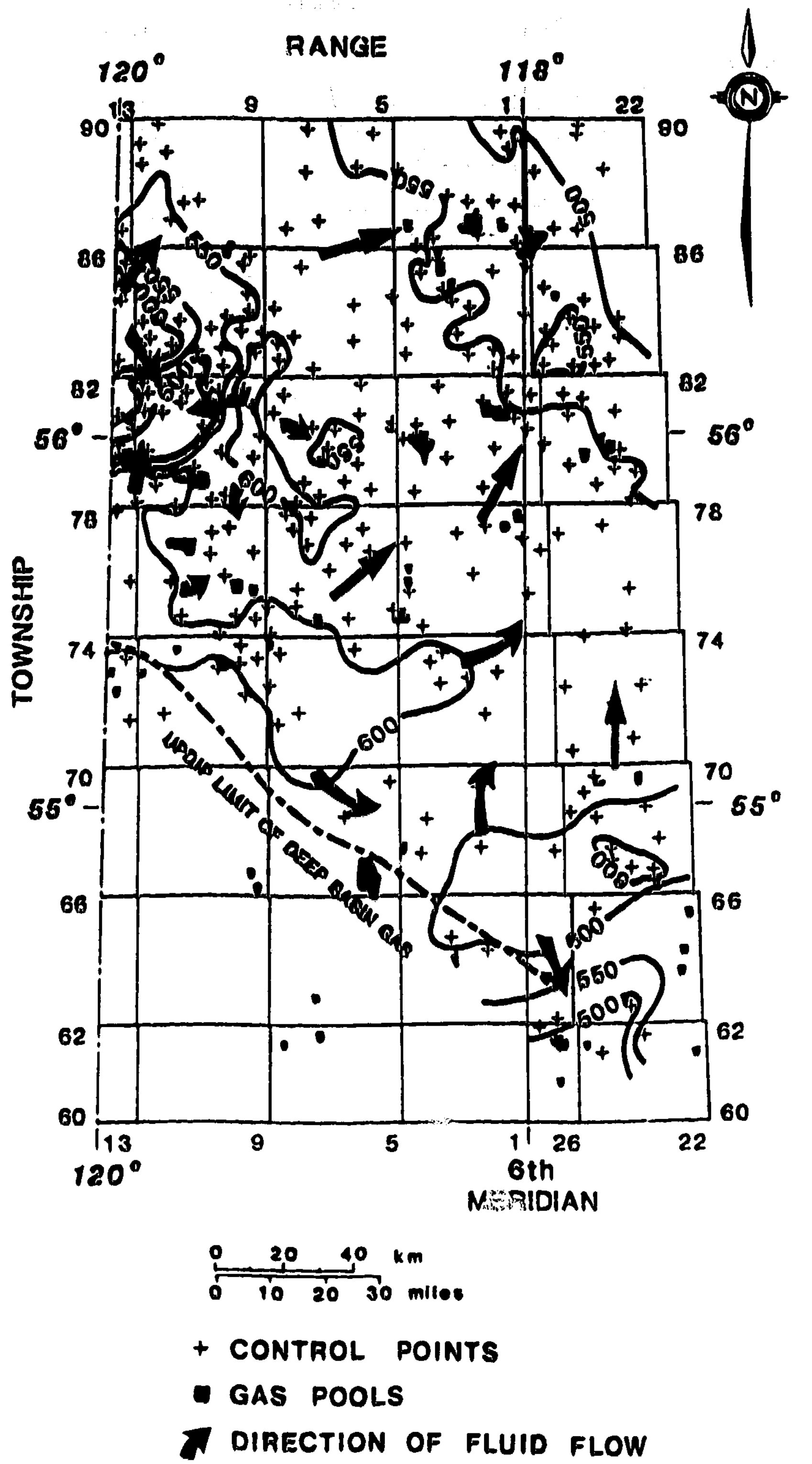


Figure 2.17 Gething Formation potentiometric surface map (hydraulic head contours in metres a.s.l.)

An anomalous low is observed in the area of Township 81, Range 11 (Figure 2.17). Values in this area drop substantially (over 100 metres) and do not appear to be due to erroneous data or drawdown effects. This low area directly underlies the potentiometric depression mapped in the Bluesky (Figure 2.16). The head values in the Cadomin are also affected. A minor depression is observed in the same area with head values between 580 and 600 metres a.m.s.l. (Figure 2.18).

When the hydraulic head values from each formation in this anomalous zone are compared, a substantial decrease is observed from the Cadomin through to the Bluesky Formation (Figure 2.13). The interpretation is upward vertical fluid movement. Thick sands are mapped in this area in the Gething (Figure 2.7) which may provide a high permeability conduit for this vertical fluid flow.

Pressure-depth analysis (pressure data from the anomalous area in the vicinity of Twp. 81, Rg. 11) indicates the Bullhead formations to be underpressured. The slope of the p-d curve is greater than hydrostatic, supporting the interpretation of an upward fluid flow direction (Tóth, 1978; Figure 2.19). Also plotted on Figure 2.19 are two pressure points from the same area of the Notikewin Formation. These data suggest the Notikewin Formation may be part of the same system, i.e., the Notikewin is in hydraulic communication with the Bullhead Group. Pressure data were relatively sparse for the Notikewin Formation, however, a tentative potentiometric surface map (Figure 2.20) does show low head values in the area overlying the anomalous depression in the Bullhead Group (Twp. 81, Rg.11). These low values are part of a potentiometric trough feature reminiscent of the Paddy and Cadotte potentiometric surface maps, with flow towards the northeast. This similarity suggests that the Notikewin may be influenced by the very low potentials in the Peace River Formation. Extensive upward cross-formational discharge may be taking place through the thin Harmon shales. Such a phenomenon was suggested

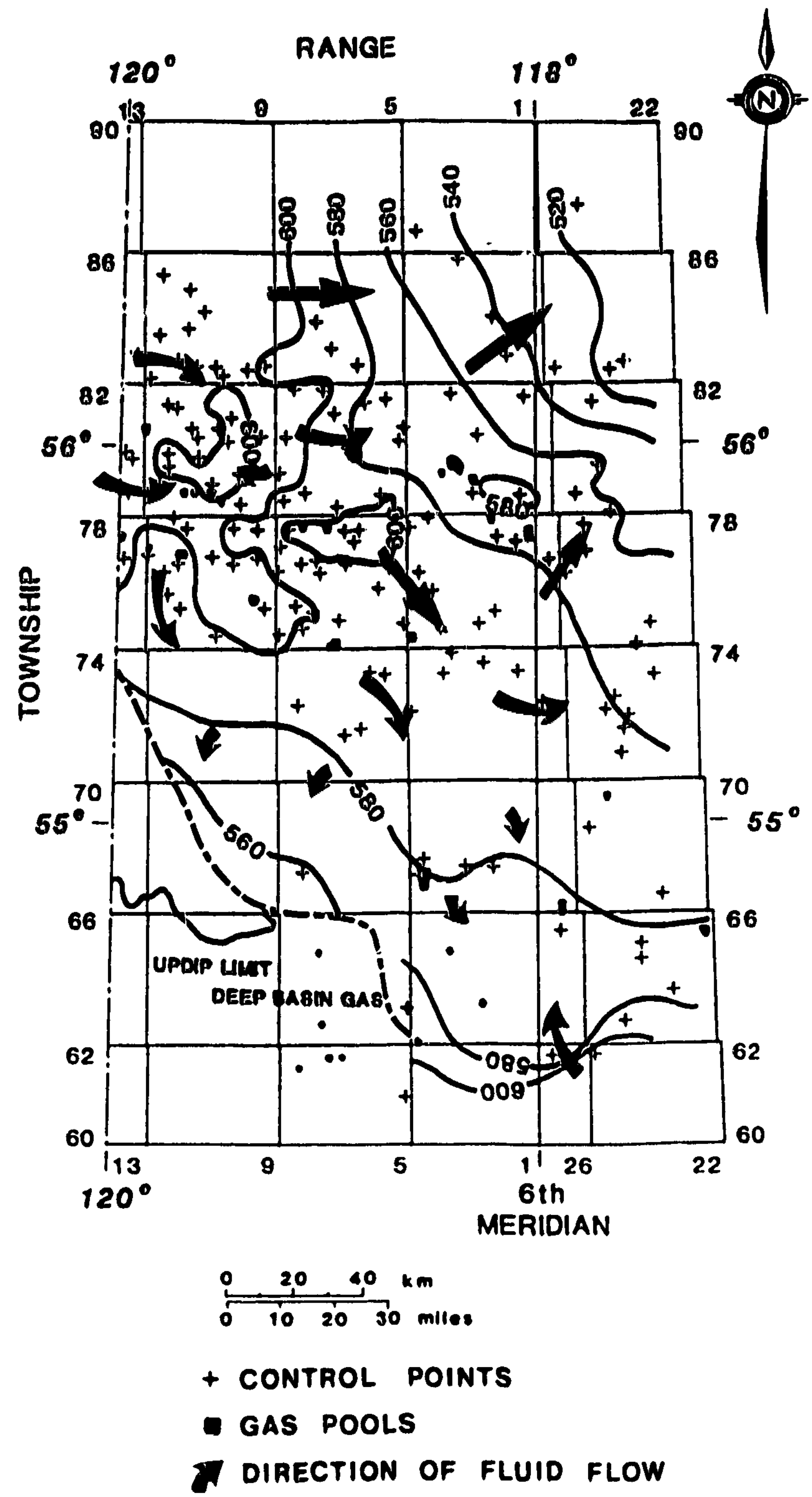


Figure 2.18 Cadomin Formation potentiometric surface map (hydraulic head contours in metres a.s.l.)

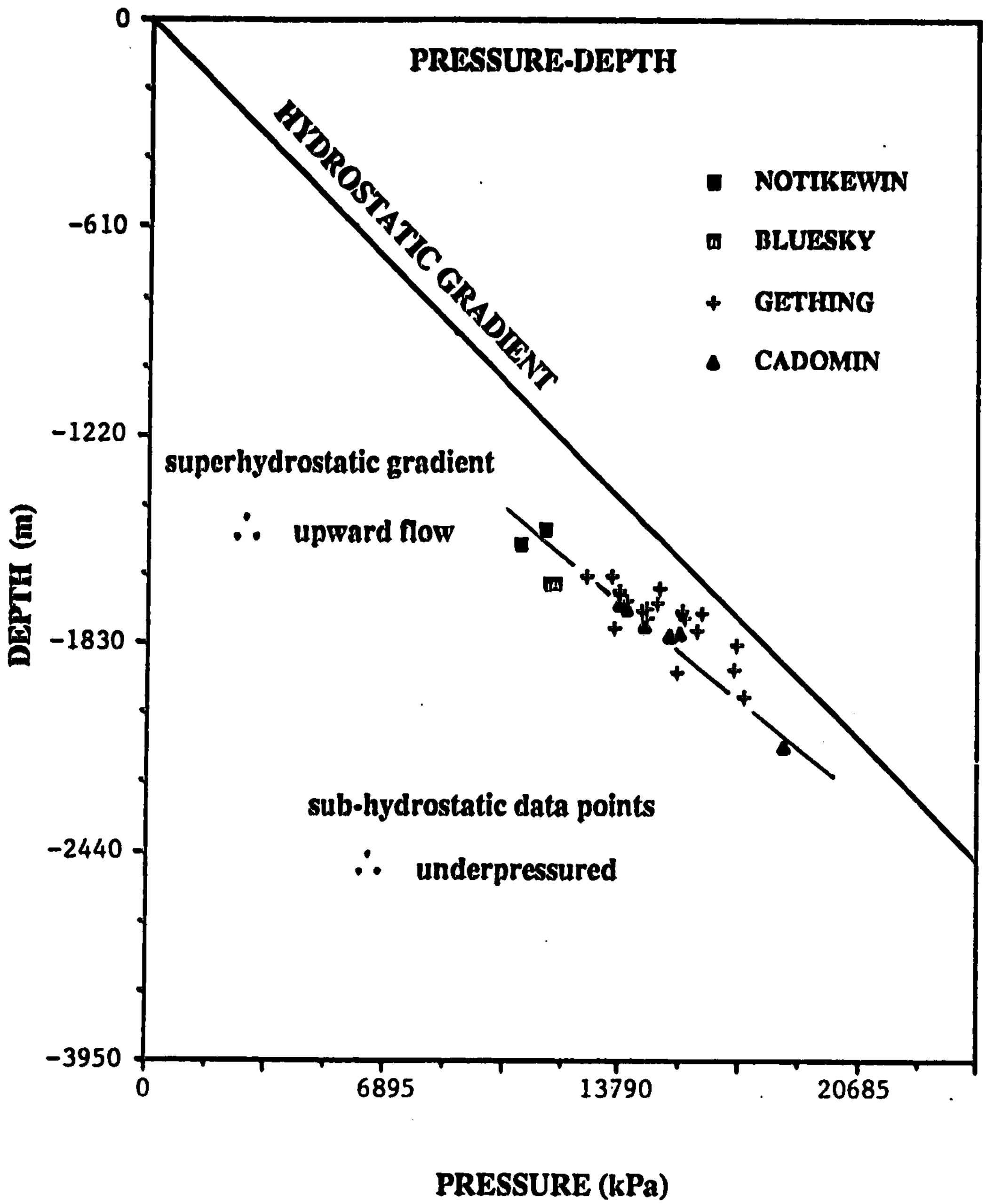


Figure 2.19 Pressure vs depth diagram (pressures taken from Cadomin, Gething, Bluesky and Notikewin Formation wells in the area of Twp. 81, Rg. 11)

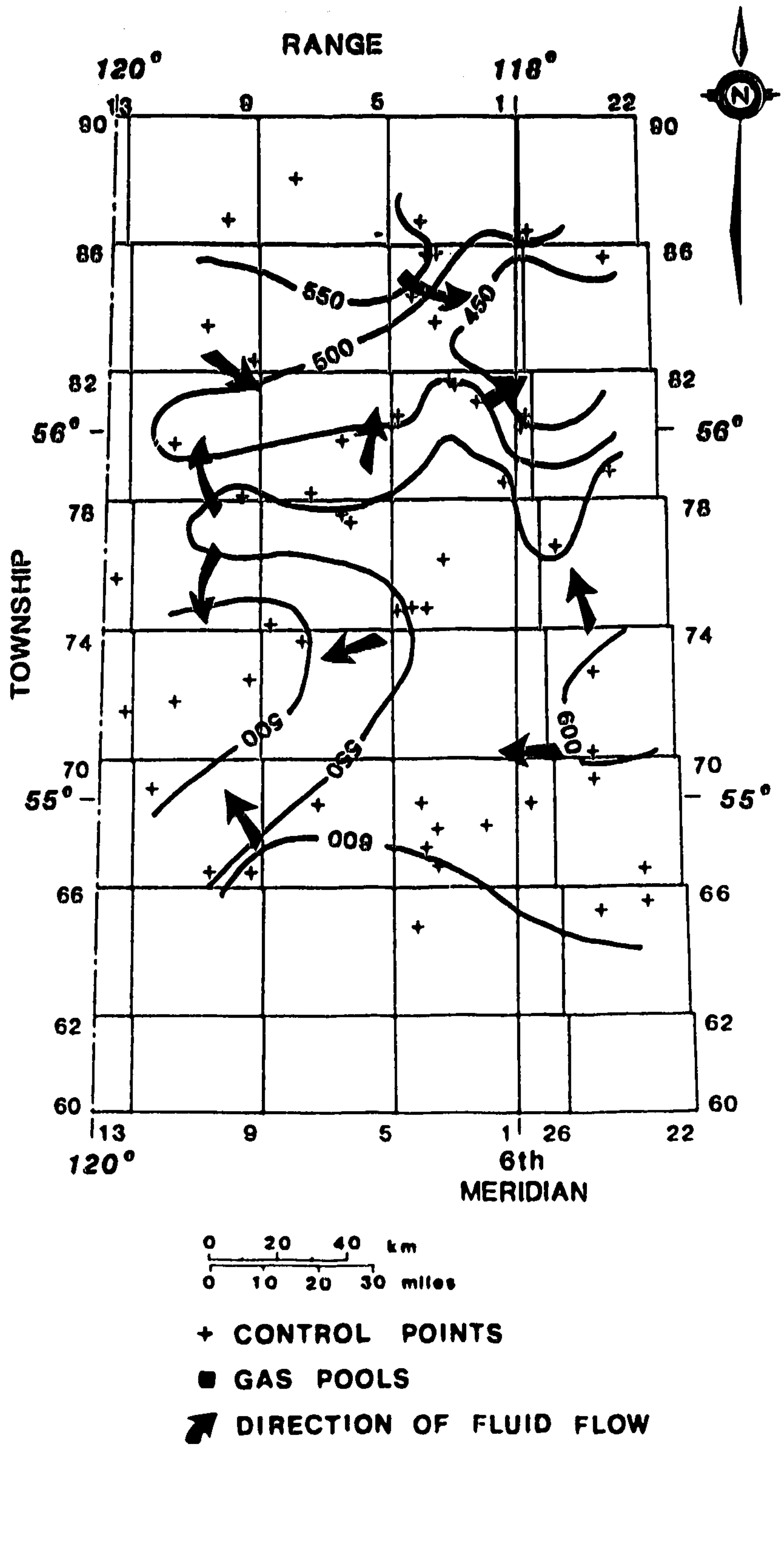


Figure 2.20 Notikewin Member (Spirit River Formation) potentiometric surface map (hydraulic head contours in metres a.s.l.)

by Wells (1988) in the Cretaceous sequence of offshore Qatar.

Flow from the Bluesky appears to be directed upwards into the Spirit River Formation in the area of Twp. 81, Rg.11. There is, however, no evidence of thinning in the Wilrich shales in this area.

Cant (1988) mapped small scale faults in the Bluesky Formation which he suggested are related to major structural anomalies in the Mississippian strata, probably related to Peace River Arch tectonics. Figure 2.21 indicates these structural anomalies defined on the top of the Mississippian Rundle Group. One of these structural anomalies occurs in the same geographic area as the Bluesky potentiometric anomaly (area of Twp. 79, Rg. 10) (Figures 2.16, 2.21). This provides an argument for faulting in this area which would allow direct hydraulic communication between the Bullhead Group and the Spirit River Formation and account for the localized vertical flow.

Returning to the regional flow patterns, hydraulic head values across the northern half of the Cadomin map decrease systematically from > 600 metres a.m.s.l. in the west to < 520 metres a.m.s.l. in the east. The result is flow from west to east as shown by the flow arrows on Figure 2.18. There is also a southeastward component of flow indicated on Figure 2.18, where formation fluid follows the high permeability pathway provided by the Spirit River Braid Plain sediments (Figure 2.6). Thrusting and uplift in the Foothills in B.C. would account for the higher potentials observed in the west. The decrease in head towards the northeast results from shallower formation depths, influence of the Peace River and eventual subcrop of the Bullhead Group to the east of the map area.

Over most of the southern half of the study area, the Cadomin potentiometric surface is relatively flat with head values consistently around 580 metres a.m.s.l. (Figure 2.18). This head distribution suggests sluggish lateral fluid flow conditions. Data are sparse in the southeast corner, however, comparison of the Cadomin, Gething and Bluesky

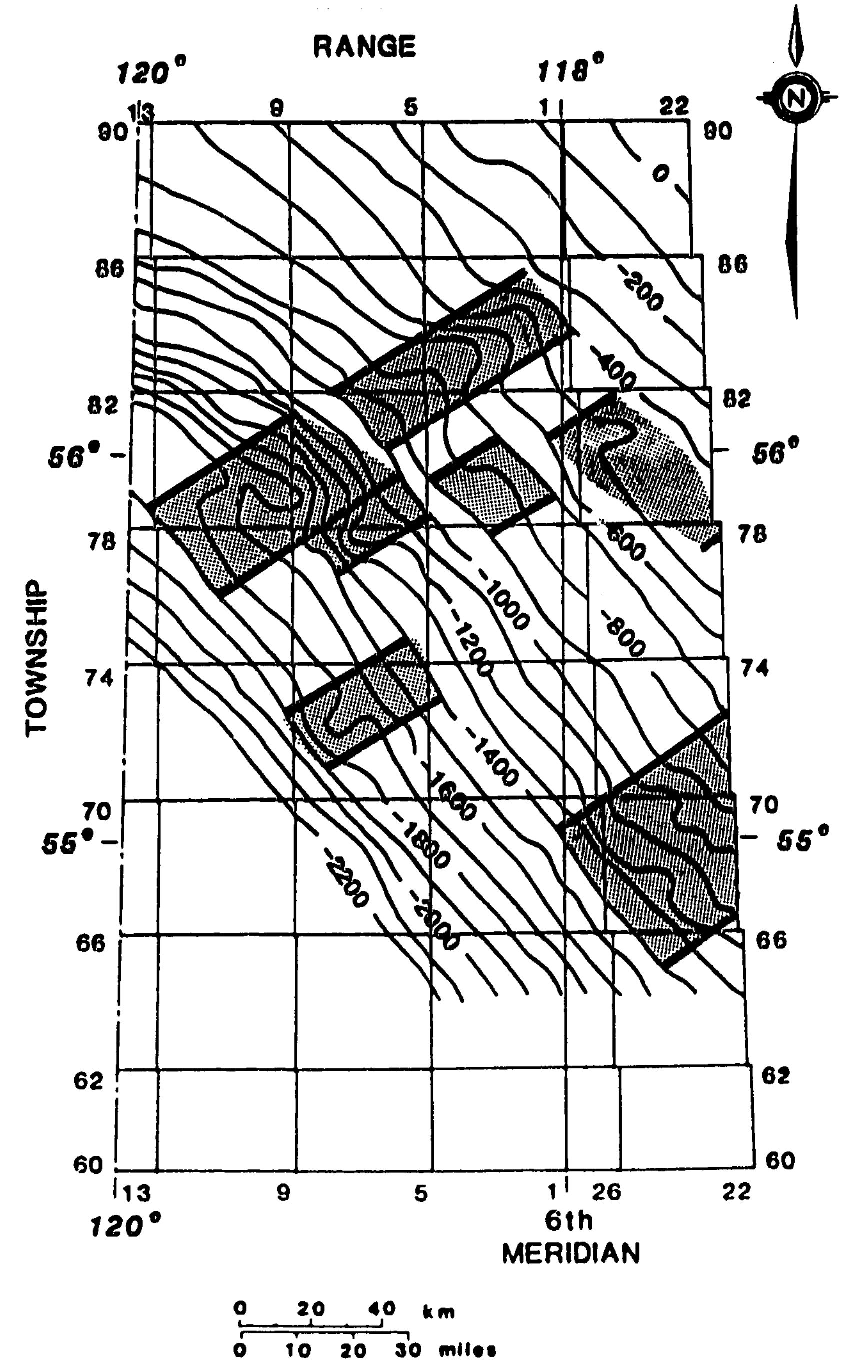


Figure 2.21 Major structural anomalies defined on the Mississippian Rundle Group structure map. Highlighted areas represent Mesozoic structural and stratigraphic anomalies as described by Cant, 1988 (modified from Cant, 1988, Figure 17)

potentiometric surfaces (Figures 2.16, 2.17, 2.18) indicates a decrease in head from the Cadomin to the Bluesky. The apparent lateral sluggishness of flow may, therefore, be explained by a predominance of vertical fluid movement (Figure 2.13).

An interesting potential low occurs along the updip limit of the Deep Basin gas accumulation (Figure 2.18). Gies (1984) originally suggested this to be the result of a reservoir discontinuity in the Cadomin although more recently has suggested that these low pressures may be a result of gas escape along the Deep Basin gas-water interface (pers. comm., 1988). It may again be an effect of vertical flow, although the lack of data in the overlying units does not allow firm conclusions to be drawn.

2.6 HYDROCHEMISTRY

Previous work by Hitchon (1964) characterized formation waters within the Early Cretaceous units by mapping the chloride content distribution (Figure 2.22). The majority of water analyses used were from the Ellerslie Formation which is correlative to the Gething and Cadomin Formations within the bounds of this study area. On the basis of the chemical data as well as potentiometric surface maps, Hitchon (1964) concluded that in proximity of the pre-Cretaceous unconformity formation fluids move in a northeast direction through the highest permeability zones.

Much more data is now available in the Peace River area due to recent exploration and continued collection of water data by the ERCB. The present study utilizes this data to refine the general Early Cretaceous flow patterns mapped by Hitchon (1964). Regional salinity (TDS) maps, as well as Sulin-Palmer water classification maps, have been completed for the Paddy and Cadotte Members of the Peace River Formation and the Bluesky, Gething and Cadomin Formations. This information allows detailed

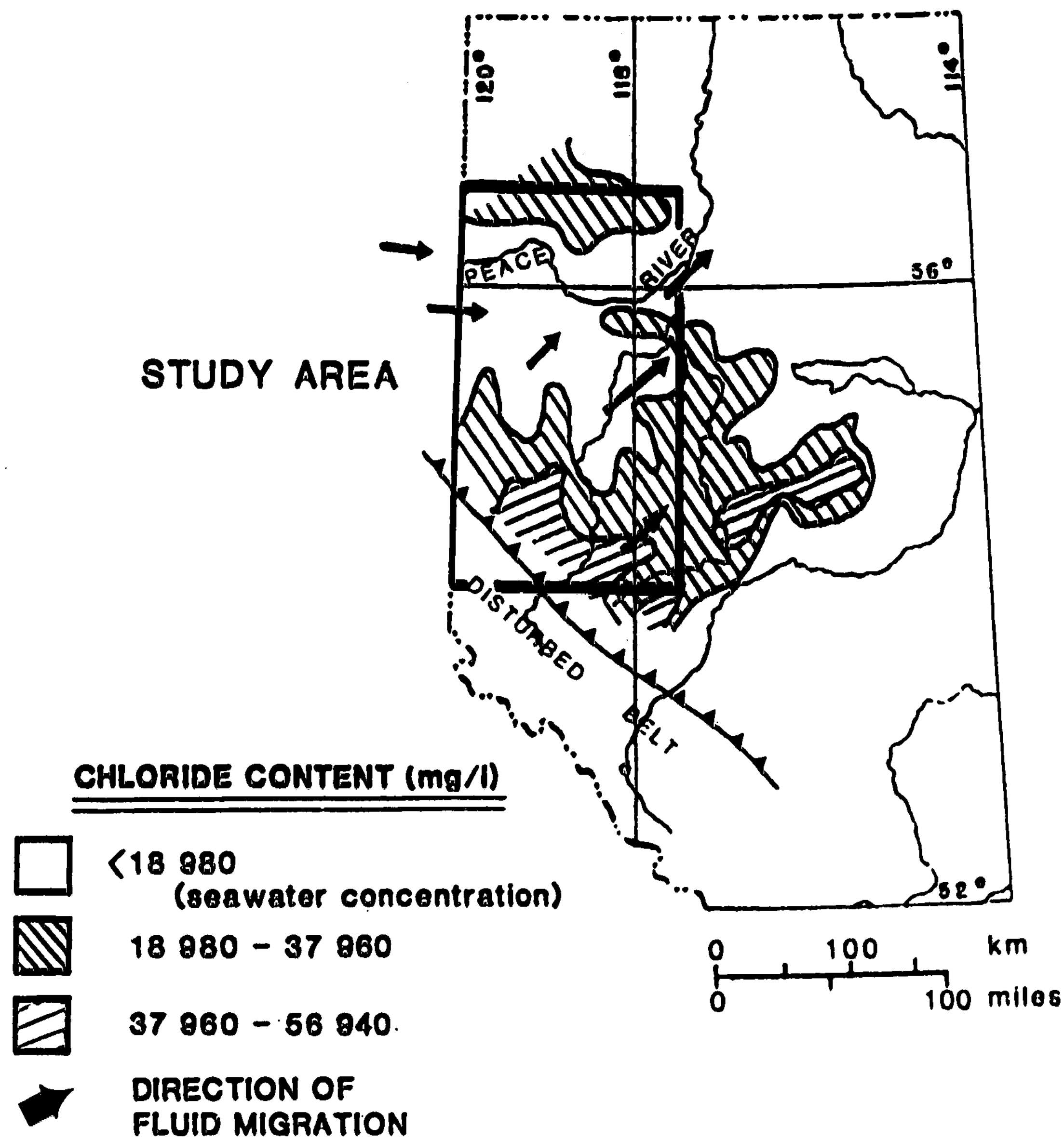


Figure 2.22 Chloride content of Lower Cretaceous formation waters. Adapted from Hitchon (1964)

characterization of water chemistry, infers genetic origin of fluids, and provides insight into regional groundwater flow patterns.

2.6.1 *Peace River Formation*

In the Paddy and Cadotte Members of the Peace River Formation, little variation in water salinity is observed, although, particularly in the Paddy Member, the limited areal extent of data may be responsible for this observation. Paddy waters range from 18 800 to 23 500 mg/l TDS and tend to increase in salinity towards the northeast (Figure 2.23). Cadotte waters range from 11 150 mg/l TDS in the south to almost 25 000 mg/l in an east-west trending band across the central part of the study area (Figure 2.24).

Sulin-Palmer classification (Section 2.3.1, Appendix III) of the Paddy water analyses illustrates a systematic change from Type 2 waters in the southwest to Type 4 waters in the northeast (Figure 2.25). A similar change is noted in the Cadotte Member where Type 2 waters dominate the south-southwest and Type 4 waters are found to the northeast (Figure 2.26). The change from bicarbonate dominated meteoric waters (Type 2) in the southwest to chloride dominated subsurface waters (Type 4) in the northeast represents natural groundwater evolution along a flow path (Chebotarev, 1955; Tóth, 1984). The water chemistry data, therefore, confirms groundwater recharge in the south-southwest and flow towards the northeast as determined by the potentiometric surface analyses.

2.6.2 *Bullhead Group*

Waters within the Bluesky Formation vary from 15 200 mg/l to over 50 000 mg/l TDS. The lower salinity waters (< 20 000 mg/l) occupy the central region separating two higher salinity regions to the north and south (Figure 2.27). Salinity distribution in the Gething Formation is almost identical (Figure 2.28).

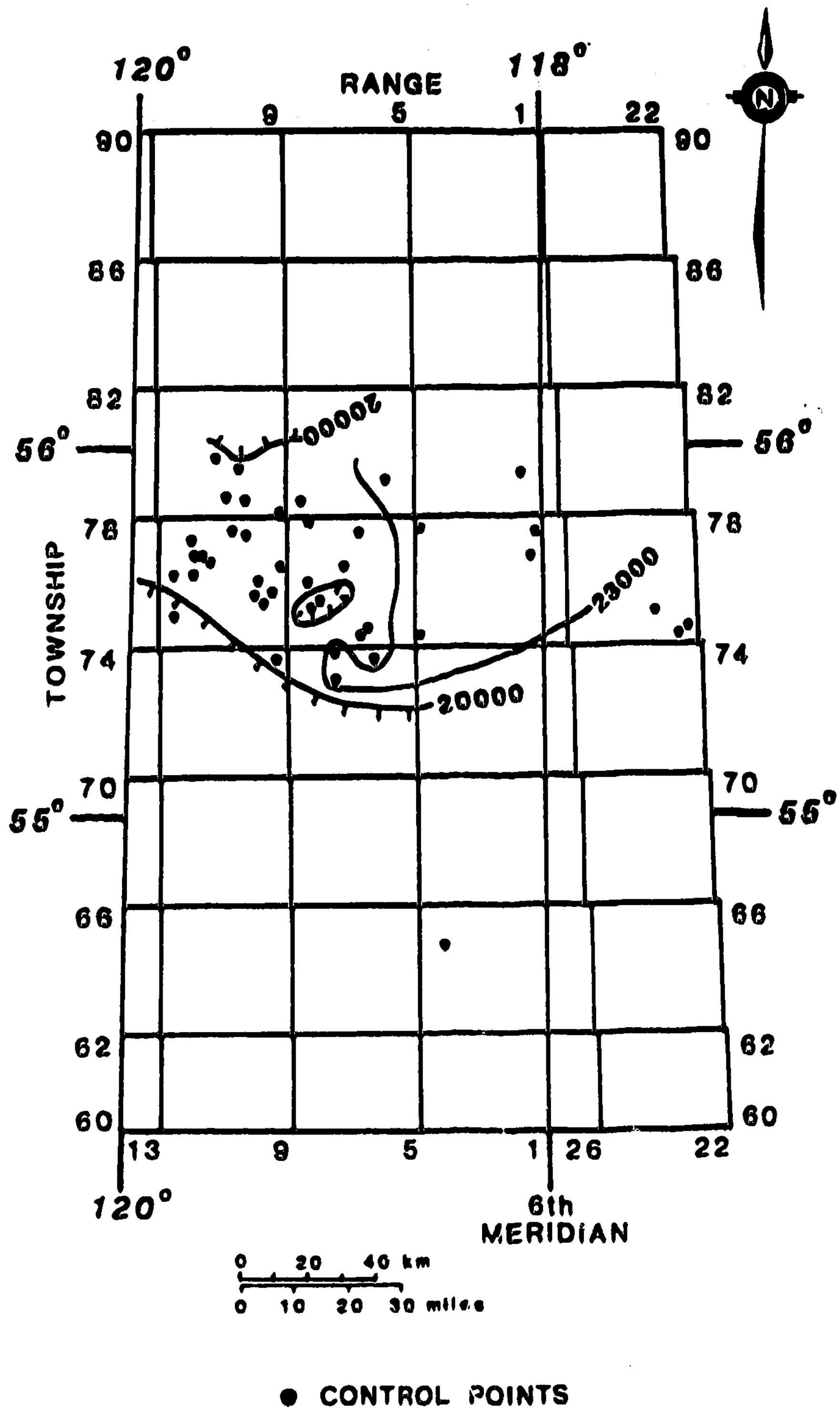


Figure 2.23 Paddy Member (Peace River Formation) total dissolved solids distribution (isoconcentration contours in mg/l)

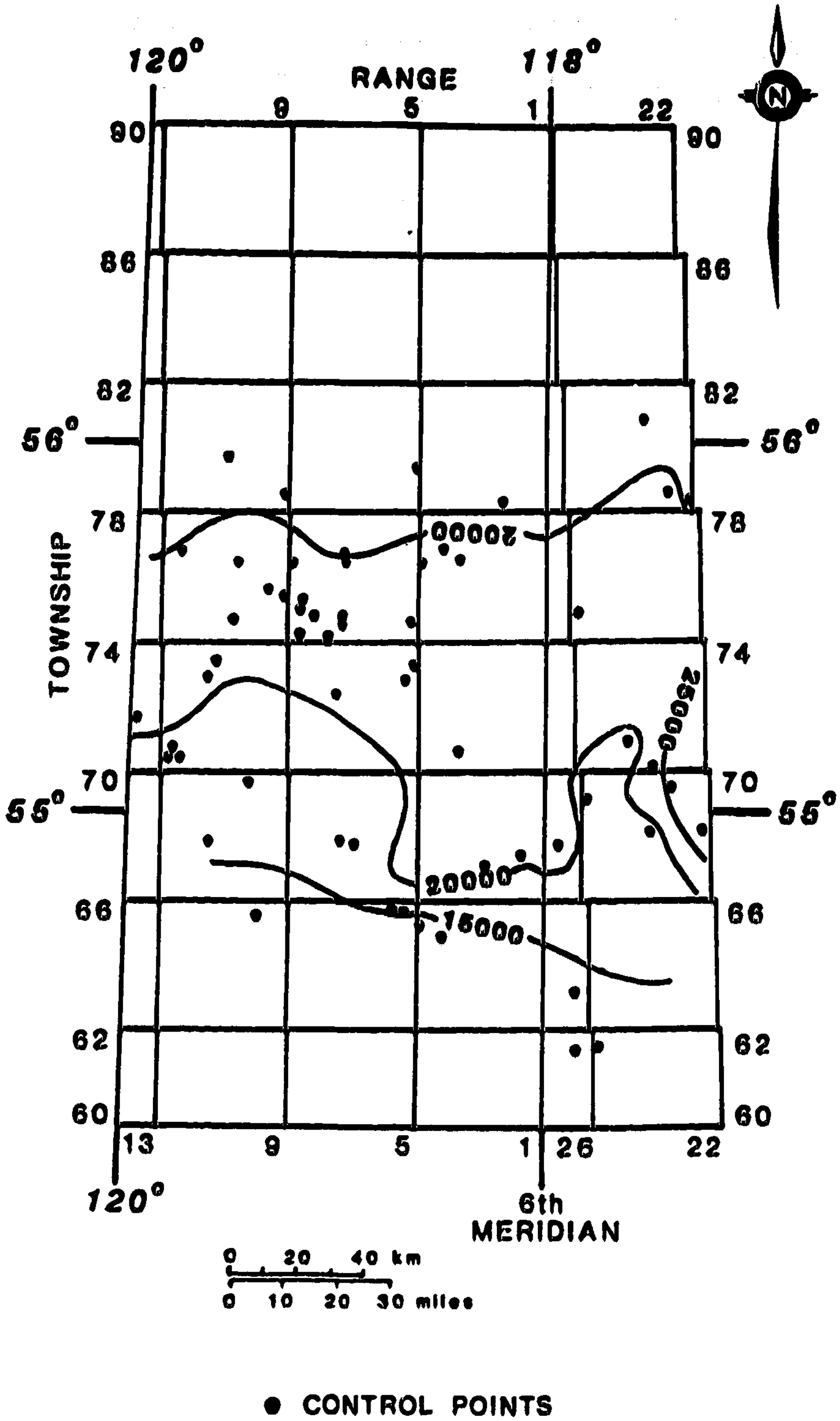


Figure 2.24 Cadotte Member (Peace River Formation) total dissolved solids distribution (isoconcentration contours in mg/l)

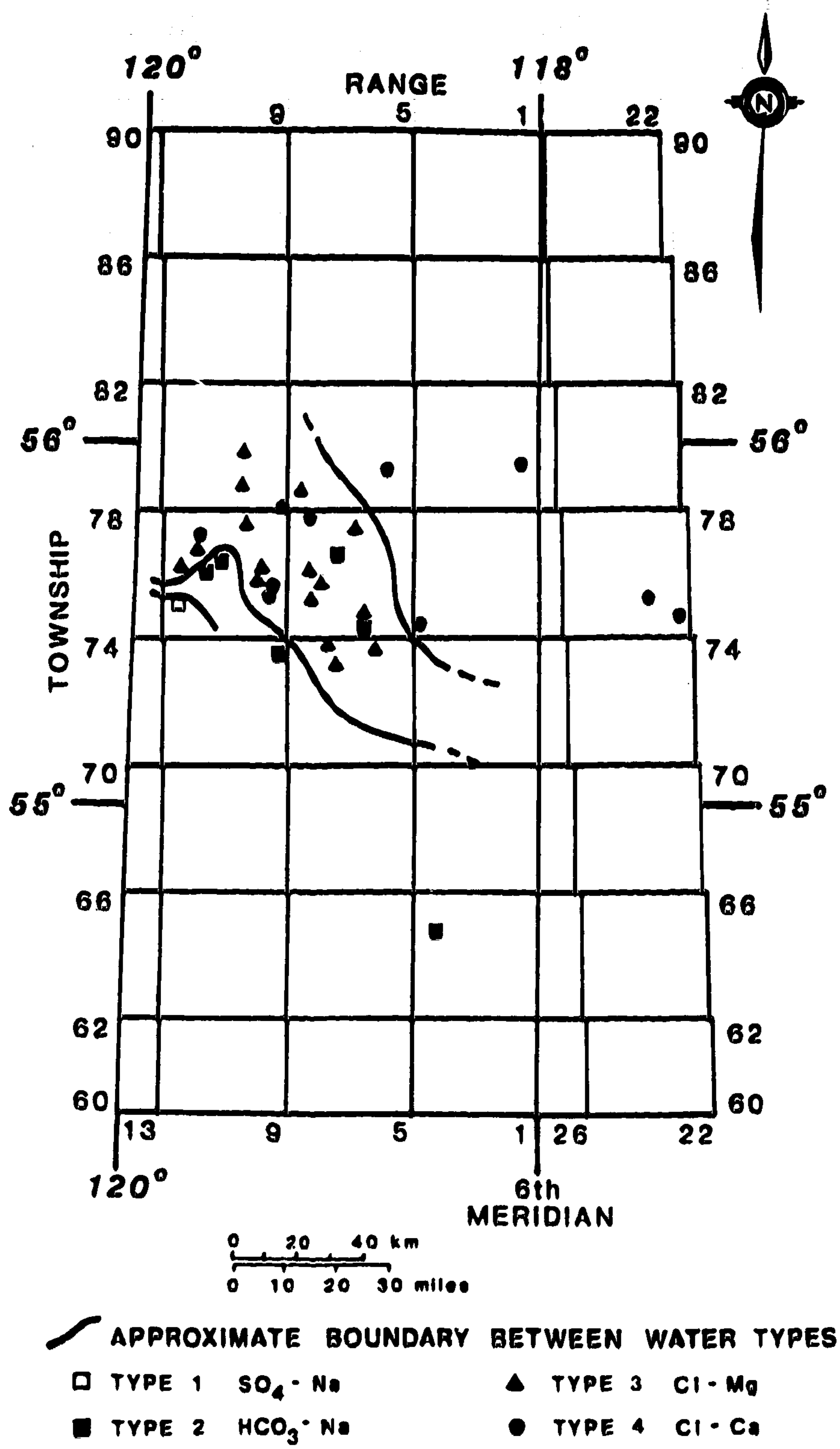


Figure 2.25 Sulin-Palmer water classification map, Paddy Member, Peace River Formation

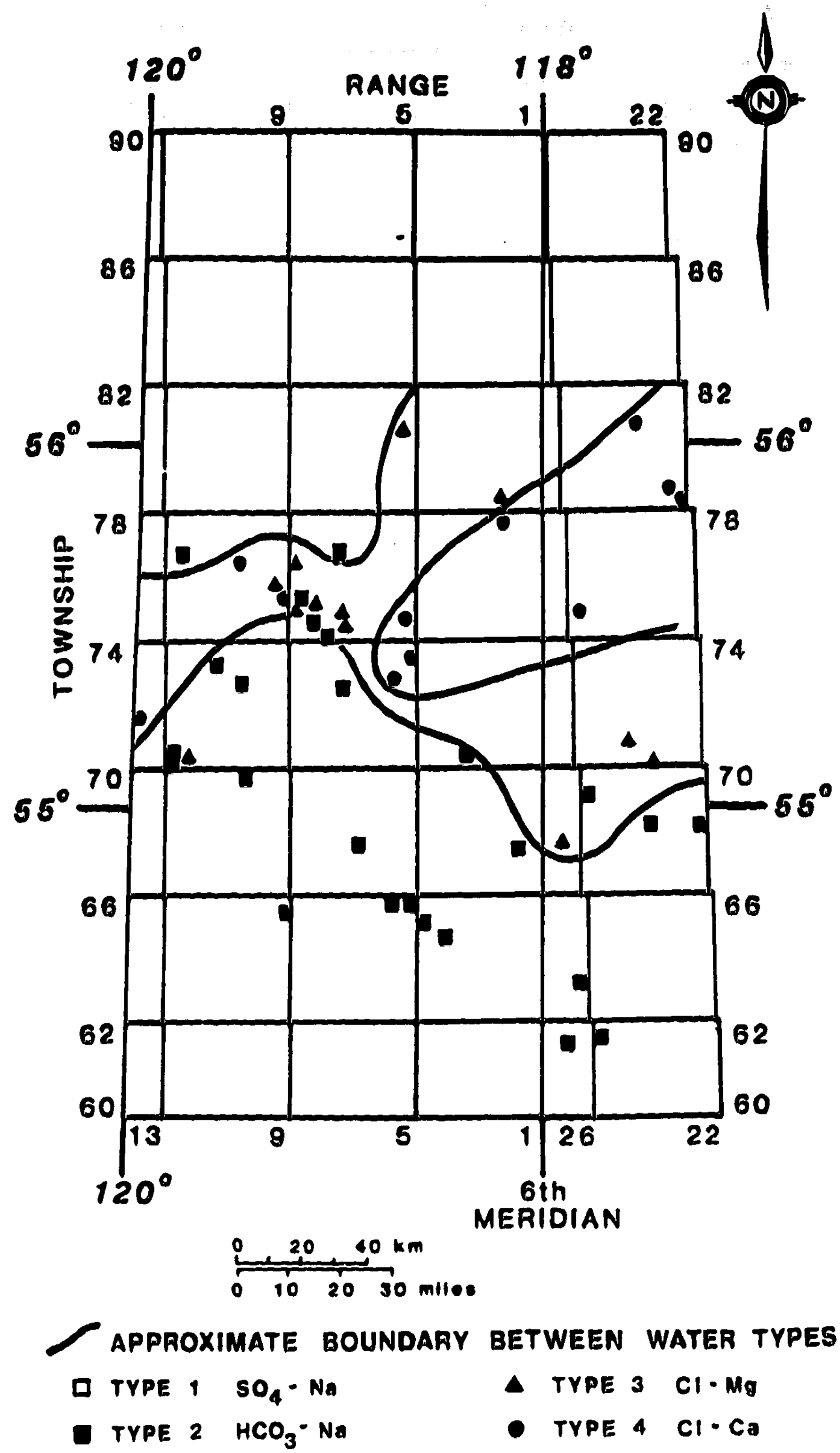


Figure 2.26 Sulin-Palmer water classification map, Cadotte Member, Peace River Formation

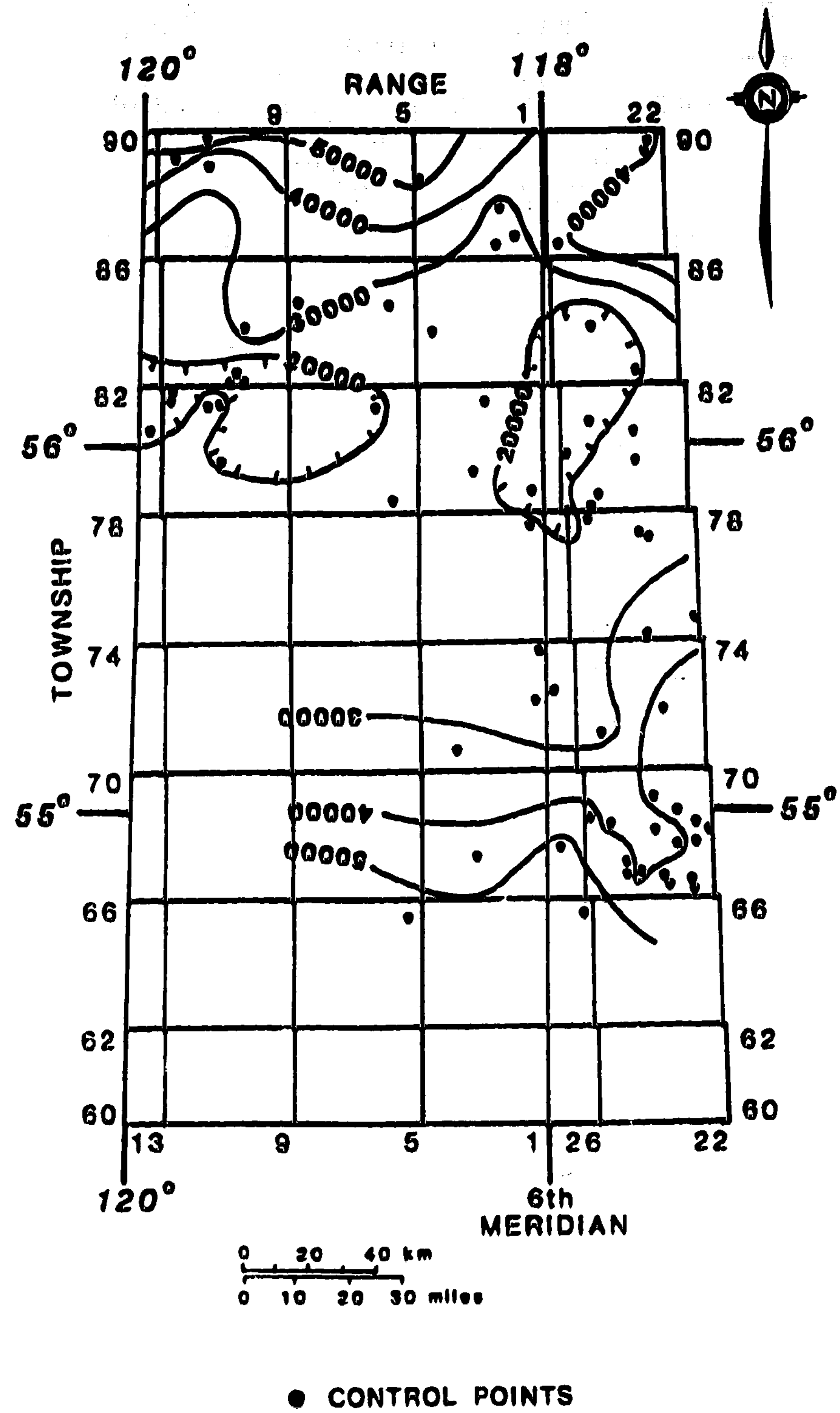


Figure 2.27 Bluesky Formation total dissolved solids distribution (isoconcentration contours in mg/l)

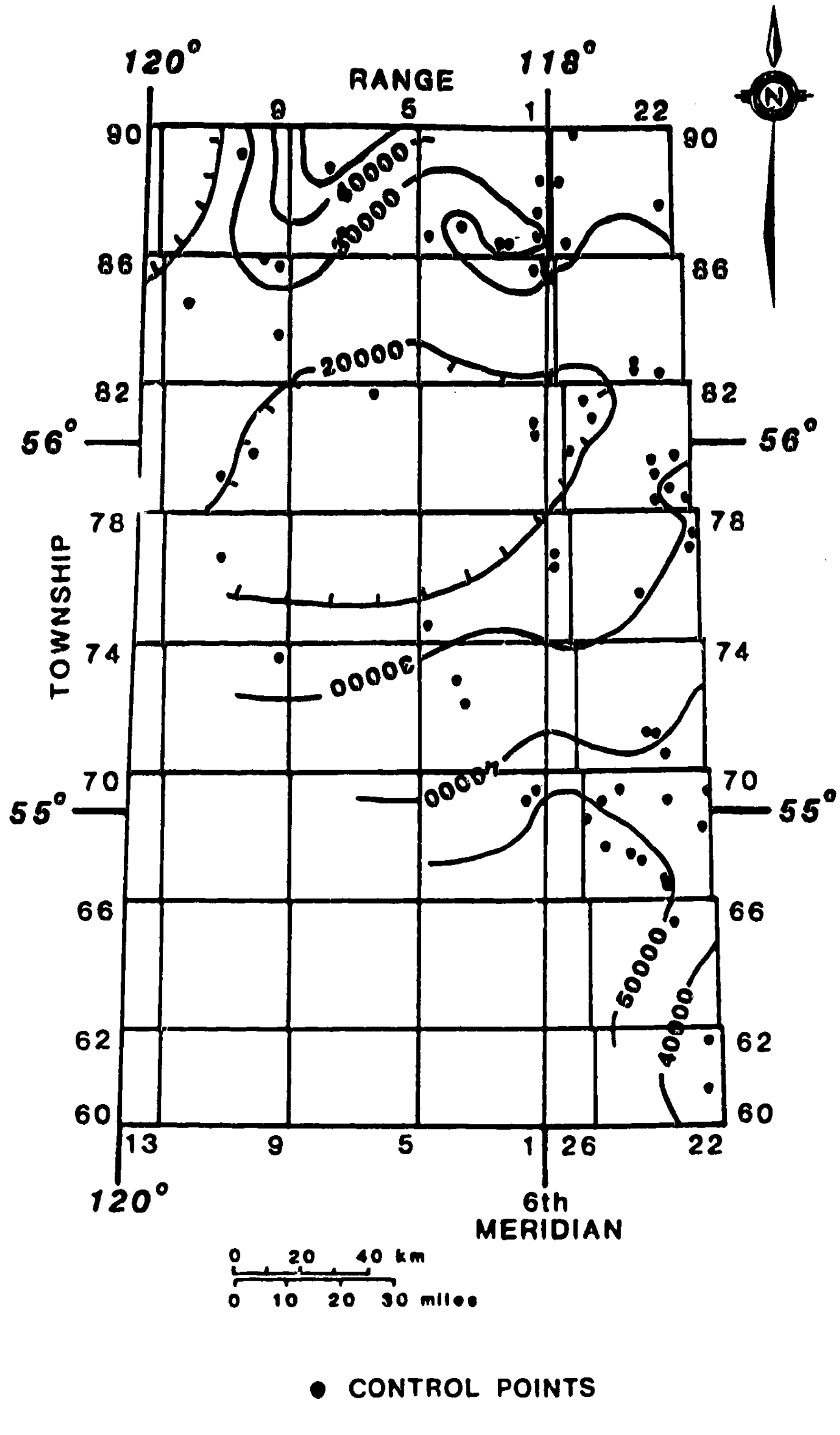


Figure 2.28 Gething Formation total dissolved solids distribution (isoconcentration contours in mg/l)

Waters within the Cadomin Formation follow a similar pattern but exhibit a much greater range of salinity, varying from < 6 000 mg/l TDS to > 75 000 mg/l TDS. The concentration contours in the southwest parallel the gas-water contact of the Deep Basin gas zone and the concentration gradients are relatively steep (Figure 2.29). These variations in salinity over such short distances are not explained by natural groundwater evolution along flow paths, as in the Peace River Formation.

Tilley (1988) suggested the high salinity zones of Hitchon (1964) (Figure 2.22) to be due to paleoflow patterns and the lower salinity areas to represent influx and dilution by modern meteoric water. A graphical comparison of Cadomin water samples from the north and south saline areas indicates similar water chemistries (Figure 2.30), suggesting that at one time the Cadomin contained water of uniform salinity. This supports the interpretation by Tilley (1988) of influx and dilution by meteoric water into the central zone. Domenico and Robbins (1985) modelled dilution patterns, resulting from influx of meteoric water, similar to the chemical patterns observed in the Cadomin Formation. Work by Schwartz et al. (1981) demonstrated a similar salinity pattern in the Milk River sandstone in southern Alberta, also interpreted as meteoric dilution of formation water.

In the Bullhead group, this explanation of the salinity pattern is supported by Sulin-Palmer water classification. The central fresh water zone in each formation is classified as Type 2 bicarbonate-sodium waters which are considered to be indicative of meteoric recharge waters (Figures 2.31, 2.32, 2.33). Meteoric water may infiltrate through formation outcrop, faults, joints or cross-formationally in the uplifted foothills of B.C. The freshest waters in the Bullhead Group are observed in the Cadomin Formation suggesting that meteoric recharge enters the Bullhead Group through the Cadomin conglomerates and probably, as suggested by Hitchon (1964), along the pre-Cretaceous unconformity. The vertical fluid movement between these units accounts for the dilution

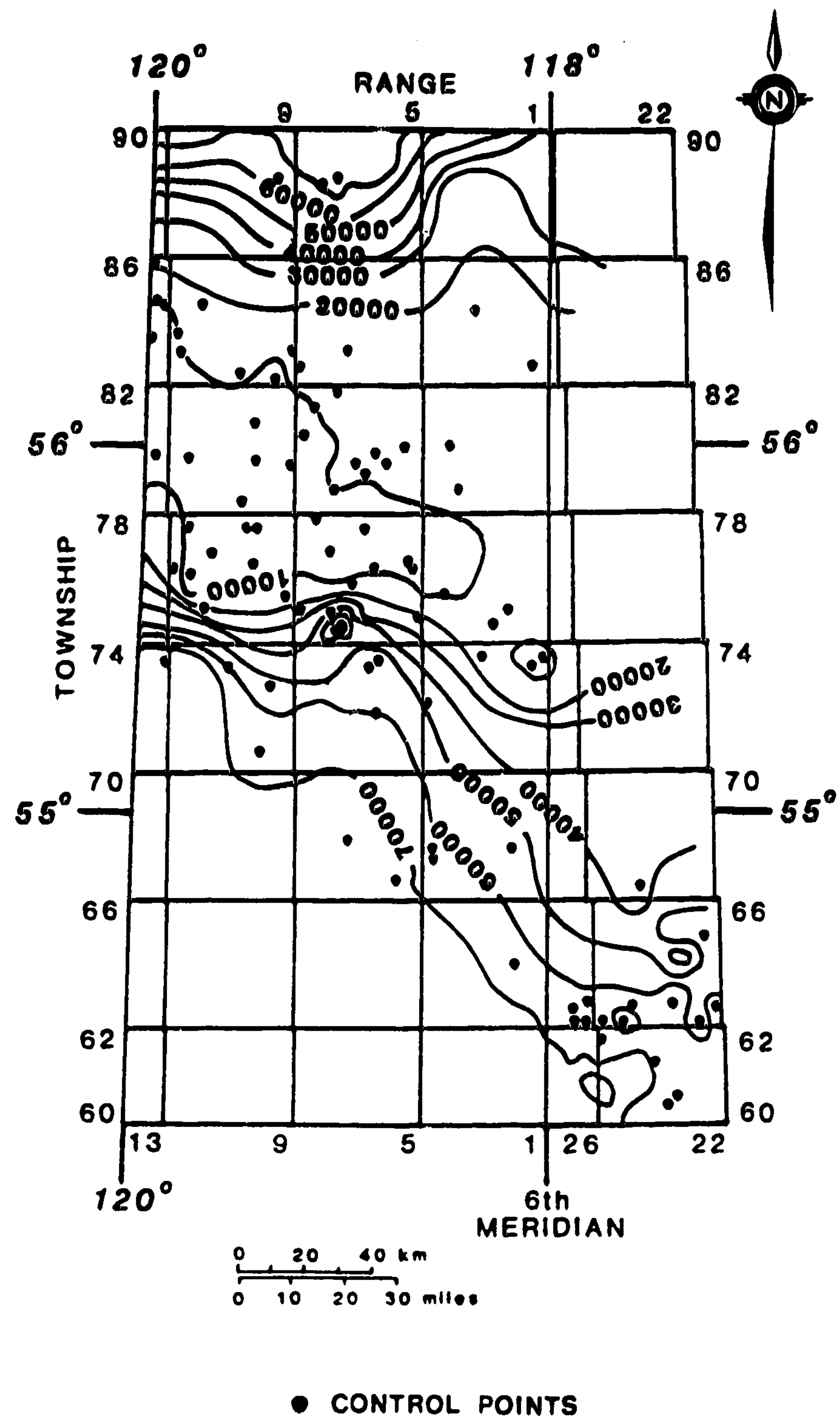


Figure 2.29 Cadomin Formation total dissolved solids distribution (isoconcentration contours in mg/l)

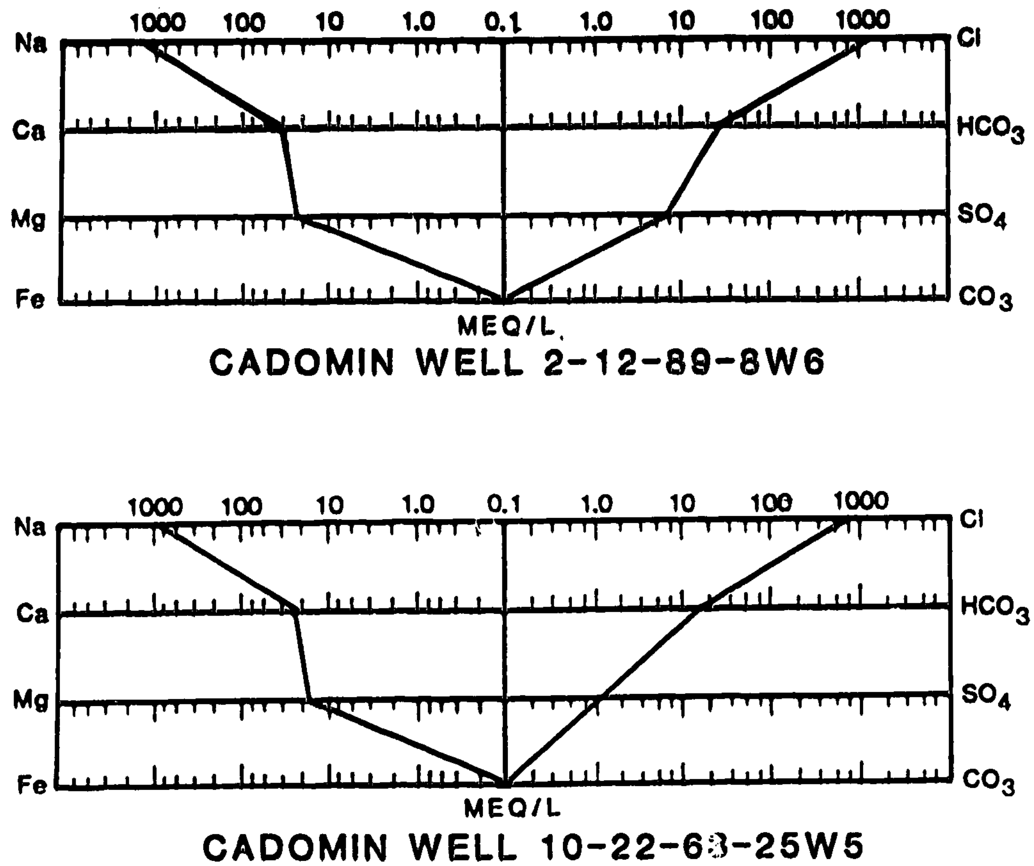


Figure 2.30 Graphical comparison of water chemistry from two separate saline zones in the Cadomin Formation

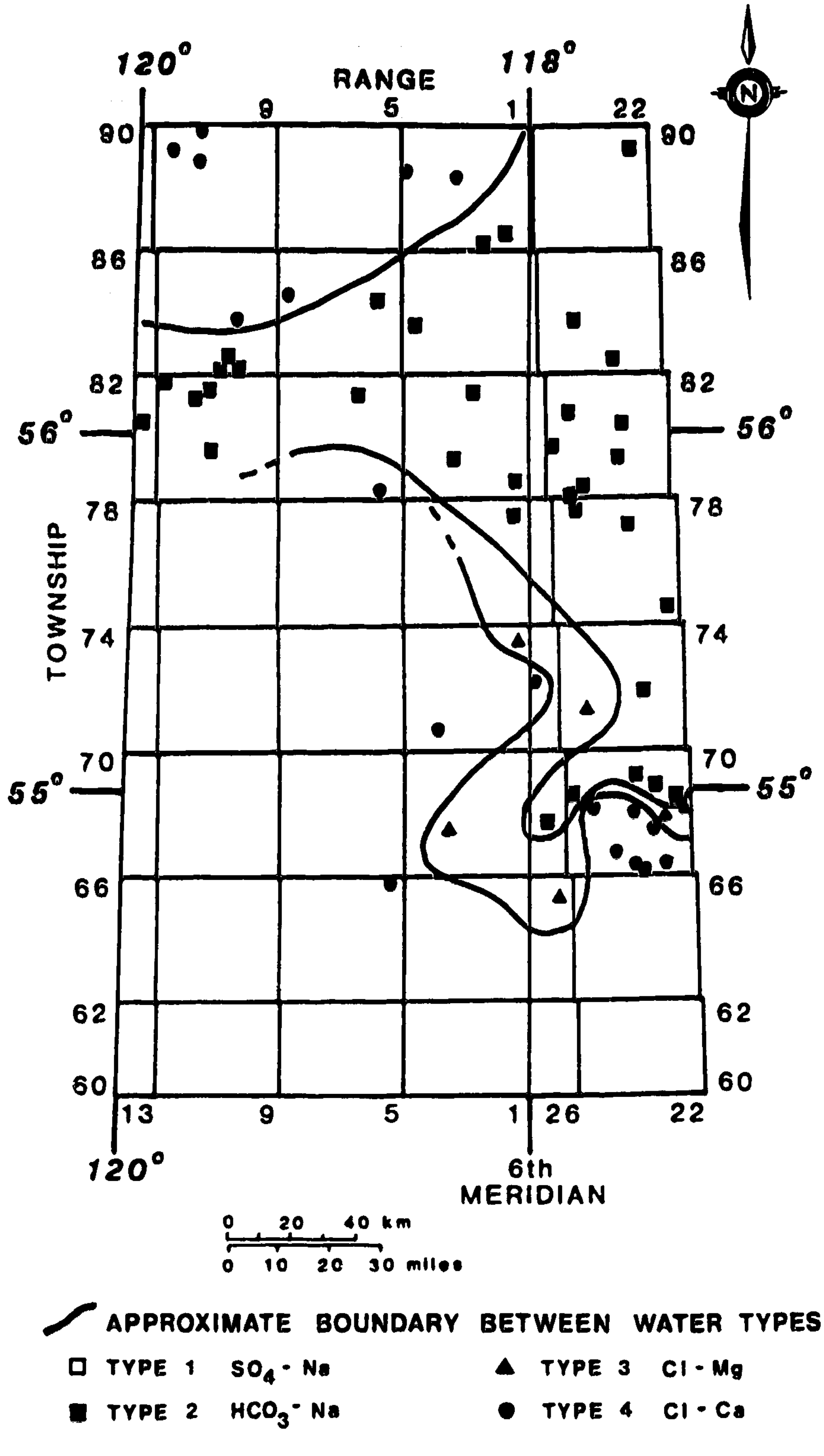


Figure 2.31 Sulin-Palmer water classification map, Bluesky Formation

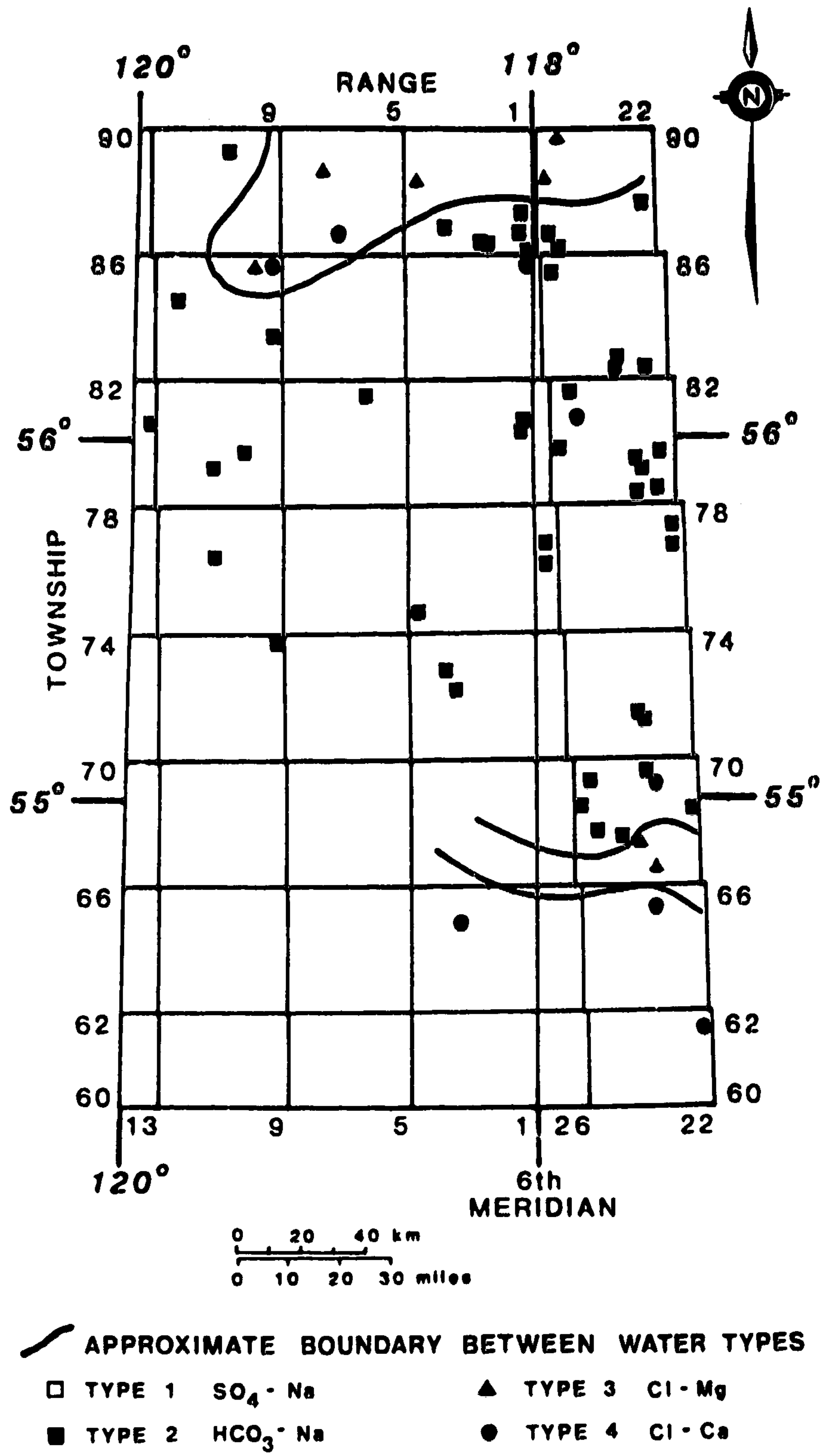


Figure 2.32 Sulin-Palmer water classification map, Gething Formation

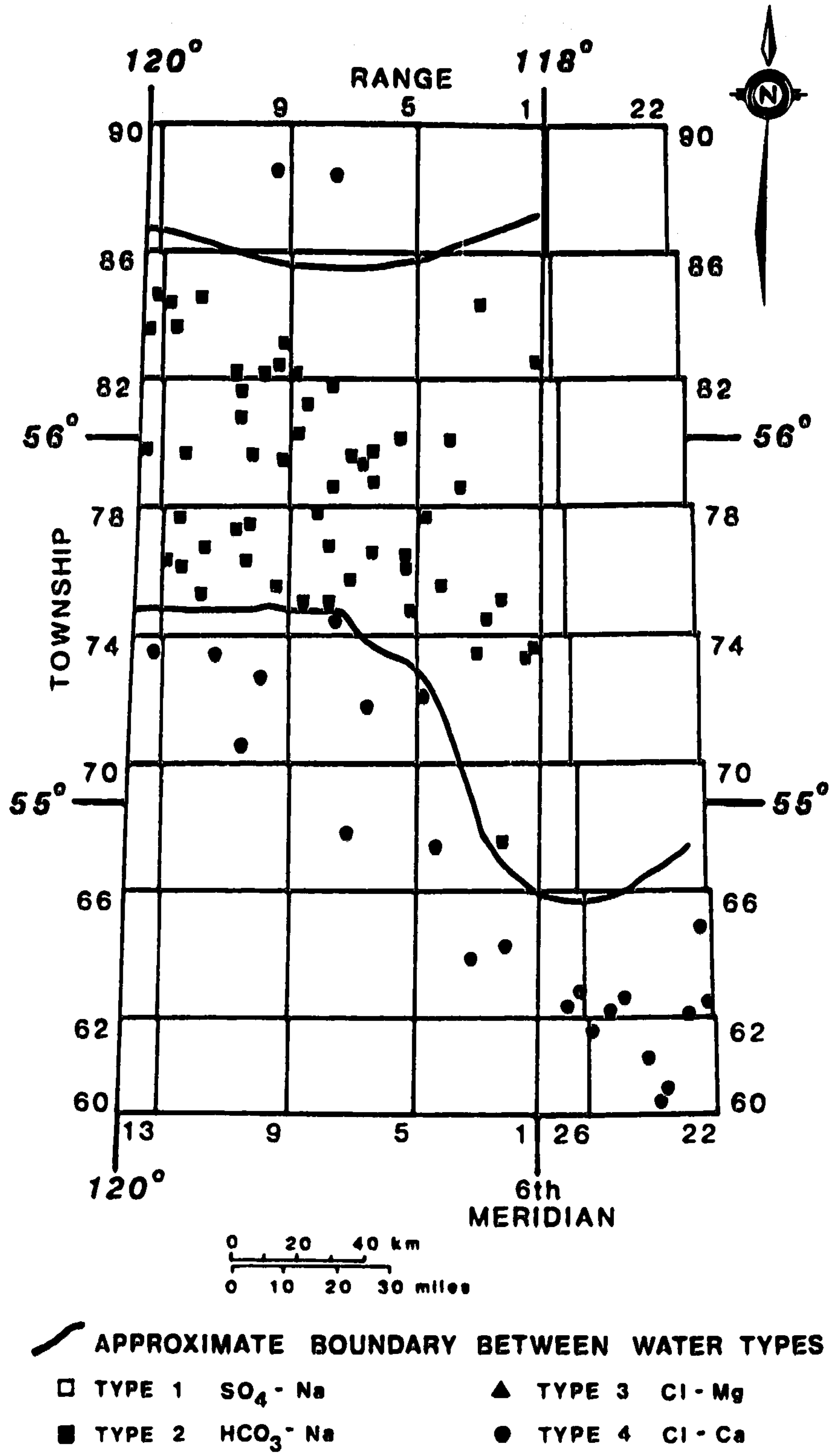


Figure 2.33 Sulin-Palmer water classification map, Cadomin Formation

patterns observed in the overlying Gething and Bluesky formation waters.

The effect of geology on the salinity distribution is clearly evident in the Cadomin, where the fresh water preferentially follows zones of higher permeability, i.e., the Peace River fan and the Spirit River Braid Plain (Figure 2.6). The edge of the braid plain is marked by the Fox Creek Escarpment which appears to be a controlling factor in directing freshwater flow to the southeast (Figure 2.29).

Geochemical gas analyses suggested no water flow in the tight part of the rock section within the Deep Basin (Welte et al., 1985). The high gas saturation and apparent absence of a continuous free water phase suggest the Deep Basin gas zone is an effective barrier to groundwater flow from the west.

A relatively sharp salinity anomaly is observed in the Cadomin in the area of Twp. 75, Rgs. 7 and 8 (Figure 2.29). A local structural high was identified at this location which was found to be gas bearing. This feature appears to disrupt the flow pattern. The isolation of the area from the influx of meteoric water leads to the preservation of the higher salinity.

The hydrochemistry results clearly show that the Peace River Formation and the Bullhead Group are influenced by the infiltration of fresh, meteoric water. The Paddy and Cadotte Members are recharged in the south and groundwater flow appears to be to the north-northeast. In the Bullhead Group, meteoric water infiltrates from the west and is flushing the units from west to east-southeast, influenced by formation permeability, structure and the flow barrier formed by the Deep Basin gas accumulation.

2.7 GAS DISTRIBUTION

Within the study area the greatest gas accumulation occurs in the tight Deep Basin area where the entire Mesozoic rock section is saturated with wet gas below a depth of about 1065 metres (Masters, 1979). The gas saturation decreases rapidly in the shallower part of the sedimentary sequence as the rock becomes more porous and permeable. The rock section becomes water saturated in the area updip of the Deep Basin and gas trapping is more conventional, with gas above water. There are a few structural traps due to local conditions, but the majority of reserves are found in stratigraphic traps (Leslie, 1969).

In the Peace River Formation, there is a strong correlation between the conventional gas pools and potentiometric minima. Most gas pools are found in areas with hydraulic head values less than 360 metres a.m.s.l. (Figures 2.12, 2.15). Exceptions occur in the west central area where gas pools in the Paddy Member are associated with a local potentiometric mound (Twps. 73-74, Rgs. 10-12), and in the southeast corner where several pools are found in areas of high hydraulic head (Figures 2.12, 2.15). In general, the gas is found in the bar sands and tidal channels, i.e., the higher permeability reservoir rocks. There is no apparent relationship between water chemistry patterns and gas distribution.

In the Bluesky Formation, gas pools are associated with potentiometric minima in the northeastern part of the study area (Figure 2.16). This relationship, however, is not observed in the Gething or Cadomin in deeper parts of the basin (Figures 2.17, 2.18). Gas is notably absent in the potentiometric low mapped in the western area of the Bluesky, where formation waters move upwards into the overlying Spirit River Formation.

Gas pools in the Gething and Cadomin formations are generally small and randomly scattered with respect to the potentiometric surfaces (Figures 2.17, 2.18). There is, however, a general relationship between water types and gas distribution. Most of the gas is found in the lower salinity zones, mapped as Type 2 bicarbonate-sodium meteoric waters (Figures 2.17, 2.18, 2.32, 2.33). The resolution of the TDS maps in relation to the size of the gas pools restricts detailed observations, except in several particular areas. In the

Gething, gas is associated with a salinity anomaly in the area of Twp. 87, Rgs. 1 to 4 (Figures 2.17 and 2.28). Gas has also been tested in the area of a sharp salinity anomaly in the Cadomin Formation at Twp. 75, Rgs. 7 and 8 (Figure 2.18), identified as a local structural high.

2.8 SYNTHESIS

Work by various authors (Tóth, 1963, 1978; Hitchon, 1969a) has confirmed the theory of gravity-induced, cross-formational flow of groundwater. Meteoric waters infiltrate and move downward in upland recharge areas, migrate laterally under regions of medium elevations and move upwards to discharge in topographic depressions. Where flow systems meet or part, relatively stagnant zones develop and flow directions may change abruptly. Basin flow patterns are also modified by permeability differences in rock units and structural features.

In 1980, Tóth advanced the generalized hydraulic theory of petroleum migration in which gravity-induced, cross-formational flow is the principal agent in the transport and accumulation of hydrocarbons. Hydrocarbons move along fluid migration paths towards discharge areas of flow systems, characterized by relative potentiometric minima, reduced or zero lateral hydraulic gradients and relatively high groundwater salinity. Numerous structural or stratigraphic conditions may occur along the way which trap hydrocarbons before they reach a discharge area, however, hydrocarbons are expected to be preferentially associated with the ascending limbs and stagnant zones of flow systems. A conceptual illustration of this theory is provided in Figure 2.34.

The generalized hydraulic theory of petroleum migration (Tóth, 1980), i.e., topographically controlled, cross-formational flow explains the fluid flow patterns, hydrochemistry and gas distribution observed in the Peace River Formation of

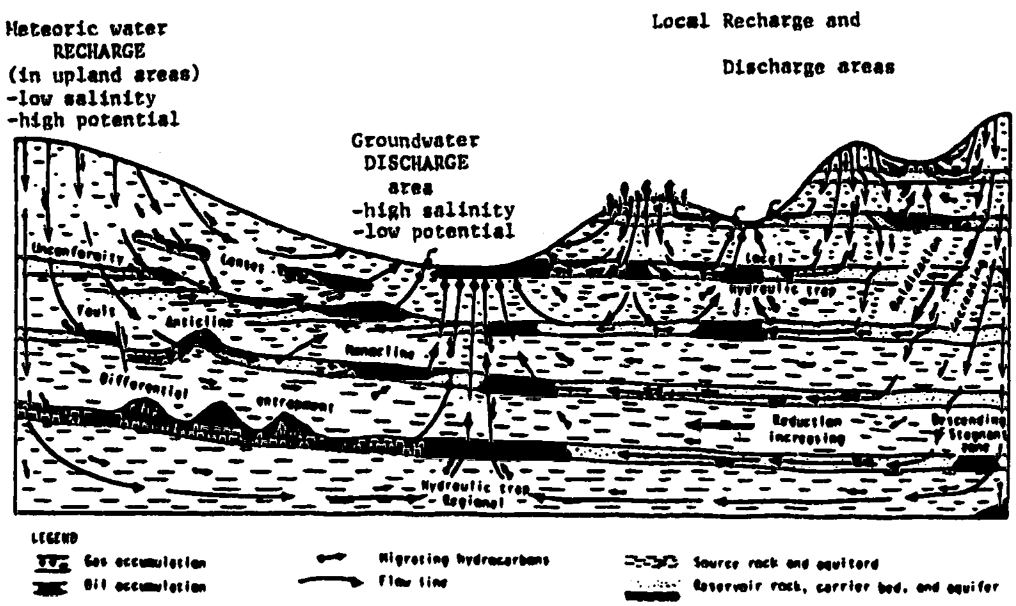


Figure 2.34 Conceptual illustration of the generalized hydraulic theory of the migration and accumulation of hydrocarbons (modified from Tóth, 1980)

northwestern Alberta. The potentiometric surfaces of the Paddy and Cadotte Members clearly reflect present topography. Recharge is evident by the infiltration of relatively fresh meteoric water under the highlands and an increase in water salinity is observed in the discharge area to the northeast. An east-west trending potentiometric trough (Figure 2.12) is related to the combined effect of high permeability sediments in the subsurface (Figure 2.10) and the hydraulic attraction of the deeply incised Peace River Valley. According to the hydraulic theory, gas is expected to be preferentially associated with potentiometric minima. Gas within the Paddy and Cadotte Members of the Peace River Formation is indeed found in the areas of lowest hydraulic head, with the majority of pools in the potentiometric trough feature (Figures 2.12, 2.15). The gas associated with the potentiometric mound in the Paddy (Twps. 73-74, Rgs. 10-12) is thought to be an example of gas trapped by descending groundwater flow. In this area, water is moving downwards into the Cadotte where there is a change to an updip direction of flow (Figure 2.13). Gas trapping is not necessarily hydraulic, but rather stratigraphic traps are enhanced by these hydrogeologic conditions.

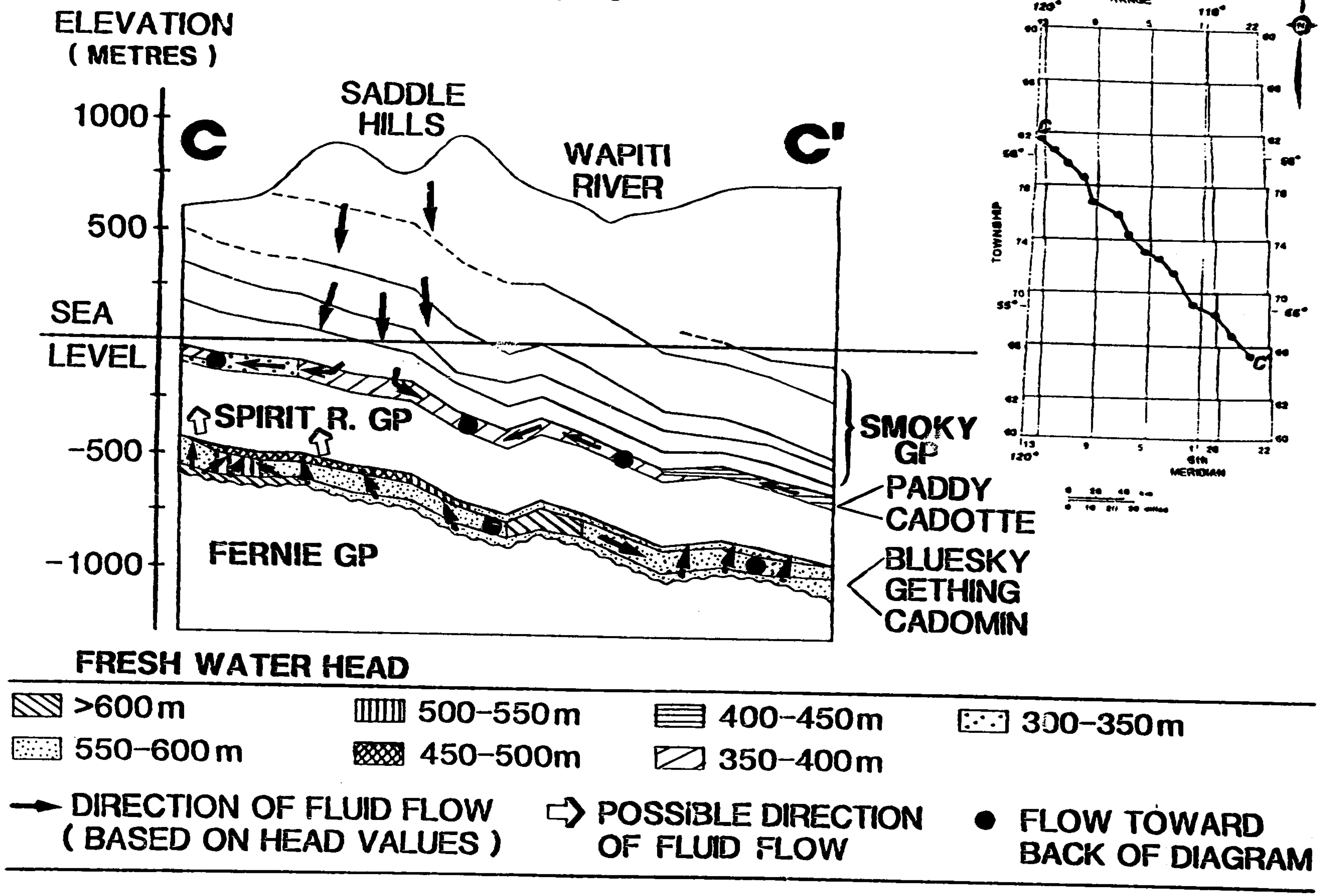
The regional flow system in the Bullhead group is adjusted to basin, as opposed to local, topography. Uplifted sediments in the Foothills constitute the recharge area and subcropping units at lower elevations in the east serve as a regional discharge area. The flow system is best developed in the shallow northern half of the study area. An upward flow component is mapped in the northeast corner which, according to the hydraulic theory, would enhance potential gas entrapment in this area. Large gas pools are in fact observed in this area in the Bluesky Formation (Figure 2.16). In contrast, a lack of gas was noted in the low potentiometric anomaly mapped in the west-central area of the Bluesky Formation (Figure 2.16), despite the vertical flow direction. This is thought to be due to direct fluid escape carrying gas out of the Bluesky into the overlying Spirit River

Formation. Small gas accumulations observed around the anomalous zones in the underlying Cadomin and Gething Formations (Figures 2.17 and 2.18) may be examples of hydrocarbons hydraulically trapped in stagnant areas caused by the change to vertical fluid flow in this area.

Flow in the southern half of the area is hindered by the presence of the Deep Basin gas accumulation which acts as a barrier to water flow. Relatively constant head values within individual hydrogeologic units suggest sluggish lateral flow, however, a definite upward flow component between these units is observed (Figure 2.35). The similar water chemistry patterns throughout the Bullhead Group are explained by this upward flow. The freshest water is found in the Cadomin Formation (Figure 2.29), probably the result of infiltration of meteoric waters into the conglomerates along the pre-Cretaceous unconformity. The upward flow component moves this meteoric water into the Gething and Bluesky Formations. This vertical movement of fluid serves to enhance gas trapping in local stratigraphic or structural traps, and accounts for the scattered gas distribution observed in the Bullhead Group (Figures 2.16, 2.17, 2.18). It also explains the association of gas with the meteoric waters. The path of the meteoric water influx delineates the most permeable areas within the Bullhead formations. Salinity anomalies may indicate zones bypassed by the regional water flow. Such disruptions to the flow system may be due to structural or stratigraphic anomalies and represent areas of good potential for hydrocarbon entrapment.

There appears to be hydraulic communication between the Peace River Formation and the Bullhead Group through the intervening Spirit River Formation. Vertical fluid migration has been mapped from the Bullhead formations into the Spirit River Formation in the western part of the study area. Although available data in the Spirit River Formation are limited, the fluid potential distribution in its upper member (Notikewin-Figure 2.20)

Figure 2.35 Hydrogeological cross-section C-C'



suggests that flow in the northern half of the study area is updip and towards the northeast. There flow appears to be upward, probably in response to the Peace River Valley. This communication is illustrated by the large open flow arrows on Figure 2.13.

2.9 SUMMARY

A regional hydrodynamic evaluation of the Early Cretaceous Peace River Formation and Bullhead Group was completed for the area inclusive of Twps. 60-90, Rgs. 22W5-13W6, N.W. Alberta. Characterization of the hydrostratigraphy, hydraulic head distribution, hydrochemistry and hydrocarbon occurrence was accomplished through the assemblage of a carefully screened data base and the preparation of numerous maps and hydraulic cross-sections. These potentiometric and geochemical data indicate extensive gravity-driven groundwater flow systems operating within the area.

Two hydrogeologic groups have been identified based on similarities in chemical and hydraulic characteristics. The Peace River hydrogeologic group consists of the Paddy and Cadotte units, and the Bullhead hydrogeologic group includes the Bluesky, Gething and Cadomin units.

The potentiometric surfaces for the Paddy and Cadotte Members mimic the local topographic surface, indicating gravity-driven, cross-formational recharge under highlands and discharge in the Peace River Valley. The water chemistry data support this interpretation. Fresher, meteoric waters are found in recharge areas, with increasing salinities in discharge areas. Flow direction is generally updip to the north-northwest, although locally, flow is clearly modified by permeability variations and local topography. Known gas accumulations are associated with potentiometric minima and hydraulically stagnant areas as predicted by the hydraulic theory of petroleum migration (Tóth, 1980).

Flow within the Bullhead Group is also gravity-driven but the effects of local topography are not as apparent as in the overlying Peace River Formation. Instead, the flow system indicates a more regional, basin control, with meteoric recharge under the Rocky Mountain Foothills in the west and flow towards a discharge area to the northeast, probably in the subcrop area of the Bullhead sediments. Hydraulic cross-sections indicate a predominant upward flow component which enhances gas trapping in local stratigraphic and structural traps. The water chemistry data provided useful insight into the nature of the flow system. Mapping the fresh meteoric water influx identified flow paths and provided an indication of hydraulic continuity, formation permeability and minor structural variations.

Understanding the relationships between flow distribution, water chemistry, geology, structure and gas accumulation can be a complex and difficult task. The hydraulic theory of petroleum migration (Tóth, 1980), however, provides a basis for the development of models to explain the observed patterns in the Peace River and Bullhead hydrogeologic groups. Such models lead to a greater understanding of the subsurface environment and identify favourable areas for hydrocarbon accumulation.

The integrated approach used in this study can be applied to any area of interest, providing of course, that sufficient useable data are available. Careful water-sampling and testing of wells has not been an exemplary practice of the oil industry in the past, a situation which can, and should, be improved. Even small amounts of data can be useful when considered within the framework of a hydrogeological model and its relationship to hydrocarbon distribution. The conclusion reached through this study, and the recommendation to industry, is that exploration programs would definitely benefit from the integration of hydrogeology with the conventional exploration methods, i.e., geology, geochemistry and geophysics, generally utilized at the present time.

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CHAPTER 3

CONCLUSION

The three main objectives of this study were:

1) to characterize the petroleum hydrogeological conditions within the Early Cretaceous units in the area inclusive of Twps. 60-90, Rgs. 22W5-13W6 in the Peace River area of northwestern Alberta, Canada

2) to determine the relationships between groundwater flow, water chemistry, geology (lithology, permeability, structure), and gas accumulation

3) to formulate a hydrogeological model to account for the observed relationships and to use this model for the prediction of favourable areas for hydrocarbon accumulations.

Characterization of the petroleum hydrogeological conditions was accomplished through the acquisition, qualification and compilation of a large volume of formation pressure and water chemistry data. The pressure data were utilized in the production of potentiometric surface maps for each of the hydrogeologic units, hydraulic cross-sections and in pressure-depth analyses. The hydrochemical data were used to produce formation water salinity (TDS) maps and in Sulin-Palmer genetic water classification. Regional geology and topography information was obtained from published literature and hydrocarbon distribution maps were assembled from ERCB individual pool boundary maps. This information determined the hydrostratigraphy of the Early Cretaceous Peace River area (Figure 3.1) and identified two dynamic systems of formation waters, i.e., the Peace River hydrogeologic group and the Bullhead hydrogeologic group.

Similarities between the topographic surface and the potentiometric surfaces of the Paddy and Cadotte Members of the Peace River Formation indicate topographically controlled (gravity-induced) cross-formational recharge under the highlands and discharge

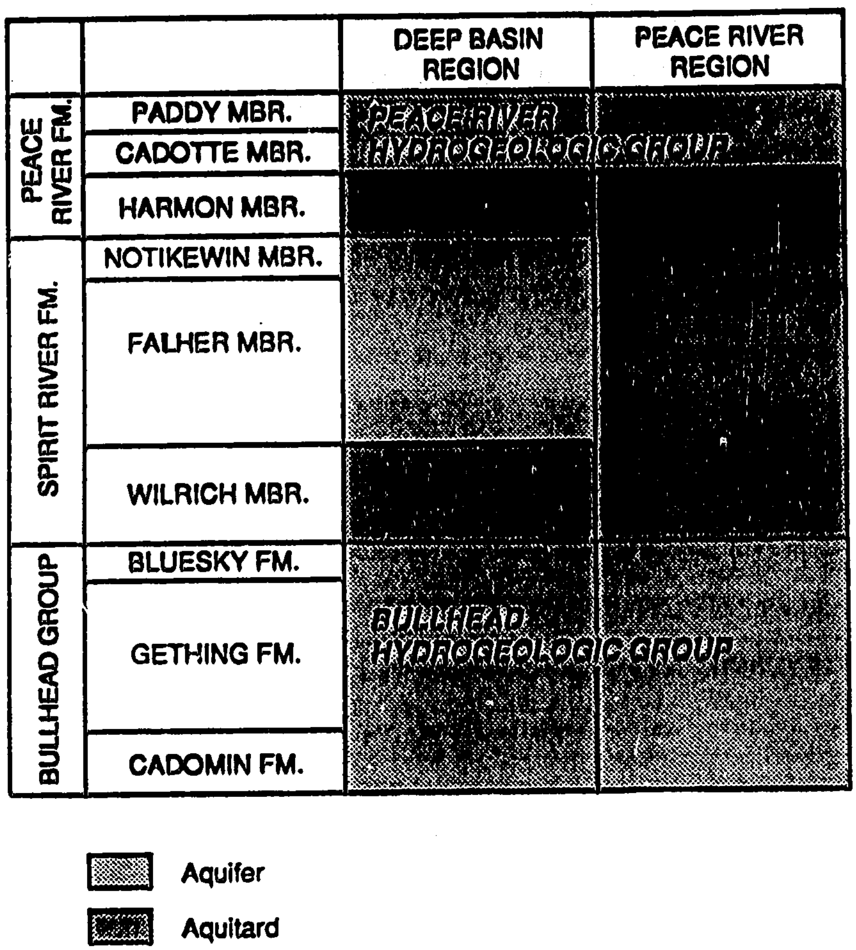


Figure 3.1 Hydrostratigraphy

in the Peace River Valley. Hydrochemistry data support this interpretation; total dissolved solids contents range from 20 000 to 25 000 mg/l, with fresher waters in recharge areas tending towards higher salinities in discharge areas. Sulin-Palmer analyses indicate the presence of meteoric water. In general, flow is updip to the north-northeast (Figure 3.2), although fluid flow directions are locally modified by permeability and lithology variations, as well as local topographic features. A definite relationship between gas accumulations and potentiometric minima is observed.

Flow within the Bullhead Group was also determined to be gravity-driven, but the effects of local topography are not as apparent as in the overlying Peace River Formation. The potentiometric and hydrochemical patterns suggest a more regional basin control, with recharge under the Rocky Mountain Foothills in the west and flow towards the subcrop area of the Bullhead sediments to the northeast. An influx of fresh (< 20 000 mg/l TDS) meteoric water from the west appears to displace more saline waters (> 75 000 mg/l TDS). A predominance of upward flow from the Cadomin into the Gething and Bluesky Formations (Figure 3.3) accounts for the similar water chemistry patterns observed in the three units and enhances gas trapping in local stratigraphic and structural traps. Gas is found in potentiometric depressions in the updip region, however, gas is not found in a major depression to the west where water is thought to be exiting the Bullhead Group.

The influence of permeability and structure on groundwater flow paths within the Bullhead units was most evident in the Cadomin Formation where a clear relationship was observed between the meteoric water influx and the most permeable sediments. Also, salinity anomalies were found to correspond to structural and stratigraphic perturbations of the flow system.

The best hydrogeological model to explain the observed relationships is the Hydraulic Theory of Petroleum Migration (Tóth, 1980) in which gravity-induced, cross-formational

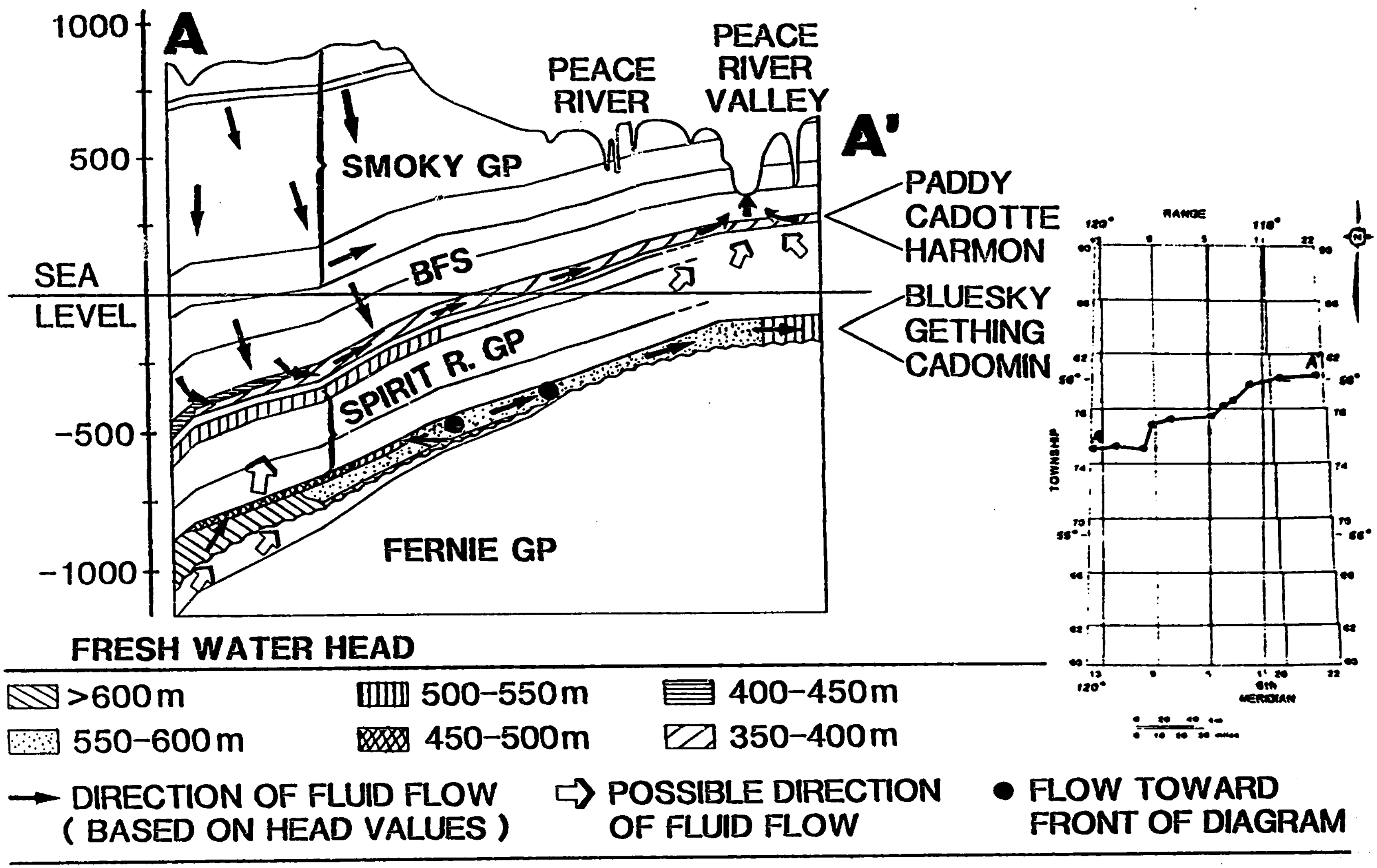
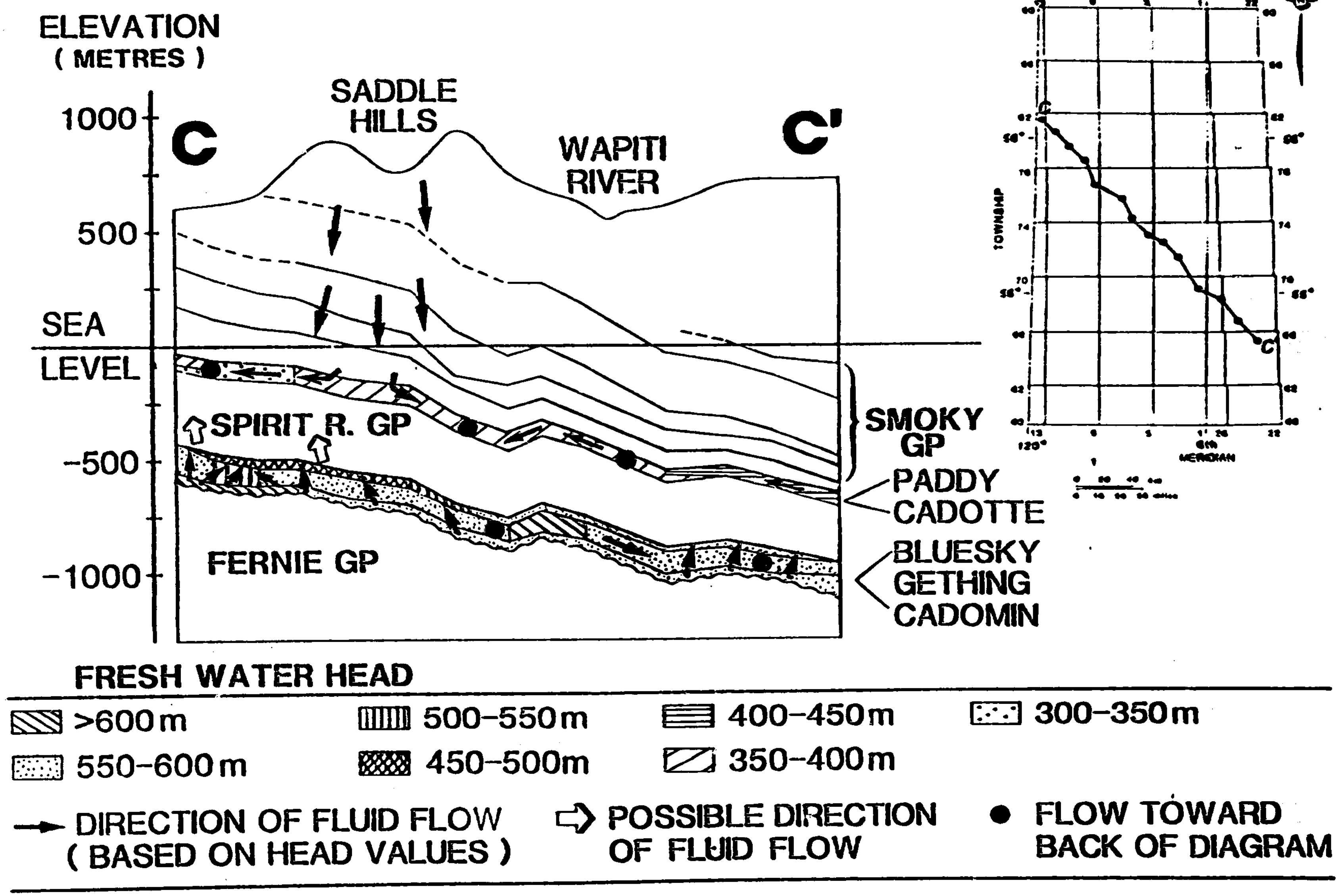


Figure 3.2 Hydrogeological cross-section A-A'

Figure 3.3 Hydrogeological cross-section C-C'



groundwater flow is the principal agent in the transport and accumulation of hydrocarbons. As predicted by this model, gas in the study area is found associated with relative potentiometric minima, hydraulically stagnant areas, and in local areas where slight disturbances of the flow regime result in favourable trapping conditions.

The ultimate goal of this thesis, i.e., to predict favourable areas for hydrocarbon exploration, is realized by the utilization of this model. The establishment of formation fluid flow patterns allows delineation of permeable zones and of possible stratigraphic and/or structural features which identify favourable areas for hydrocarbon accumulations. The increased understanding of subsurface fluid behaviour provided by this model can be effectively used by the exploration geologist.

The characterization of formation water chemistry is an important part of understanding fluid flow and is also necessary in industry for accurate geophysical log analysis, formation identification when drilling, mud filtrate identification, diagenesis studies, etc. Clearly, hydrogeology is a valuable, economic source of information and it should be incorporated along with geology, geochemistry and geophysics into current exploration strategies.

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APPENDIX I

DRILL STEM TEST DATA

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DRILL STEM TEST DATA

Formation pressure data were obtained from the Canadian Institute of Formation Evaluation (CIFE) DST-80 microfiche file. This data file provides one-page summary reports of available drill stem test information. Reports include qualitative descriptions of original DST charts and problems encountered with tests and recovery information, often accompanied by one or more pages of incremental data, depending upon test quality and shut-in duration.

All tests that display shut-ins and build-ups are processed by CIFE. This processing involves digitization of data and an attempt to calculate in-situ formation pressures. In the case of fluid phase recoveries, the Horner plot technique (Horner, 1951) is used. This method of analysis of pressure build-up curves uses the best fit line to late time data points to extrapolate formation pressure from the test data. In the case of gas phase recoveries, the pressure-squared technique introduced by Tracy is used (Tracy, 1956). CIFE notes the subjective nature of such analyses.

In addition, tests processed by CIFE are analyzed for mechanical soundness, data quality and accuracy. Results are recorded as "Quality Codings", A through G, where A represents the highest quality DST's available. Letter codes are further described by a series of number codes. The following list states the coding criteria for A and B quality tests as defined by CIFE.

"A" Tests: HIGHEST QUALITY DST

1. Tests mechanically sound: -no plugging - no skidding.
2. Recorder used, chart good, pressures compare.
3. Flow pressures verify recoveries and/or flow rates:
   -except when reverse circulated or tight hole sub used
4. Bottom packer held on straddle tests.

5. Recorder depths given.
6. Recorder within interval tested:
   -except when using recorder from above interval, but pressures compare with recorder within interval.
7. Initial shut-in stabilized or nearing stabilization with increments:
   -except when test has all the qualification of an "A" and falls in the P-MAX range given. Shut-ins can still be building.
8. Preflow time long enough to release hydrostatic heads.
9. KB elevation given.
10. Two good shut-ins required.
11. P-MAX range of approximately 7 to 69 kPa (1 to 10 psi) from read shut-in pressure.
88. Plugging, fluid to surface, resets on flows (Irregularities).
99. Flows incremented.

"B" Tests: SLIGHT MECHANICAL DIFFICULTIES

12. Slight mechanical difficulties, but does not affect the test.
13. Shut-ins not fully stabilized or still building with increments:
    -P-MAX range 69 kPa to 138 kPa (10 to 20 psi).
15. Recorder pressures disagree from 7 to 131 kPa (1to 19 psi) after recorder drag and depth difference.
16. Require extrapolating.
17. P-MAX range of approximately 138 to 241 kPa (20 to 35 psi) from read shut-in pressure.
48. Flow pressures do not verify recoveries.
88. Plugging, fluid to surface, resets on flows (Irregularities).
99. Flows incremented.

Over fourteen hundred A and B tests were considered in this study. Data recorded included: well location, kelly bushing elevation (feet), test interval, formation name, recorder elevation, quality code, assigned pressure (P-MAX), and test recovery. These data were sorted and grouped by formation and entered into a computer mapping file. Numerous points stood out as anomalous. Investigation of these anomalous pressure points identified an association with the fluid phase of the test recovery; the problems occurred when condensate, gas, and multiple phase (gas, oil, water, mud) recoveries were obtained.

In cases of multiphase flow, the total compressibility and total mobility of the reservoir fluid system must be substituted for the corresponding single fluid quantities in the pressure analysis technique (Matthews and Russell, 1967). As stated earlier, CIFE used the Horner method to extrapolate formation pressures from water recovery tests. In cases of gas phase recoveries, the Tracy method was used. There is, however, no special consideration given to condensate, or mixed phase recoveries. CIFE selects the dominant fluid phase recovered or simply uses the water recovery (personal comm., 1988). In many cases, one fluid will strongly dominate the recovery, in which case the error due to mixed recoveries is small and CIFE is justified in their analytical techniques. But in cases where the volume of each phase is significant, the theoretical analysis and extrapolated pressure is clearly affected. It is a difficult problem to deal with, and careful consideration of such tests is required. For mapping purposes in this study, therefore, all questionable multiphase recovery tests were removed from the "A" and "B" quality file.

Another common problem with the data file was the identification of which formation the tests were from. CIFE provides three possible choices, often surprisingly different. For drill stem tests used in this study, the interval was checked against PIX cards or logs if available, and erroneously reported tests were removed from the data base.

The CIFE data were also carefully screened for errors in data reporting, i.e., typographical errors such as misplaced decimal points or transposed numbers, and missing information. The end result was the removal of approximately 25% of CIFE's "A" and "B" data, due to questionable validity of the extrapolation methods, formation identification or erroneous recording of data. The remaining CIFE data were used for the calculation of hydraulic head values.

Hubbert (1940) defined fluid potential as the energy contained by a unit mass of fluid. This energy (ϕ) is related to hydraulic head (h) by the equation ϕ=gh, where g is the acceleration of gravity. Gravity is nearly constant at the earth's surface, therefore, the fluid potential energy is almost perfectly correlated with fresh water head (h) where head is simply the height above datum of a column of fresh water that is in equilibrium with the pore pressure at the point of measurement.

Hydraulic head values are calculated by the equation: $h=z+p/\gamma$

where h=hydraulic head

z=recorder elevation with respect to datum, commonly sea level

p=undisturbed formation fluid pressure (assigned P-max)

$\gamma=\rho g$ = fluid density x gravity = specific weight of the fluid

γ is commonly known as the pressure gradient. The CIFE data file reports pressures in psi, and elevations in feet, therefore, a fresh water gradient of 0.433 psi/ft was used for the calculations. Hydraulic head values in feet were subsequently converted to metres for mapping purposes.

Contour maps of hydraulic head values are known as potentiometric surface maps. Such maps are used to determine fluid flow directions as fluids always move from areas of high hydraulic head or fluid potential to areas of low hydraulic head or fluid potential.

The use of freshwater head is theoretically valid for horizontal flow conditions where density-related gravity effects are small and can be ignored. Davies (1987) modelled variable density groundwater flow using equivalent freshwater head and analysed the potentially significant errors in this method. He introduced a simple nomograph type plot that can be used to identify situations where density related gravity effects may be significant. According to this nomograph the salinity, i.e., density effects, within the study area will not significantly alter the results. Also Hitchon (1969a) and Tóth (1978), working with similar water salinities, concluded that density effects do not invalidate general flow directions inferred from fresh water head data. It was, therefore, considered justified to calculate hydraulic head using the 0.433 psi/ft fresh water gradient.

Hydraulic head values were entered into a standard mapping file and plotted using an interactive surface mapping (ISM) package made available at Canadian Hunter Exploration Ltd. Individual maps were hand contoured.

Although potentiometric surface maps were constructed for individual formations they are not meant to imply that groundwater flow is restricted within these units. Cross-formational flow is an important aspect of fluid flow patterns. To aid interpretation of the three-dimensional flow system, hydraulic cross-sections were constructed (Figures 2-13, 2-35). Wells for these sections were chosen for completeness of sections, and not all wells had associated DST's. In these cases, hydraulic head values were estimated from the potentiometric contour maps.

The following pages list the CIFE data used in this study, including well location, DST number, formation name, recorder depth (feet), recorder elevation (feet) and fluid pressure calculated by CIFE (assigned P-max, psi). Also listed are the hydraulic head values calculated in feet and in metres. The data are grouped by formation in stratigraphic order (Peace River Formation to Cadomin Formation), however, within each formation, data are randomly listed. Potentiometric surface maps for each formation are provided in Chapter 2 (Figures 2.12, 2.15, 2.16, 2.17, 2.18).

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WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-14-82-09W6	2	PDY	2155.51	205.71	457.50	1262.29	384.75
11-05-69-07W6	6	PDY	5769.00	-3358.00	2086.21	1460.04	445.02
06-08-77-05W6	3	PDY	2539.37	-414.70	719.20	1246.27	379.86
14-17-77-09W6	1	PDY	3576.12	-651.25	833.80	1274.39	388.43
06-16-75-06W6	2	PDY	4205.00	-987.00	930.00	1160.81	353.81
14-20-79-04W6	6	PDY	1679.79	235.01	434.95	1239.51	377.80
06-25-82-06W6	7	PDY	1604.33	430.45	331.27	1195.51	364.39
03-26-77-07W6	1	PDY	2883.20	-380.25	715.73	1272.71	387.92
08-02-77-08W6	1	PDY	3290.69	-646.00	820.04	1247.86	380.35
06-34-78-02W6	3	PDY	1656.83	201.44	428.90	1191.97	363.31
11-12-75-06W6	3	PDY	4024.00	-934.00	931.85	1218.08	371.27
10-16-82-01W6	8	PDY	1609.00	591.98	241.00	1148.56	350.08
08-12-76-08W6	2	PDY	3451.45	-834.32	885.15	1209.91	368.78
06-06-82-05W6	1	PDY	1742.00	308.00	368.93	1160.03	353.58
10-27-78-08W6	11	PDY	2579.00	-219.00	616.44	1204.65	367.18
07-26-74-09W6	6	PDY	4025.00	-1423.00	1148.84	1230.21	374.97
10-23-78-10W6	1	PDY	2974.00	-395.00	653.26	1113.68	339.45
10-02-79-08W6	1	PDY	2428.00	-171.00	584.00	1177.73	358.97
14-07-76-07W6	7	PDY	3339.89	-787.07	890.10	1268.59	386.67
06-26-77-09W6	1	PDY	3726.00	-530.00	764.00	1234.43	376.26
07-24-74-13W6	4	PDY	4579.00	-1945.00	1397.00	1281.33	390.55
06-23-75-06W6	3	PDY	3727.00	-873.00	896.13	1196.58	364.72
06-21-79-06W6	7	PDY	2060.36	-76.44	555.37	1206.17	367.64
10-18-82-05W6	1	PDY	1598.00	390.00	338.00	1170.60	356.80
07-02-75-07W6	1	PDY	3940.00	-1044.00	1020.00	1311.66	399.79
06-22-76-07W6	4	PDY	3178.78	-751.61	870.02	1257.67	383.34
14-05-77-08W6	1	PDY	3603.00	-717.00	854.19	1255.73	382.75
06-27-76-09W6	3	PDY	3814.00	-909.00	924.50	1226.10	373.72
11-07-76-08W6	1	PDY	3784.00	-850.00	903.00	1235.45	376.57
10-30-68-06W6	1	PDY	5541.44	-3241.57	2035.42	1459.17	444.75
06-27-82-05W6	1	PDY	1671.00	389.00	334.00	1160.36	353.68
10-36-75-07W6	5	PDY	3511.10	-870.41	897.19	1201.62	366.25
06-34-82-05W6	1	PDY	1643.00	426.00	339.00	1208.91	368.48
06-33-74-07W6	1	PDY	3921.39	-1214.04	1038.90	1185.27	361.27

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
16-25-79-08W6	5	PDY	2222.77	-59.38	526.34	1156.19	352.41
10-05-79-06W6	2	PDY	2103.00	-73.00	552.00	1201.83	366.32
06-30-72-23W5	3	PDY	3254.60	-677.17	837.20	1256.32	382.93
06-22-65-02W6	5	PDY	5993.17	-3404.92	2082.08	1403.58	427.81
06-27-71-07W6	8	PDY	4639.10	-2173.88	1578.90	1472.54	448.83
10-34-79-02W6	6	PDY	1620.00	262.00	435.82	1268.51	386.64
06-27-79-09W6	1	PDY	2817.83	-243.03	589.00	1117.25	340.54
11-10-65-23W5	2	PDY	5085.30	-2551.84	1727.60	1438.00	438.30
06-29-75-04W6	1	PDY	3194.72	-701.28	790.59	1124.56	342.77
07-32-65-03W6	1	PDY	6520.34	-3672.24	2185.43	1374.94	419.08
07-13-71-12W6	2	PDY	5999.67	-3299.21	1987.55	1290.97	393.49
14-03-73-08W6	2	PDY	4295.01	-1941.34	1362.60	1205.54	367.45
10-15-80-03W6	1	PDY	1571.00	357.00	358.00	1183.79	360.82
11-18-77-08W6	8	PDY	3735.00	-584.00	827.80	1327.78	404.71
10-15-74-10W6	2	PDY	4217.52	-1740.49	1283.29	1223.23	372.84
07-25-76-10W6	5	PDY	3733.03	-801.84	899.20	1274.83	388.57
07-13-66-09W6	1	PDY	7543.87	-4626.87	2597.90	1372.90	418.46
15-14-73-10W6	5	PDY	4537.07	-2059.71	1475.24	1347.31	410.66
14-20-77-05W6	1	PDY	2468.41	-368.67	707.20	1264.59	385.45
14-04-77-05W6	1	PDY	2562.33	-424.11	726.39	1253.47	382.06
07-08-77-07W6	1	PDY	3413.00	-641.00	795.00	1195.03	364.24
11-24-79-09W6	1	PDY	2584.00	-217.00	592.45	1151.24	350.90
10-27-78-12W6	2	PDY	3128.00	-455.00	687.00	1131.61	344.91
08-12-72-08W6	6	PDY	4580.05	-2210.30	1510.70	1278.61	389.72
11-21-79-05W6	1	PDY	1832.00	89.00	470.00	1174.45	357.97
16-16-76-09W6	1	PDY	3885.66	-830.87	890.14	1224.88	373.34
06-18-79-08W6	1	PDY	2509.00	-187.00	587.29	1169.33	356.41
02-36-77-01W6	3	PDY	1780.24	131.23	448.17	1166.26	355.48
06-26-80-06W6	2	PDY	1779.00	179.00	431.00	1174.38	357.95
03-03-74-07W6	1	PDY	3919.62	-1490.81	1185.14	1246.23	379.85
10-24-78-08W6	4	PDY	2604.00	-208.00	603.04	1184.70	361.10
16-32-77-12W6	4	PDY	3339.89	-666.99	805.15	1192.48	363.47
06-09-79-10W6	5	PDY	2808.40	-318.24	597.70	1062.13	323.74
16-24-76-10W6	8	PDY	3832.03	-802.17	884.80	1241.25	378.33

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
15-14-77-26W5	2	PDY	1803.00	121.00	463.00	1190.28	362.80
08-23-73-09W6	4	PDY	4253.61	-1813.98	1345.53	1293.48	394.25
07-21-79-08W6	2	PDY	2374.00	-110.00	582.00	1234.11	376.16
12-18-78-09W6	1	PDY	2968.00	-432.00	692.31	1166.87	355.66
06-29-72-13W6	2	PDY	5738.19	-2882.55	1810.94	1299.76	396.17
16-28-79-09W6	4	PDY	2923.03	-324.93	631.60	1133.73	345.56
04-22-65-24W5	2	PDY	5456.00	-2568.00	1715.17	1393.13	424.63
06-04-66-24W5	1	PDY	5262.47	-2400.59	1673.01	1463.17	445.98
10-13-76-09W6	1	PDY	3818.90	-871.72	917.50	1247.22	380.15
08-21-75-10W6	3	PDY	3897.64	-1248.69	1072.84	1229.00	374.60
06-11-77-08W6	3	PDY	3379.26	-562.66	777.92	1233.92	376.10
07-36-82-06W6	1	PDY	1620.00	400.00	330.00	1162.12	354.22
07-02-78-05W6	5	PDY	2208.00	-175.85	584.21	1173.36	357.64
15-11-80-03W6	9	PDY	1502.63	381.23	338.20	1162.29	354.27
10-11-79-10W6	1	PDY	2886.00	-228.00	541.00	1021.42	311.33
11-09-81-04W6	1	PDY	1506.00	390.00	332.00	1156.74	352.58
10-26-80-10W6	1	PDY	2656.00	-97.00	523.55	1112.12	338.97
16-21-75-10W6	2	PDY	3897.63	-1218.50	1075.02	1264.23	385.34
07-01-79-09W6	1	PDY	2706.47	-340.98	600.02	1044.75	318.44
06-08-82-25W5	7	PDY	1415.00	665.00	323.20	1411.42	430.20
10-18-77-11W6	5	PDY	3231.63	-748.69	809.64	1121.15	341.73
11-01-81-04W6	1	PDY	1540.00	401.00	323.00	1146.96	349.59
10-12-74-05W6	1	PDY	3694.23	-1146.00	1040.24	1256.40	382.95
06-14-74-07W6	1	PDY	3782.80	-1288.71	1113.74	1283.44	391.19
10-18-75-04W6	1	PDY	3320.00	-688.00	813.48	1190.71	362.93
10-33-81-23W5	1	PDY	849.00	777.00	150.00	1123.42	342.42
10-21-80-11W6	1	PDY	2474.00	-208.00	603.00	1184.61	361.07
14-28-79-09W6	[illegible]	PDY	2845.51	-235.60	581.06	1106.34	337.21
14-22-71-07W6	4	PDY	4533.66	-2207.25	1494.59	1244.46	379.31
16-20-78-08W6	1	PDY	2736.22	-272.97	638.70	1202.09	366.40
10-24-77-11W6	1	PDY	3136.00	-625.00	792.00	1204.10	367.01
08-13-72-08W6	1	PDY	4499.67	-2143.70	1509.52	1342.49	409.19
06-33-73-05W6	7	PDY	3700.00	-1305.00	1109.00	1256.20	382.89
10-18-73-07W6	2	PDY	5853.00	-3649.00	2151.27	1319.29	402.12

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-35-76-05W6	1	PDY	2733.44	-513.95	744.25	1204.87	367.25
07-11-75-07W6	1	PDY	4015.09	-979.99	909.60	1120.70	341.59
14-31-80-03W6	6	PDY	1551.83	396.33	335.33	1170.76	356.85
12-36-74-25W5	1	PDY	2586.98	-377.66	696.04	1229.82	374.85
08-19-77-09W6	7	PDY	3553.15	-610.24	810.60	1261.82	384.60
10-02-81-04W6	1	PDY	1596.00	339.00	352.00	1151.93	351.11
12-32-80-23W5	2	PDY	1126.97	748.52	196.96	1203.39	366.79

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-33-73-05W6	5	CDT	3723.00	-1328.00	1100.00	1212.42	369.54
10-08-75-07W6	1	CDT	3997.00	-1213.00	1029.00	1163.44	354.62
10-19-69-26W5	3	CDT	4012.00	-1785.00	1330.28	1287.24	392.35
07-20-72-04W6	6	CDT	3980.00	-1498.00	1199.69	1272.65	387.90
11-19-75-04W6	2	CDT	3391.00	-708.00	774.42	1080.50	329.34
11-07-66-04W6	3	CDT	6353.68	-3737.21	2169.58	1273.37	388.12
09-15-77-25W5	3	CDT	1728.00	125.00	451.00	1166.57	355.57
09-10-66-10W6	1	CDT	7933.08	-5005.91	2863.60	1607.48	489.96
06-27-79-09W6	6	CDT	2883.85	-309.05	633.00	1152.84	351.39
06-30-78-11W6	5	CDT	3040.03	-508.86	669.10	1036.41	315.90
07-10-80-05W6	7	CDT	1769.00	105.00	474.82	1201.58	366.24
07-25-80-08W6	2	CDT	2049.00	32.00	495.00	1175.19	358.20
04-08-74-05W6	8	CDT	3766.00	-1211.00	1065.17	1248.98	380.69
10-30-73-09W6	3	CDT	4370.01	-1916.27	1368.00	1243.08	379.89
04-04-71-23W5	1	CDT	3292.00	-1049.00	1046.00	1366.70	416.57
07-30-69-25W5	3	CDT	4075.00	-1580.00	1268.37	1349.26	411.25
10-25-74-12W6	2	CDT	4470.00	-1770.00	1326.02	1292.40	393.92
14-04-75-09W6	2	CDT	3897.97	-1305.58	1115.10	1269.71	387.01
10-28-66-05W6	6	CDT	6486.00	-3733.00	2188.24	1320.67	402.54
08-15-81-09W6	6	CDT	2089.89	174.87	465.14	1249.10	380.72
07-09-76-08W6	1	CDT	3805.00	-887.00	898.00	1186.90	361.77
11-14-81-25W5	3	CDT	1187.00	659.00	224.00	1176.32	358.54
11-18-77-08W6	3	CDT	3787.00	-636.00	817.47	1251.92	381.59
14-31-72-07W6	3	CDT	4146.99	-1949.48	1379.00	1235.28	376.51
10-12-74-06W6	10	CDT	3769.00	-1224.00	1072.75	1253.48	382.06
06-05-77-08W6	5	CDT	3530.79	-772.65	865.80	1226.89	373.96
11-24-79-09W6	2	CDT	2550.00	-283.00	634.44	1182.22	360.34
11-36-73-01W6	7	CDT	2920.00	-745.00	863.39	1248.97	380.69
06-33-77-11W6	1	CDT	3210.00	-663.00	835.34	1266.19	385.94
06-09-76-04W6	4	CDT	3183.03	-622.01	776.68	1171.71	357.14
13-24-61-26W5	1	CDT	7981.30	-4188.65	2359.80	1261.23	384.42
14-26-77-06W6	4	CDT	2591.86	-362.53	670.20	1185.28	361.27
07-36-75-05W6	2	CDT	3368.00	-698.00	831.00	1221.17	372.21
10-06-83-05W6	1	CDT	1703.00	378.00	339.00	1160.91	353.85

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-26-62-25W5	4	CDT	6673.23	-3564.96	2073.30	1223.26	372.85
03-24-81-05W6	4	CDT	1574.81	362.53	339.77	1147.22	349.67
06-23-75-06W6	2	CDT	3807.00	-953.00	927.04	1187.97	362.09
10-17-64-24W5	2	CDT	5886.00	-2993.00	1861.44	1305.94	398.05
12-18-78-09W6	3	CDT	3012.00	-476.00	726.68	1202.24	366.44
06-18-79-05W6	6	CDT	1551.00	-7.00	523.16	1201.22	366.13
15-11-80-03W6	8	CDT	1555.12	328.74	372.00	1187.86	362.06
10-24-62-01W6	4	CDT	7923.23	-4094.49	2264.60	1135.53	346.11
06-35-74-10W6	2	CDT	4027.88	-1547.57	1204.25	1233.61	376.00
07-16-62-26W5	1	CDT	7092.00	-3906.00	2221.00	1223.33	372.87
07-03-79-02W6	3	CDT	1681.43	185.37	423.80	1164.12	354.82
07-33-73-10W6	1	CDT	4512.00	-2008.00	1401.22	1228.07	374.32
05-09-72-08W6	6	CDT	5032.81	-2288.39	1528.70	1242.09	378.59
07-02-74-04W6	4	CDT	3307.00	-1074.00	1011.72	1262.54	384.82
06-03-62-25W5	5	CDT	7408.13	-3831.69	2194.38	1236.16	376.78
10-12-74-06W6	4	CDT	3785.00	-1240.00	1092.51	1283.12	391.09

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-03-79-02W6	2	NOT	2954.40	-1087.60	1265.10	1834.11	559.04
10-33-79-23W5	6	NOT	2493.00	-621.00	1065.38	1839.46	560.67
06-22-81-26W5	4	NOT	1617.46	357.61	482.11	1471.03	448.37
14-34-80-06W6	4	NOT	2017.72	-47.90	741.75	1665.15	507.54
11-23-66-23W5	5	NOT	5000.00	-2391.73	1877.22	1943.65	592.42
06-36-82-03W6	6	NOT	1956.00	568.00	502.59	1728.72	526.91
08-24-75-04W6	4	NOT	4189.63	-1923.23	1643.90	1873.31	570.98
10-29-67-10W6	2	NOT	7577.43	-4820.21	2851.01	1764.11	537.70
11-19-75-04W6	3	NOT	3561.00	-878.00	1142.16	1759.78	536.38
10-06-89-07W6	5	NOT	4030.74	-667.88	1099.36	1871.06	570.30
06-22-81-26W5	5	NOT	1542.00	433.07	432.79	1432.59	436.65
10-26-85-04W6	1	NOT	3228.00	-507.00	995.00	1790.92	545.87
07-27-79-01W6	1	NOT	2843.00	-981.00	1239.00	1880.43	573.16
13-16-73-24W5	3	NOT	4176.51	-1748.36	1630.50	2017.23	614.85
12-30-87-03W6	3	NOT	3140.00	-384.00	944.09	1796.35	547.53
06-31-87-09W6	1	NOT	3707.78	-904.30	1188.44	1840.37	560.94
08-05-75-08W6	2	NOT	5141.07	-2583.33	1803.04	1580.73	481.81
14-21-75-04W6	2	NOT	4373.36	-1964.90	1618.78	1773.62	540.60
07-30-74-07W6	3	NOT	5167.32	-2595.14	1829.20	1629.34	496.62
10-25-69-04W6	2	NOT	4777.92	-2665.06	1997.52	1948.15	593.80
08-09-79-07W6	7	NOT	2427.82	-320.60	915.80	1794.41	546.94
06-07-68-03W6	3	NOT	5639.76	-3282.15	2257.60	1931.71	588.78
07-21-78-06W6	3	NOT	2642.72	-370.41	930.65	1778.90	542.21
08-26-69-07W6	2	NOT	5512.14	-3248.46	2219.90	1878.33	572.51
07-28-84-03W6	2	NOT	1936.00	432.00	491.00	1565.95	477.30
06-13-72-13W6	1	NOT	6171.26	-3427.82	2170.32	1584.47	482.95
14-21-84-10W6	1	NOT	2238.00	-111.00	777.17	1683.85	513.24
07-07-66-24W5	6	NOT	5518.00	-2747.00	2143.96	2204.41	671.90
11-35-65-04W6	1	NOT	6617.13	-3947.51	2768.32	2445.84	745.49
06-16-87-25W5	1	NOT	2456.00	-265.00	867.45	1738.35	529.85
10-07-70-24W5	5	NOT	4093.00	-1626.99	1521.00	1885.71	574.77
07-07-66-24W5	5	NOT	5388.00	-2617.00	1970.00	1932.65	589.07
06-21-67-10W6	1	NOT	7775.92	-4877.95	2860.58	1728.47	526.84

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-01-87-26W5	4	NOT	1376.00	777.00	314.65	1503.67	458.32
05-14-67-23W5	7	NOT	4435.70	-2111.22	1734.07	1893.56	577.16
10-23-83-09W6	5	NOT	2214.00	42.00	710.44	1682.74	512.90
05-15-81-26W5	5	NOT	1517.00	446.00	449.50	1484.11	452.36
14-23-86-23W5	2	NOT	2086.61	-13.12	708.65	1623.49	494.84
01-33-80-11W6	5	NOT	2792.00	-603.02	966.58	1629.27	496.60
06-20-72-11W6	2	NOT	5750.99	-3128.94	2030.30	1559.97	475.48
04-33-86-03W6	4	NOT	2664.04	21.33	819.13	1913.09	583.11
10-03-70-12W6	2	NOT	6810.37	-4315.62	2546.15	1564.63	476.90
06-30-82-02W6	1	NOT	1895.67	399.28	517.60	1594.66	486.05
10-33-68-03W6	2	NOT	5088.58	-2871.39	2078.60	1929.07	587.98
11-36-63-02W6	3	NOT	4870.00	-2662.00	1996.89	1949.76	594.29
05-05-71-24W5	13	NOT	4543.97	-2242.13	1843.40	2015.14	614.22
07-02-82-02W6	10	NOT	1986.55	148.29	699.50	1763.76	537.60
10-19-69-26W5	4	NOT	4300.00	-2073.00	1716.00	1890.05	576.09
06-27-67-09W6	1	NOT	6866.80	-4369.75	2848.83	2209.53	673.47
10-15-78-06W6	5	NOT	3687.67	-1536.75	1483.20	1888.65	575.66
06-21-76-13W6	4	NOT	4281.50	-1679.79	1485.40	1750.69	533.61
14-20-75-04W6	6	NOT	3562.99	-1053.15	1290.70	1927.68	587.56
10-32-86-03W6	8	NOT	2089.89	645.35	418.20	1611.17	491.08
02-16-77-25W5	7	NOT	2057.09	-183.40	839.00	1754.24	534.69
08-29-81-04W6	4	NOT	1758.53	181.76	577.00	1514.32	461.57
06-15-73-09W6	2	NOT	4894.36	-2405.51	1684.61	1485.04	452.64
02-02-77-03W6	1	NOT	3648.95	-1516.73	1499.00	1945.16	592.89
07-25-81-13W6	1	NOT	3636.00	-1555.00	1396.00	1669.02	508.72
10-09-79-09W6	1	NOT	2929.79	-491.80	1006.40	1832.45	558.53

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-02-87-03W6	1	HARM	2192.16	625.75	398.27	1545.54	471.08
10-02-81-04W6	2	HARM	1766.00	169.00	604.00	1563.92	476.68
12-32-80-23W5	1	HARM	1279.53	595.96	354.65	1415.01	431.30
10-32-85-25W5	4	HARM	1459.00	815.00	266.00	1429.32	435.66
07-19-82-02W6	1	HARM	1906.00	367.00	505.10	1533.51	467.41
07-07-87-25W5	4	HARM	1373.03	782.81	323.14	1529.09	466.07
15-11-80-03W6	7	HARM	1696.20	187.66	605.27	1585.51	483.26

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
11-08-82-11W6	2	BLSKY	3513.77	-1447.83	1345.88	1660.44	506.10
12-07-82-12W6	1	BLSKY	3514.27	-1507.71	1374.70	1667.12	508.14
06-23-78-01W6	5	BLSKY	3000.00	-1122.00	1256.12	1778.97	542.23
11-26-84-06W6	2	BLSKY	2911.75	-774.61	1114.90	1800.22	548.71
12-10-87-25W5	2	BLSKY	2358.92	-225.39	859.02	1758.49	535.99
11-32-67-23W5	7	BLSKY	5606.00	-3041.00	2159.76	1946.90	593.41
08-06-83-10W6	1	BLSKY	3284.12	-1231.30	1245.70	1645.61	501.58
10-11-77-26W5	3	BLSKY	3100.39	-1182.74	1342.64	1918.05	584.62
10-16-80-01W6	1	BLSKY	2772.31	-853.02	1176.40	1863.84	568.10
07-32-83-02W6	8	BLSKY	3125.00	-842.00	1139.62	1789.92	545.57
15-14-82-25W5	1	BLSKY	2676.51	-554.13	1032.50	1830.40	557.90
06-22-79-04W6	2	BLSKY	3353.00	-1435.00	1447.85	1908.76	581.79
11-12-83-24W5	2	BLSKY	2426.00	-340.00	922.00	1789.33	545.39
10-23-73-03W6	5	BLSKY	4363.52	-2214.57	1823.70	1997.21	608.75
01-08-88-24W5	5	BLSKY	2198.13	-75.13	781.27	1729.19	527.06
10-31-73-13W6	1	BLSKY	6689.63	-3843.83	2117.29	1045.99	318.82
06-07-80-11W6	4	BLSKY	4016.77	-1773.33	1438.00	1547.69	471.73
07-11-64-25W5	4	BLSKY	7000.00	-4165.00	2472.27	1544.63	470.80
11-20-80-23W5	2	BLSKY	2443.00	-549.00	1052.44	1881.58	573.50
10-11-80-03W6	1	BLSKY	2876.00	-1019.00	1259.39	1889.52	575.93
16-23-81-13W6	1	BLSKY	3618.34	-1542.88	1361.76	1602.06	488.31
11-01-80-11W6	1	BLSKY	4416.00	-1816.00	1403.80	1426.03	424.65
03-35-69-23W5	1	BLSKY	4745.00	-2355.00	1870.90	1965.79	599.17
13-34-86-25W5	1	BLSKY	2317.98	-193.64	856.32	1784.00	543.76
07-13-83-24W5	1	BLSKY	2535.35	-442.83	953.80	1759.94	536.43
16-22-81-11W6	1	BLSKY	3560.04	-1427.49	1305.20	1586.83	483.67
06-06-80-24W5	3	BLSKY	2706.70	-803.81	1146.80	1844.69	562.26
06-32-80-23W5	3	BLSKY	2390.09	-520.34	1042.70	1887.74	575.38
16-06-76-07W6	3	BLSKY	4756.89	-2168.31	1707.41	1774.90	540.99
07-20-83-05W6	3	BLSKY	3174.22	-1057.42	1232.41	1788.79	545.22
07-03-88-02W6	4	BLSKY	2600.06	-304.46	797.68	1537.76	468.71
06-30-81-04W6	1	BLSKY	2987.00	-1086.00	1301.00	1918.62	584.80
09-09-79-05W6	4	BLSKY	3211.95	-1274.84	1399.77	1957.89	596.76
14-21-84-10W6	2	BLSKY	3250.00	-1123.00	1275.61	1822.98	555.64

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
10-32-86-03W6	5	BLSKY	3067.59	-332.35	880.52	1701.18	518.52
11-13-74-13W6	2	BLSKY	6165.00	-3478.00	2012.71	1170.29	356.70
06-18-76-02W6	2	BLSKY	3540.02	-1559.71	1521.30	1953.68	595.48
06-21-83-12W6	2	BLSKY	3400.59	-1292.65	1281.68	1667.35	508.21
07-22-90-03W6	1	BLSKY	2629.00	-329.00	845.00	1622.50	494.54
06-33-87-03W6	2	BLSKY	3013.00	-359.00	933.00	1795.73	547.34
06-13-88-05W6	1	BLSKY	3442.03	-479.43	979.15	1781.89	543.12
14-10-75-09W6	1	BLSKY	5430.12	-2644.69	1718.90	1325.06	403.88
14-15-76-10W6	3	BLSKY	5347.80	-2388.48	1678.50	1487.96	453.53
10-26-80-11W6	3	BLSKY	3937.00	-1632.00	1381.75	1559.11	475.22
09-20-77-26W5	1	BLSKY	3287.40	-1153.87	1311.04	1873.94	571.18
06-31-80-01W6	2	BLSKY	2816.10	-837.43	1152.61	1824.49	556.10
06-11-81-26W5	3	BLSKY	2623.17	-720.28	1126.16	1880.55	573.19
07-07-87-25W5	2	BLSKY	2414.70	-258.53	830.78	1660.13	506.01
09-13-82-13W6	1	BLSKY	3416.01	-1449.80	1343.20	1652.28	503.61
07-17-76-09W6	2	BLSKY	5431.21	-2332.02	1698.81	1591.33	485.04
06-35-76-09W6	1	BLSKY	5036.09	-2177.49	1576.69	1463.83	446.17

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-09-76-23W5	1	GETH	3011.00	-1153.00	1334.04	1927.92	587.63
06-02-65-03W6	1	GETH	8121.39	-5210.30	3065.08	1868.41	569.49
07-24-74-13W6	2	GETH	6470.00	-3836.00	2506.09	1951.74	594.89
10-16-87-06W6	1	GETH	2956.04	-717.85	1096.89	1815.38	553.33
11-25-77-11W6	1	GETH	5068.90	-2474.08	1881.72	1871.69	570.49
07-04-88-07W6	1	GETH	3270.00	-754.00	1116.00	1823.37	555.76
06-21-67-10W6	3	GETH	9176.51	-6278.54	3425.10	1631.62	497.32
10-06-89-07W6	3	GETH	4005.38	-642.52	1116.46	1935.91	590.07
06-35-78-08W6	1	GETH	4288.06	-1993.77	1693.80	1918.01	584.61
10-17-85-03W6	2	GETH	3261.00	-696.00	1085.67	1811.32	552.09
06-14-74-09W6	1	GETH	5711.94	-3268.70	2337.54	2129.78	649.16
06-23-86-03W6	1	GETH	3218.50	-737.86	1092.60	1785.47	544.21
14-18-77-05W6	4	GETH	4251.97	-2130.25	1772.20	1962.59	598.20
06-08-82-07W6	2	GETH	3278.00	-1171.00	1291.64	1812.00	552.30
11-01-80-11W6	3	GETH	4744.00	-2144.00	1788.72	1986.99	605.64
14-34-87-02W6	1	GETH	2688.00	-412.00	927.18	1729.29	527.09
12-12-69-04W6	1	GETH	6276.25	-4118.44	2596.00	1876.94	572.09
06-27-83-12W6	3	GETH	3592.52	-1485.89	1525.20	2036.51	620.73
07-27-83-01W6	4	GETH	2812.00	-623.00	1036.07	1769.77	539.43
06-16-89-07W6	2	GETH	4011.00	-643.00	1068.82	1825.41	556.38
07-19-69-25W5	1	GETH	5598.00	-3063.00	2170.52	1949.75	594.28
14-20-75-04W6	5	GETH	4642.39	-2132.55	1765.50	1944.82	592.78
16-25-85-13W6	3	GETH	3716.87	-1358.60	1474.02	2045.60	623.50
11-17-87-02W6	2	GETH	2772.00	-379.00	956.46	1829.91	557.76
06-24-70-25W5	4	GETH	5111.00	-2764.00	2040.00	1947.32	593.54
07-19-82-02W6	6	GETH	3108.00	-835.00	1174.43	1877.31	572.20
11-33-76-02W6	4	GETH	3684.00	-1575.00	1514.00	1921.54	585.68
08-20-87-04W6	5	GETH	3446.00	-456.00	1018.40	1895.96	577.89
08-05-82-03W6	2	GETH	3273.96	-1100.30	1298.38	1898.27	578.59
06-27-75-03W6	1	GETH	4151.67	-2008.95	1685.83	1884.42	574.37
03-08-78-09W6	3	GETH	4717.84	-2189.30	1837.40	2054.12	626.10
06-32-81-07W6	3	GETH	3275.00	-1210.00	1310.60	1816.79	553.76
11-21-77-10W6	8	GETH	5305.00	-2522.00	1925.80	1925.58	586.92
11-25-87-03W6	4	GETH	2874.00	-434.00	949.00	1757.69	535.74

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
05-05-71-24W5	1	GETH	4826.12	-2524.28	1943.20	1963.48	598.47
06-32-80-23W5	4	GETH	2479.95	-610.20	1060.20	1838.30	560.31
07-02-82-02W6	3	GETH	3005.25	-870.41	1187.50	1872.08	570.61
11-08-87-25W5	2	GETH	2452.00	-254.00	890.38	1802.30	549.34
10-33-67-07W6	7	GETH	7798.56	-5313.98	3153.38	1968.65	600.05
05-15-81-26W5	2	GETH	2685.00	-722.00	1128.35	1883.89	574.21
01-21-83-13W6	4	GETH	3854.99	-1685.04	1609.92	2033.02	619.66
07-26-65-03W6	1	GETH	7360.00	-4697.00	3001.65	2235.22	681.29
06-22-74-06W6	4	GETH	5487.00	-2905.00	2096.19	1936.09	590.12
16-08-77-05W6	3	GETH	4137.14	-2026.25	1701.20	1902.62	579.92
06-23-72-02W6	2	GETH	4730.97	-2604.00	1935.82	1866.72	568.98
05-31-80-25W5	5	GETH	2630.00	-881.00	1170.40	1822.00	555.35
06-32-87-11W6	2	GETH	3540.00	-1111.00	1243.00	1759.67	536.35
07-28-83-02W6	2	GETH	3222.00	-932.00	1191.58	1819.92	554.71
11-26-81-25W5	1	GETH	2739.50	-835.30	1157.38	1837.63	560.11
05-15-81-26W5	4	GETH	2713.00	-750.00	1135.10	1871.48	570.43
11-18-81-06W6	3	GETH	3304.00	-1321.00	1365.00	1831.42	558.22
16-17-74-24W5	6	GETH	4196.19	-1776.90	1591.91	1899.57	578.99
08-33-77-06W6	3	GETH	4284.77	-2016.17	1698.30	1906.00	580.95
07-31-77-07W6	1	GETH	4490.91	-1874.44	1664.19	1968.95	600.14
06-13-72-13W6	2	GETH	7536.09	-4792.65	2717.73	1483.86	452.28
04-10-73-23W5	2	GETH	4350.00	-1759.00	1614.10	1968.71	600.06
11-06-83-08W6	2	GETH	3527.00	-1189.00	1367.24	1968.60	600.03
06-27-85-25W5	1	GETH	3008.53	-386.48	920.99	1740.52	530.51
08-22-75-09W6	3	GETH	5666.01	-2894.59	2114.98	1989.89	606.52
06-28-80-11W6	1	GETH	3902.00	-1703.00	1415.00	1564.90	476.98
16-24-79-04W6	7	GETH	3179.14	-1341.21	1407.70	1909.83	582.12
11-15-83-08W6	1	GETH	3436.68	-1163.71	1361.30	1980.17	603.56
14-30-75-08W6	5	GETH	5610.24	-2693.24	2021.00	1974.20	601.74
11-35-80-02W6	2	GETH	2979.00	-1004.00	1255.43	1895.38	577.71
11-15-82-07W6	6	GETH	3293.00	-1164.00	1358.97	1974.50	601.83
05-29-75-02W6	2	GETH	3841.87	-1771.00	1592.60	1907.06	581.27
11-36-75-08W6	5	GETH	5551.18	-2657.15	1998.04	1957.26	596.57
11-34-78-04W6	2	GETH	3412.00	-1480.00	1464.70	1902.68	579.94

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-32-81-08W6	6	GETH	3694.22	-1515.09	1484.40	1913.09	583.11
04-10-78-24W5	1	GETH	2236.00	-978.00	1251.68	1912.72	583.00
14-24-80-07W6	1	GETH	3507.22	-1491.47	1431.30	1814.07	552.93
06-13-79-10W6	4	GETH	4323.00	-1706.00	1458.31	1661.92	506.55
06-11-79-10W6	5	GETH	4832.68	-2171.92	1783.30	1946.56	593.31
10-36-84-26W5	2	GETH	2866.00	-387.00	941.69	1787.80	544.92
06-12-81-09W6	1	GETH	3773.00	-1544.00	1524.27	1976.25	602.36
16-08-77-05W6	4	GETH	4215.88	-2104.99	1712.80	1850.67	564.08
10-17-84-09W6	2	GETH	3305.00	-1209.00	1368.00	1950.35	594.47
07-02-82-02W6	4	GETH	2929.79	-794.95	1132.60	1820.75	554.97
10-05-80-12W6	2	GETH	4237.21	-2070.21	1776.48	2032.52	619.51
07-20-83-09W6	1	GETH	3324.00	-1089.00	1245.33	1787.05	544.69
06-25-80-04W6	4	GETH	3011.51	-1126.67	1252.37	1765.64	538.17
10-32-81-01W6	5	GETH	2946.00	-831.00	1164.50	1858.38	566.43
16-26-77-06W6	5	GETH	4293.63	-2090.22	1734.94	1916.57	584.17
08-28-84-12W6	2	GETH	3789.56	-1435.56	1522.80	2081.30	634.38
04-06-76-08W6	7	GETH	5419.95	-2580.71	1981.50	1995.50	608.23
06-03-70-25W5	3	GETH	5106.00	-2562.00	1991.24	2036.71	620.79
13-09-84-25W5	2	GETH	2827.00	-629.00	1028.36	1745.97	532.17
15-09-81-02W6	4	GETH	3057.74	-1036.09	1265.50	1886.54	575.02
10-07-83-01W6	3	GETH	2955.00	-722.00	1104.00	1827.65	557.07
11-08-73-25W5	3	GETH	4515.00	-2043.00	1706.58	1898.29	578.60
11-15-84-09W6	6	GETH	3745.00	-1680.00	1407.00	1569.42	478.36
07-21-82-06W6	2	GETH	3226.00	-1153.00	1308.72	1869.45	569.81
11-02-75-10W6	5	GETH	5695.53	-3172.24	2260.50	2048.31	624.33
06-03-62-25W5	4	GETH	8576.11	-4999.67	2781.95	1425.16	434.39
14-16-75-03W6	2	GETH	4467.71	-2239.30	1773.62	1856.82	565.96
03-11-83-05W6	1	GETH	3172.57	-1018.37	1273.43	1922.58	586.00
10-23-85-03W6	3	GETH	3225.00	-682.00	1082.00	1816.85	553.77
04-26-67-23W5	1	GETH	5365.00	-2972.00	2145.40	1982.73	604.34
05-09-72-08W6	3	GETH	6738.84	-3994.42	2601.00	2012.51	613.41
07-06-82-01W6	3	GETH	2887.00	-756.00	1098.00	1779.80	542.48
06-19-75-09W6	3	GETH	5626.64	-3003.28	2149.19	1960.21	597.47
14-35-82-24W5	2	GETH	2358.92	-375.98	940.50	1796.08	547.44

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-02-82-02W6	2	GETH	3038.06	-903.22	1199.60	1867.22	569.13
06-33-80-06W6	1	GETH	3314.00	-1323.00	1251.00	1566.15	477.36
06-29-79-07W6	1	GETH	3805.77	-1697.90	1568.28	1923.99	586.43
04-06-76-08W6	4	GETH	5172.41	-2333.17	1714.39	1626.16	495.65
07-11-65-02W6	2	GETH	7691.44	-4901.74	2986.20	1994.80	608.01
07-02-78-05W6	8	GETH	3768.04	-1735.89	1609.00	1980.05	603.52
06-12-78-06W6	3	GETH	4081.37	-1995.41	1681.10	1887.04	575.17
10-11-81-01W6	3	GETH	2661.00	-688.00	1105.37	1864.82	568.40
07-25-80-07W6	2	GETH	3438.32	-1422.57	1419.77	1856.34	565.81
06-04-84-12W6	2	GETH	3660.10	-1491.14	1537.60	2059.90	627.86
06-22-76-07W6	3	GETH	4912.73	-2485.56	1930.97	1973.96	601.66
07-16-83-23W5	5	GETH	2293.00	-343.00	923.56	1789.93	545.57
06-28-74-08W6	4	GETH	5535.11	-3106.30	2185.40	1940.81	591.56
02-15-78-08W6	1	GETH	4467.95	-2006.66	1718.80	1962.86	598.28
08-03-77-01W6	5	GETH	3546.59	-1427.82	1442.50	1903.59	580.21
15-20-90-01W6	2	GETH	2434.38	-224.08	765.97	1544.90	470.89
06-10-82-08W6	6	GETH	3520.34	-1332.68	1439.50	1991.80	607.10
06-35-77-10W6	2	GETH	5121.39	-2359.25	1849.60	1912.34	582.88
11-23-80-09W6	1	GETH	4221.89	-1846.23	1668.00	2005.96	611.42
06-11-85-13W6	3	GETH	3873.00	-1430.00	1500.71	2035.84	620.52
08-07-81-02W6	1	GETH	3081.04	-1044.29	1268.65	1885.62	574.74
10-24-87-25W5	4	GETH	2381.00	-252.00	846.31	1702.53	518.93
08-12-78-08W6	1	GETH	4489.76	-2039.63	1724.90	1943.97	592.52
16-25-72-08W6	1	GETH	5688.97	-3412.07	2331.70	1972.92	601.35
10-22-80-09W6	2	GETH	4222.44	-1827.10	1666.80	2022.32	616.40
06-08-83-25W5	1	GETH	2683.00	-477.00	999.30	1830.85	558.04
07-32-83-11W6	1	GETH	3664.70	-1596.46	1569.03	2027.17	617.88
10-26-86-01W6	2	GETH	2491.00	-253.00	883.46	1787.32	544.78
06-09-71-25W5	2	GETH	5022.97	-2721.79	2019.20	1941.49	591.77
06-15-86-13W6	2	GETH	3730.00	-1190.00	1400.57	2044.57	623.19
11-26-84-23W5	2	GETH	2481.00	-363.00	856.00	1613.91	491.92
06-32-78-07W6	5	GETH	4084.65	-1854.99	1679.67	2024.16	616.96
14-16-69-06W6	8	GETH	6770.87	-4584.19	2859.10	2018.81	615.33
04-14-80-23W5	4	GETH	2415.00	-539.00	1045.50	1875.55	571.67

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
15-14-81-08W6	3	GETH	3494.10	-1402.89	1446.90	1938.68	590.91
11-05-87-25W5	1	GETH	2369.00	-241.00	877.36	1785.24	544.14
14-20-77-05W6	4	GETH	4172.67	-2072.93	1757.51	1985.98	605.33
14-13-85-12W6	1	GETH	3363.00	-1169.00	1305.96	1847.07	562.99
06-11-82-12W6	1	GETH	4012.47	-1940.49	1735.14	2066.76	629.95
07-13-83-24W5	5	GETH	2593.50	-500.98	922.90	1630.43	496.95
11-32-80-03W6	1	GETH	3086.00	-1127.00	1300.18	1875.73	571.72
02-22-66-25W5	1	GETH	5826.00	-3413.00	2388.33	2102.77	640.93
16-12-82-12W6	2	GETH	3897.64	-1815.62	1586.00	1847.20	563.03
04-08-87-03W6	3	GETH	3334.00	-482.00	956.60	1727.24	526.46
10-25-80-04W6	1	GETH	3016.00	-1105.00	1307.59	1914.84	583.64
10-15-87-02W6	3	GETH	2675.00	-376.00	968.13	1859.87	566.89
07-28-75-11W6	4	GETH	6272.97	-3202.10	2233.30	1955.64	596.08
06-12-78-01W6	1	GETH	3149.00	-1216.00	1343.62	1887.05	575.17
07-20-78-02W6	1	GETH	3064.00	-1175.00	1341.38	1922.88	586.09
06-23-80-23W5	3	GETH	2538.00	-646.00	1070.90	1827.21	556.93
16-12-84-08W6	3	GETH	3198.82	-1069.55	1313.32	1963.52	598.48
07-02-82-02W6	5	GETH	2857.61	-722.77	968.40	1513.72	461.38
16-24-76-10W6	6	GETH	5593.84	-2563.98	2025.60	2114.08	644.37
10-08-83-09W6	1	GETH	3346.00	-1133.00	1231.01	1709.98	521.20
06-31-77-05W6	3	GETH	4066.93	-1921.26	1684.00	1967.89	599.81
10-06-83-09W6	5	GETH	3279.00	-1090.00	1205.38	1693.79	516.27
08-05-75-08W6	3	GETH	5607.94	-3050.20	2204.18	2040.28	621.68
07-01-87-01W6	1	GETH	2451.00	-257.00	887.37	1792.35	546.31
06-22-81-04W6	1	GETH	3016.00	-1040.00	1280.40	1917.04	584.31
10-36-67-24W5	4	GETH	5700.00	-3166.00	2182.91	1875.36	571.61
10-24-72-12W6	4	GETH	7119.43	-4528.22	2801.24	1941.16	591.66
14-20-79-04W6	5	GETH	3313.65	-1398.85	1445.01	1938.36	590.81
07-03-79-02W6	1	GETH	3091.54	-1224.74	1347.40	1887.04	575.17
07-29-77-07W6	1	GETH	4593.18	-2069.23	1758.80	1992.66	607.36
10-27-79-05W6	1	GETH	3330.00	-1445.00	1456.45	1918.63	584.80
07-34-77-11W6	1	GETH	4973.52	-2429.56	1544.80	1138.11	346.90
16-29-83-04W6	2	GETH	3041.00	-865.00	1185.87	1873.73	571.11
07-31-82-10W6	5	GETH	3425.00	-1325.00	1290.12	1654.49	504.29

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-34-78-02W6	4	GETH	3067.59	-1209.32	1338.60	1882.13	573.67
07-28-78-01W6	1	GETH	2979.00	-1102.00	1299.62	1899.43	578.95
06-15-73-09W6	5	GETH	6246.72	-3757.87	2471.59	1950.19	594.42
06-29-82-09W6	1	GETH	3727.70	-1302.17	1446.52	2038.52	621.34
10-26-80-10W6	7	GETH	4445.00	-1886.00	1668.20	1966.66	599.44
09-35-77-25W5	1	GETH	2953.00	-1080.00	1299.36	1920.83	585.47
11-14-81-08W6	2	GETH	3492.00	-1388.00	1447.85	1955.76	596.12
04-15-83-07W6	1	GETH	3225.10	-987.57	1247.54	1893.58	577.16
16-11-68-04W6	4	GETH	6754.30	-4487.40	2703.20	1755.56	535.09
06-02-72-24W5	1	GETH	4586.45	-2099.57	1714.80	1860.71	567.14
06-13-77-04W6	1	GETH	4146.98	-1853.67	1583.52	1803.42	549.68
06-18-76-09W6	2	GETH	5259.18	-2314.30	1672.60	1548.52	471.99
06-15-77-05W6	2	GETH	4078.09	-1978.35	1702.50	1953.52	595.43
10-01-82-06W6	4	GETH	3167.00	-1125.00	1308.00	1895.79	577.84
10-33-80-04W6	3	GETH	3036.00	-1138.00	1329.95	1933.48	589.32
07-23-70-05W6	3	GETH	5344.49	-3502.30	2327.40	1872.76	570.82
09-28-83-11W6	1	GETH	3415.36	-1596.13	1549.50	1982.39	604.23
10-07-77-23W5	2	GETH	2481.00	-1078.00	1287.11	1894.54	577.46
06-15-77-05W6	4	GETH	4149.94	-2050.20	1741.40	1971.51	600.92
11-12-86-26W5	4	GETH	2510.00	-246.00	896.14	1823.61	555.84
11-36-75-05W6	1	GETH	4930.00	-2350.00	1898.00	2033.37	619.77
14-21-84-10W6	3	GETH	3250.00	-1123.00	1281.13	1835.73	559.53
06-09-79-10W6	4	GETH	4662.08	-2171.92	1792.50	1967.80	599.79
10-30-87-25W5	1	GETH	2536.00	-285.00	896.56	1785.58	544.24
05-23-79-12W6	7	GETH	4429.14	-2204.07	1800.10	1953.20	595.34
11-19-79-07W6	7	GETH	4060.00	-1899.00	1670.00	1957.81	596.74
10-13-89-06W6	1	GETH	3474.41	-541.01	1008.06	1787.07	544.70
11-18-78-07W6	7	GETH	4386.49	-1954.07	1673.52	1910.87	582.43
12-18-79-24W5	2	GETH	2720.00	-864.00	1164.34	1825.01	556.26
11-31-86-12W6	2	GETH	3662.00	-1181.00	1273.00	1758.95	536.13
10-33-81-23W5	3	GETH	2216.00	-590.00	1013.33	1750.25	533.48
06-17-89-07W6	3	GETH	4075.00	-714.00	1112.99	1856.42	565.84
10-34-80-04W6	1	GETH	3048.00	-1153.00	1325.80	1908.89	581.83
06-31-72-07W6	1	GETH	5643.05	-3406.17	2552.70	2489.21	758.71

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
14-32-77-04W6	1	GETH	3894.35	-1884.51	1626.60	1872.07	570.61
11-28-82-03W6	5	GETH	3087.00	-877.00	1227.85	1958.68	597.01
10-36-80-04W6	1	GETH	3058.00	-1119.00	1313.00	1913.33	583.18
10-10-77-23W5	2	GETH	2882.00	-1040.00	1299.40	1960.92	597.69
06-16-68-24W5	2	GETH	5601.00	-3188.00	2199.05	1890.64	576.27
14-05-84-08W6	2	GETH	3403.87	-1159.78	1353.35	1965.74	599.16
10-28-81-13W6	2	GETH	4051.84	-1986.55	1694.33	1926.45	587.18
06-18-76-02W6	1	GETH	4133.85	-2153.54	1789.90	1980.18	603.56
06-03-84-12W6	2	GETH	3752.50	-1604.53	1570.50	2022.49	616.46
10-23-83-24W5	3	GETH	2443.00	-290.00	892.18	1770.46	539.64
08-19-79-05W6	1	GETH	3435.04	-1478.67	1489.84	1962.07	598.04
04-27-81-03W6	5	GETH	3064.30	-973.75	1246.16	1904.22	580.41
16-12-84-08W6	6	GETH	3198.82	-1069.55	1316.68	1971.28	600.85
11-15-68-02W6	4	GETH	5879.00	-3606.00	2458.97	2072.91	631.82
10-32-81-01W6	3	GETH	3010.00	-895.00	1170.30	1807.77	551.01
10-02-72-25W5	1	GETH	4552.00	-2049.00	1767.70	2033.45	619.79
14-33-79-06W6	1	GETH	3575.78	-1605.64	1531.80	1932.00	588.87
10-11-85-06W6	1	GETH	2919.00	-715.00	1116.20	1862.83	567.79
08-09-79-07W6	4	GETH	3969.82	-1862.60	1657.80	1966.04	599.25
09-27-69-23W5	2	GETH	4774.00	-2344.00	1888.30	2016.97	614.77
10-05-90-12W6	2	GETH	3910.77	-903.22	1177.91	1817.13	553.86
07-09-78-01W6	2	GETH	3134.00	-1102.00	1305.00	1911.86	582.73
11-36-90-12W6	1	GETH	3579.40	-878.28	1169.18	1821.90	555.32
06-17-88-02W6	1	GETH	2974.00	-324.00	892.21	1736.53	529.29
05-11-86-04W6	4	GETH	3092.55	-484.94	967.98	1750.58	533.58
11-28-77-26W5	1	GETH	3184.00	-1144.00	1325.36	1916.88	584.26
10-30-81-07W6	3	GETH	3466.00	-1414.00	1446.65	1926.99	587.35
06-24-85-05W6	1	GETH	3074.00	-586.00	1089.00	1929.01	587.96
06-01-77-07W6	7	GETH	4875.33	-2284.78	1838.80	1961.87	597.98
11-21-83-23W5	4	GETH	2289.00	-256.00	871.29	1756.22	535.29
06-31-81-01W6	3	GETH	2939.63	-848.75	1167.12	1846.68	562.87
10-24-79-23W5	5	GETH	2610.00	-736.00	1098.54	1801.04	548.96
06-20-78-23W5	9	GETH	2958.69	-1118.47	1259.94	1791.32	546.00
10-24-80-04W6	6	GETH	2970.00	-1080.00	1326.00	1982.36	604.22

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04-33-86-03W6	1	GETH	3257.88	-572.51	1028.22	1802.13	549.29
10-36-81-12W6	4	GETH	3549.00	-1468.00	1338.00	1622.07	494.41
07-36-82-06W6	3	GETH	3095.00	-1075.00	1294.42	1914.42	583.52
11-36-78-26W5	1	GETH	2833.00	-958.00	1220.00	1859.55	566.79
06-01-80-23W5	4	GETH	2547.00	-682.00	1092.87	1841.95	561.43
11-36-79-03W6	4	GETH	2932.84	-1027.00	1296.50	1967.23	599.61
11-18-73-08W6	5	GETH	6024.94	-3596.79	2433.41	2023.09	616.64
11-17-80-11W6	4	GETH	3905.00	-1647.00	1399.28	1584.59	482.98
14-33-78-13W6	3	GETH	4675.25	-2465.93	1948.20	2033.38	619.77
07-05-78-25W5	1	GETH	2956.00	-1080.00	1275.11	1864.83	568.40
06-06-74-09W6	1	GETH	6015.35	-3609.84	2485.50	2130.34	649.33
11-31-84-24W5	1	GETH	2553.01	-188.00	878.77	1841.49	561.29
10-18-88-01W6	4	GETH	2893.69	-351.05	892.63	1710.45	521.35
01-33-81-10W6	1	GETH	3571.00	-1284.00	1261.79	1630.06	496.84
11-07-84-05W6	3	GETH	3385.83	-1233.60	1329.20	1836.15	559.66
07-06-82-01W6	2	GETH	2797.00	-666.00	986.66	1612.66	491.54
15-03-86-03W6	3	GETH	3316.93	-788.06	1111.70	1779.38	542.35
13-18-75-25W5	1	GETH	3708.00	-1634.00	1537.30	1916.35	584.10
07-24-63-03W6	5	GETH	8569.55	-5569.55	3223.17	1874.26	571.27
14-29-80-23W5	2	GETH	2388.45	-513.12	1015.15	1831.34	558.19
14-36-82-12W6	4	GETH	3366.14	-1394.36	1306.10	1622.04	494.40
10-20-82-12W6	1	GETH	3427.00	-1443.00	1341.00	1654.00	504.14
11-26-84-06W6	1	GETH	3085.63	-948.49	1216.30	1860.52	567.09
10-15-87-02W6	2	GETH	2622.00	-323.00	906.44	1770.39	539.62
11-26-81-25W5	3	GETH	2447.51	-543.31	1022.52	1818.17	554.18
10-35-90-24W5	1	GETH	1700.00	64.00	662.99	1595.15	486.20
04-12-79-23W5	1	GETH	2545.93	-682.41	1096.48	1849.88	563.84
06-02-87-03W6	2	GETH	3187.76	-369.85	913.59	1740.06	530.37
07-11-80-24W5	3	GETH	2569.06	-637.63	1078.70	1853.59	564.98
06-14-80-06W6	1	GETH	3268.00	-1323.00	1390.10	1887.39	575.28
13-21-80-23W5	5	GETH	2401.57	-515.09	1035.60	1876.60	571.99
11-07-74-03W6	3	GETH	4410.00	-2155.00	1802.79	2008.49	612.19
06-33-80-23W5	1	GETH	2826.96	-964.43	994.30	1331.87	405.96
06-04-88-10W6	1	GETH	3458.00	-1101.00	1306.20	1915.63	583.88

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
03-12-90-01W6	1	GETH	2390.55	-129.40	783.84	1680.85	512.32
09-28-83-11W6	3	GETH	3103.68	-1284.45	1262.30	1630.79	497.07
06-25-87-08W6	1	GETH	3099.30	-779.42	1128.50	1826.82	556.81
11-08-83-24W5	3	GETH	2457.00	-326.00	933.05	1828.85	557.43
11-29-78-24W5	2	GETH	2663.00	-826.00	1181.00	1901.48	579.57
11-32-82-05W6	1	GETH	3024.00	-924.00	1224.80	1904.64	580.53
05-10-68-26W5	1	GETH	5462.60	-3205.38	2277.00	2053.28	625.84
10-23-74-01W6	2	GETH	4243.00	-2191.00	1767.00	1889.83	576.02
07-23-86-26W5	2	GETH	2512.00	-218.00	857.13	1761.52	536.91
07-33-81-01W6	1	GETH	2810.00	-692.00	1037.63	1704.37	519.49
05-15-77-25W5	2	GETH	2985.56	-1123.36	1295.70	1869.02	569.68
10-18-75-04W6	2	GETH	4616.00	-1984.00	1729.71	2010.71	612.86
16-35-74-24W5	1	GETH	3611.48	-1565.55	1498.68	1895.60	577.78
10-17-82-24W5	3	GETH	2405.00	-430.00	962.20	1792.17	546.25
14-25-82-12W6	2	GETH	3402.23	-1411.09	1287.59	1562.56	476.27
10-27-79-24W5	1	GETH	2655.00	-746.00	1128.57	1860.40	567.05
06-29-77-05W6	3	GETH	4039.05	-1944.23	1687.54	1953.09	595.30
06-13-69-25W5	1	GETH	5230.00	-2744.00	2062.55	2019.39	615.51
07-09-89-07W6	3	GETH	4163.39	-832.68	1160.01	1846.33	562.76
06-22-79-04W6	1	GETH	3253.00	-1335.00	1401.00	1900.57	579.29
08-04-75-05W6	2	GETH	5370.73	-2544.32	1936.65	1928.31	587.75
07-03-90-01W6	1	GETH	2506.00	-168.00	783.00	1640.31	499.97
11-04-85-08W6	2	GETH	3126.64	-1031.50	1296.59	1962.93	598.30
10-28-80-24W5	1	GETH	2489.00	-582.00	1072.43	1894.74	577.52
03-01-78-08W6	1	GETH	4790.03	-1813.65	1502.40	1656.10	504.78
11-25-68-23W5	4	GETH	4944.00	-2566.00	1995.87	2043.40	622.83
07-12-84-03W6	3	GETH	3093.00	-848.00	1128.82	1758.97	536.14
11-10-85-24W5	4	GETH	2550.00	-268.00	842.17	1676.97	511.14
16-04-77-06W6	2	GETH	4520.99	-2194.55	1765.70	1883.28	574.02
11-19-85-05W6	1	GETH	2943.00	-666.00	1086.00	1842.08	561.47
07-22-76-11W5	4	GETH	5360.90	-2558.73	1861.20	1739.65	530.25
10-02-79-24W5	1	GETH	2586.00	-765.00	1150.00	1890.89	576.34
16-04-78-10W6	3	GETH	5229.98	-2554.13	1834.10	1681.67	512.57
[illegible]-18-89-04W6	1	GETH	3161.00	-422.00	956.80	1787.70	544.89

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-14-76-09W6	3	GETH	5492.13	-2503.28	1998.20	2111.50	643.59
06-36-84-01W6	1	GETH	2870.00	-428.00	944.70	1753.76	534.54
14-03-83-09W6	3	GETH	3451.12	-1159.78	1405.00	2085.02	635.52
07-17-83-10W6	1	GETH	3291.00	-1268.00	1257.52	1636.20	498.71
03-24-81-05W6	3	GETH	2867.46	-930.12	1264.12	1989.33	606.35
10-13-81-13W6	1	GETH	3647.00	-1575.00	1396.00	1649.02	502.62
06-14-76-09W6	2	GETH	5530.85	-2542.00	1993.00	2060.77	628.12
14-18-81-12W6	4	GETH	3651.58	-1592.85	1374.91	1582.46	482.33
10-32-86-03W6	3	GETH	3293.97	-558.73	1031.07	1822.49	555.50
14-07-76-07W6	4	GETH	4734.25	-2181.43	1692.30	1726.88	526.35
08-29-81-04W6	3	GETH	2988.85	-1048.56	1274.00	1893.70	577.20
10-28-84-04W6	1	GETH	2998.00	-694.00	1092.00	1827.94	557.16
10-12-75-03W6	4	GETH	4288.06	-2049.87	1719.40	1921.03	585.53
07-31-87-02W6	2	GETH	2694.00	-317.00	855.08	1657.78	505.29
08-23-87-13W6	3	GETH	4009.18	-1105.64	1256.70	1796.67	547.62
10-34-80-02W6	3	GETH	2887.70	-900.50	1208.60	1890.72	576.29
06-10-77-05W6	2	GETH	4035.43	-2006.23	1703.37	1927.65	587.55
15-09-81-02W6	2	GETH	2988.84	-967.19	1218.10	1845.97	562.65
16-15-76-26W5	3	GETH	3411.91	-1463.91	1454.29	1894.73	577.51
12-05-80-23W5	4	GETH	2514.76	-616.47	1064.16	1841.17	561.19
10-32-86-03W6	4	GETH	3146.33	-411.09	975.83	1842.56	561.61
14-02-87-04W6	3	GETH	3497.37	-533.46	1029.03	1843.05	561.76
03-24-81-05W6	2	GETH	2890.42	-953.08	1274.06	1989.32	606.35
13-06-78-24W5	3	GETH	2978.00	-1096.00	1305.49	1918.99	584.91
06-29-77-05W6	2	GETH	4126.97	-2032.15	1748.87	2006.81	611.68
14-01-79-08W6	5	GETH	4168.30	-1933.56	1687.51	1963.69	598.53
06-22-77-09W6	1	GETH	5331.37	-2307.09	1841.30	1945.33	592.94
14-15-82-08W6	3	GETH	3530.19	-1287.11	1267.01	1639.01	499.57
05-27-87-02W6	1	GETH	2672.42	-415.86	900.60	1664.05	507.20
06-15-84-12W6	1	GETH	3747.00	-1525.00	1543.72	2040.17	621.84
05-15-81-26W5	6	GETH	2787.00	-824.00	1170.40	1879.00	572.72
16-31-80-23W5	7	GETH	2490.16	-620.08	1038.00	1777.15	541.67
06-35-62-27W5	4	GETH	8736.88	-5292.65	3060.00	1774.32	540.81
14-36-77-08W6	2	GETH	5016.40	-2195.21	1793.20	1946.13	593.18

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-36-80-07W6	2	GETH	3428.47	-1412.07	1372.90	1758.60	536.02
06-25-76-13W6	1	GETH	5469.16	-2837.27	2157.50	2145.41	653.92
06-02-74-10W6	3	GETH	5885.83	-3410.76	2316.48	1939.08	591.03
15-21-83-08W6	2	GETH	3373.03	-1141.73	1361.30	2002.15	610.26
15-32-78-11W6	1	GETH	4845.80	-2221.13	1863.76	2083.17	634.95
08-07-82-11W6	5	GETH	3900.91	-1822.83	1678.54	2053.71	625.97
11-12-78-08W6	1	GETH	4465.22	-2003.61	1693.80	1908.17	581.61
04-27-85-07W6	2	GETH	3162.00	-934.00	1240.58	1931.08	588.59
06-16-89-07W6	3	GETH	4025.00	-657.00	1039.88	1744.57	531.75
06-35-76-10W6	5	GETH	5354.33	-2582.02	1964.40	1954.70	595.79
06-34-78-02W6	2	GETH	3028.22	-1169.95	1336.30	1916.19	584.06
11-05-79-04W6	2	GETH	3451.44	-1547.90	1485.00	1881.66	573.53
16-20-79-24W5	2	GETH	2728.02	-859.55	1180.71	1867.26	569.14
16-12-75-03W6	2	GETH	4245.41	-2009.19	1682.50	1876.49	571.95
10-27-79-05W6	2	GETH	3264.00	-1379.00	1441.08	1949.13	594.09
13-22-88-03W6	1	GETH	2784.00	-367.00	942.22	1809.03	551.39
14-20-75-04W6	3	GETH	4829.39	-2319.55	1845.50	1942.57	592.10
04-19-87-02W6	1	GETH	2660.00	-299.00	911.00	1804.93	550.14
14-21-75-04W6	1	GETH	4730.97	-2322.51	1825.50	1893.43	577.12
06-25-85-13W6	1	GETH	3721.00	-1333.00	1470.00	2061.92	628.47
15-19-76-04W6	1	GETH	4414.30	-2091.14	1752.64	1956.53	596.35
01-34-83-25W5	6	GETH	2610.00	-449.00	1015.50	1896.27	577.98
10-33-80-01W6	4	GETH	2878.00	-907.00	1204.00	1873.60	571.07
08-12-78-10W6	3	GETH	4894.82	-2278.35	1837.60	1965.53	599.09
14-03-75-04W6	2	GETH	4963.92	-2339.90	1856.50	1947.63	593.64
06-31-89-11W6	5	GETH	4116.00	-851.00	1143.00	1788.72	545.20
10-04-77-02W6	2	GETH	3792.00	-1597.00	1503.00	1874.13	571.24
10-36-81-06W6	1	GETH	3234.00	-1173.00	1319.17	1873.58	571.07
06-02-87-03W6	6	GETH	3327.19	-509.28	982.01	1758.64	536.03
10-03-82-23W5	1	GETH	2150.00	-195.00	951.38	2002.18	610.27
06-16-80-12W6	1	GETH	4179.79	-2009.84	1607.20	1701.94	518.75
11-26-81-01W6	1	GETH	2878.00	-808.00	1150.00	1847.89	563.24
01-22-87-24W5	4	GETH	2364.00	-221.00	817.56	1667.13	508.14
07-24-84-24W5	2	GETH	2454.00	-314.00	901.48	1767.94	538.87

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
11-14-87-02W6	2	GETH	2657.48	-389.76	944.69	1791.97	546.19
10-20-90-05W6	1	GETH	3587.80	-463.80	976.25	1790.82	545.84
06-11-85-13W6	1	GETH	3627.00	-1184.00	1326.23	1878.89	572.68
11-05-63-26W5	5	GETH	8169.29	-4897.64	2862.92	1714.18	522.48
05-11-88-01W6	1	GETH	2687.00	-260.00	862.76	1732.52	528.07
10-29-85-25W5	2	GETH	2680.00	-288.00	873.00	1728.17	526.75
06-19-78-09W6	1	GETH	4680.00	-2176.00	1777.84	1929.87	588.22
06-02-81-04W6	4	GETH	3016.00	-1086.00	1287.73	1887.97	575.45
15-35-87-07W6	2	GETH	3340.00	-590.00	1079.39	1902.82	579.98
10-16-82-01W6	5	GETH	3063.00	-862.02	1133.60	1755.99	535.23
10-33-80-01W6	2	GETH	2910.00	-939.00	1220.45	1879.59	572.90
06-24-81-01W6	2	GETH	2719.00	-729.00	1104.21	1821.14	555.08
06-10-83-09W6	2	GETH	3403.00	-1133.00	1358.56	2004.55	610.99
07-07-86-01W6	3	GETH	2786.00	-322.00	911.82	1783.82	543.71
16-01-78-03W6	1	GETH	3413.71	-1475.39	1451.38	1876.53	571.97
10-29-90-07W6	2	GETH	3549.00	-558.00	1035.97	1834.54	559.17
10-14-85-24W5	1	GETH	2450.00	-192.00	830.00	1724.86	525.74
06-05-77-05W6	2	GETH	4273.30	-2126.97	1752.70	1920.84	585.47
10-05-75-23W5	1	GETH	3447.00	-1476.00	1469.50	1917.76	584.53
10-06-79-12W6	2	GETH	4547.24	-2275.59	1843.50	1981.92	604.09
07-04-85-02W6	1	GETH	2752.00	-496.00	1007.32	1830.37	557.90
13-35-83-09W6	8	GETH	3322.00	-1120.00	1377.63	2061.59	628.37
11-08-88-10W6	1	GETH	3411.19	-928.25	1219.39	1887.89	575.43
10-17-83-06W6	5	GETH	3015.00	-952.00	1240.42	1912.71	582.99
07-22-63-24W5	4	GETH	7271.00	-4461.00	2654.00	1668.33	508.51
10-08-83-09W6	2	GETH	3541.00	-1328.00	1442.39	2003.15	610.56
10-07-73-26W5	2	GETH	4471.00	-2082.00	1784.05	2038.21	621.25
11-27-85-03W6	3	GETH	3093.00	-603.00	1028.37	1771.99	540.10
13-09-84-25W5	1	GETH	2623.00	-425.00	994.60	1872.00	570.58
07-34-83-23W5	2	GETH	2439.66	-364.86	878.09	1663.06	506.90
16-22-81-03W6	2	GETH	3110.24	-1025.92	1273.26	1914.63	583.58
06-17-89-07W6	1	GETH	4048.00	-687.00	1094.69	1841.15	561.18
15-28-84-11W6	3	GETH	3243.00	-1205.00	1319.64	1842.67	561.65
06-16-86-03W6	1	GETH	3412.08	-563.98	1031.96	1819.30	554.52

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
06-07-87-01W6	1	GETH	2509.00	-262.00	911.00	1841.93	561.42
10-04-68-24W5	4	GETH	5515.00	-3023.00	2166.21	1979.79	603.44
06-21-80-23W5	1	GETH	2442.75	-555.61	989.77	1730.23	527.38
06-14-82-11W6	1	GETH	3506.00	-1397.00	1321.67	1655.36	504.55
07-14-79-02W6	1	GETH	2957.00	-1110.00	1284.68	1856.93	565.99
09-23-79-24W5	3	GETH	2683.73	-801.18	1134.78	1819.56	554.60
10-15-87-01W6	1	GETH	2520.00	-288.00	897.00	1783.59	543.64
06-31-72-07W6	3	GETH	5587.27	-3350.39	2270.78	1893.91	577.26
06-09-76-04W6	3	GETH	4470.76	-1909.74	1673.04	1954.09	595.61
07-01-87-26W5	1	GETH	2410.00	-257.00	888.42	1794.78	547.05
02-23-90-24W5	5	GETH	1920.93	-17.06	660.65	1508.69	459.85
10-26-71-25W5	2	GETH	4982.01	-2439.03	1831.96	1791.82	546.15
06-18-79-05W6	1	GETH	3247.00	-1303.00	1403.38	1938.06	590.72
11-09-81-05W6	2	GETH	3264.43	-1254.59	1342.18	1845.13	562.40
06-23-80-23W5	2	GETH	2424.00	-532.00	1027.92	1841.95	561.43
05-31-80-25W5	3	GETH	2536.00	-787.00	1150.05	1869.00	569.67
08-29-80-23W5	3	GETH	2390.09	-508.53	1010.36	1824.86	556.22
15-09-81-02W6	3	GETH	3077.42	-1055.77	1280.10	1900.58	579.30
06-11-88-11W6	2	GETH	3773.00	-973.00	1219.92	1844.37	562.16
07-33-80-13W6	6	GETH	3574.00	-1503.00	1365.78	1651.23	503.29
01-32-71-23W5	1	GETH	4841.00	-2191.00	1776.00	1910.62	582.36
12-36-74-25W5	4	GETH	3882.06	-1672.74	1539.76	1883.29	574.03
07-15-89-23W5	1	GETH	1915.00	22.00	656.61	1538.42	468.91
15-35-76-07W6	3	GETH	4895.01	-2380.25	1870.10	1938.69	590.91
06-31-73-01W6	1	GETH	4405.27	-2344.25	1828.30	1878.15	572.46
11-13-74-13W6	1	GETH	6521.00	-3836.00	2523.00	1990.79	606.79
07-07-89-05W6	1	GETH	3643.44	-541.73	1030.93	1839.17	560.58
16-24-76-10W6	6	GETH	5593.84	-2563.98	2025.60	2114.08	644.37
14-20-77-05W6	2	GETH	3793.87	-1694.13	1563.61	1916.98	584.30
08-07-82-11W6	4	GETH	3979.65	-1901.57	1755.97	2153.79	656.47
02-31-83-01W6	2	GETH	2725.00	-506.00	1023.11	1856.84	565.97
07-25-62-24W5	2	GETH	7710.37	-4623.10	2860.20	1982.44	604.25
07-14-82-26W5	1	GETH	2750.00	-639.00	1055.40	1798.41	548.16
06-13-78-02W6	3	GETH	3028.21	-1124.34	1231.14	1718.94	523.93

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
10-32-85-25W5	2	GETH	2540.00	-266.00	864.48	1730.49	527.45
10-08-89-25W5	1	GETH	2438.00	-134.00	815.69	1749.81	533.34
11-14-84-05W6	2	GETH	3075.00	-886.00	1197.01	1878.46	572.55
10-05-81-04W6	1	GETH	2685.00	-1102.00	1301.77	1904.40	580.46
16-21-86-09W6	1	GETH	3033.78	-912.39	1197.40	1852.97	564.78
10-36-86-10W6	1	GETH	3165.00	-861.00	1195.00	1898.82	578.76
06-09-82-05W6	2	GETH	2926.00	-945.00	1256.57	1957.01	596.50
04-09-70-02W6	2	GETH	5367.45	-3265.42	2244.02	1917.07	584.32
06-02-84-23W5	2	GETH	2354.94	-218.79	831.17	1700.77	518.40
04-33-86-03W6	3	GETH	3063.98	-378.61	1001.96	1935.39	589.91
16-20-79-24W5	3	GETH	2691.93	-823.46	1180.69	1903.31	580.13
10-15-87-02W6	1	GETH	2678.00	-379.00	938.00	1787.28	544.76
07-02-85-26W5	1	GETH	2843.00	-397.00	947.26	1790.67	545.80
11-26-81-25W5	2	GETH	2559.06	-654.86	1069.70	1815.58	553.39
06-06-78-07W6	5	GETH	4540.68	-1891.40	1598.80	1800.98	548.94
14-14-78-02W6	2	GETH	3129.92	-1234.58	1352.60	1889.21	575.83
10-13-87-01W6	3	GETH	2500.00	-282.00	881.00	1752.64	534.21
07-29-77-02W6	1	GETH	3522.00	-1468.00	1448.00	1876.11	571.84
12-18-79-24W5	1	GETH	2617.00	-761.00	1151.00	1897.20	578.27
07-23-83-05W6	1	GETH	3058.00	-922.00	1212.33	1877.84	572.37
06-36-81-25W5	1	GETH	2443.00	-539.00	1036.83	1855.53	565.56
10-24-80-04W6	3	GETH	2970.00	-1080.00	1325.02	1980.09	603.53
10-11-83-10W6	3	GETH	3326.00	-1196.00	1235.48	1657.30	505.15
06-34-86-09W6	2	GETH	3446.00	-1079.00	1299.00	1921.00	585.52
06-18-81-10W6	1	GETH	3792.65	-1481.30	1326.40	1581.98	482.19
02-08-76-26W5	1	GETH	3185.00	-1454.00	1456.00	1908.59	581.74
07-07-87-25W5	3	GETH	2432.74	-276.90	904.31	1811.58	552.17
16-12-84-09W6	1	GETH	3116.00	-1051.00	1255.00	1847.38	563.08
07-04-82-11W6	1	GETH	3520.00	-1436.00	1334.36	1645.66	501.60
10-35-72-24W5	2	GETH	4466.00	-1945.00	1683.89	1943.89	592.50
02-36-77-01W6	2	GETH	3136.48	-1145.01	1222.00	1677.16	511.20
09-35-77-25W5	4	GETH	2927.00	-1054.00	1281.01	1904.45	580.48
07-21-89-12W6	3	GETH	4135.00	-792.00	1162.48	1892.71	576.90
09-18-86-07W6	8	GETH	2998.68	-879.59	1201.58	1895.42	577.72

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
09-17-83-23W5	6	GETH	2270.34	-275.92	879.70	1755.72	535.14
11-36-86-26W5	1	GETH	2450.00	-246.00	889.00	1807.12	550.81
10-03-84-25W5	1	GETH	2562.00	-406.00	960.76	1812.85	552.56
08-19-85-12W6	1	GETH	3812.34	-1404.20	1477.88	2008.92	612.32
10-30-83-11W6	1	GETH	3321.00	-1242.00	1252.75	1651.19	503.28
14-18-81-12W6	3	GETH	4107.61	-2048.88	1747.08	1985.95	605.32
10-12-80-25W5	1	GETH	2542.00	-687.00	1115.00	1888.06	575.48
06-36-82-03W6	4	GETH	3128.00	-604.00	1156.31	2066.46	629.86
11-18-88-10W6	1	GETH	3713.92	-971.14	1248.99	1913.36	583.19
10-21-75-06W6	5	GETH	5099.00	-2280.00	1836.97	1962.42	598.15
07-20-83-08W6	10	GETH	3398.00	-1124.00	1373.56	2048.19	624.29
04-33-87-07W6	1	GETH	3201.00	-831.00	1141.45	1805.14	550.21
07-02-84-06W6	1	GETH	2949.00	-802.00	1175.48	1912.73	583.00
06-21-85-25W5	1	GETH	3001.97	-405.18	918.12	1715.19	522.79
14-09-86-13W6	1	GETH	3693.50	-1190.55	1295.50	1801.37	549.06
06-16-74-03W6	4	GETH	4665.36	-2408.04	1918.84	2023.46	616.75
10-21-73-03W6	2	GETH	4436.00	-2258.00	1857.15	2031.03	619.06
11-07-84-05W6	4	GETH	3067.58	-915.35	1218.20	1898.04	578.52
06-29-81-07W6	6	GETH	3413.00	-1362.00	1399.06	1869.09	569.70
07-04-87-25W5	1	GETH	2406.00	-287.00	888.93	1765.96	538.26
12-20-85-08W6	1	GETH	3064.00	-887.00	1177.00	1831.24	558.16
06-13-83-12W6	2	GETH	3653.21	-1607.61	1545.80	1962.37	598.13
14-13-76-08W6	5	GETH	4756.89	-2160.76	1725.83	1824.99	556.26
16-25-85-13W6	1	GETH	3670.93	-1312.66	1471.55	2085.84	635.76
06-29-81-07W6	5	GETH	3454.00	-1403.00	1472.40	1997.46	608.83
10-19-89-07W6	2	GETH	4056.00	-869.00	1185.16	1868.09	569.39
11-30-73-02W6	1	GETH	4211.00	-2127.00	1820.00	2076.23	632.84
10-15-87-02W6	7	GETH	2708.00	-409.00	946.46	1776.82	541.57
11-20-84-23W5	2	GETH	2329.00	-194.00	825.54	1712.56	521.99
11-32-83-12W6	2	GETH	3707.00	-1549.00	1556.12	2044.81	623.26
01-14-67-23W5	4	GETH	5196.85	-2846.13	2109.76	2026.29	617.61
02-11-76-04W6	2	GETH	4675.20	-2155.84	1750.20	1886.19	574.91
06-31-74-09W6	7	GETH	5748.03	-3227.03	2263.20	1999.76	609.53
05-15-84-12W6	2	GETH	3749.34	-1511.38	1540.36	2046.03	623.63

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
11-22-78-05W6	2	GETH	3687.99	-1718.17	1611.10	2002.62	610.40
07-27-77-26W5	1	GETH	3041.00	-1103.00	1299.10	1897.23	578.28
11-03-82-09W6	1	GETH	3812.33	-1463.58	1505.50	2013.33	613.66
06-22-80-03W6	1	GETH	3047.00	-1118.00	1307.56	1901.77	579.66
14-29-74-05W6	2	GETH	5721.78	-3242.45	2255.34	1966.19	599.29
15-14-82-25W5	4	GETH	2864.18	-741.80	1083.10	1759.59	536.32
06-25-82-06W6	4	GETH	3093.84	-1059.06	1263.24	1858.35	566.43
10-09-82-11W6	1	GETH	3401.00	-1333.00	1338.54	1758.32	535.93
06-31-80-01W6	3	GETH	2951.11	-972.44	1239.64	1890.47	576.22
11-12-83-24W5	5	GETH	2518.00	-432.00	915.25	1681.74	512.59
07-30-76-11W6	4	GETH	5685.36	-2826.44	2085.00	1988.80	606.19
07-01-84-06W6	1	GETH	3085.00	-927.00	1208.00	1862.84	567.79

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-26-79-25W5	3	CAD	2877.30	-1027.23	1240.20	1836.97	559.91
11-06-73-24W5	1	CAD	4390.00	-2024.00	1707.90	1920.34	585.32
10-30-83-11W6	4	CAD	3713.00	-1634.00	1579.20	2013.11	613.60
10-30-63-24W5	3	CAD	7458.00	-4567.00	2829.96	1968.70	600.06
08-13-81-05W6	2	CAD	3024.94	-1096.13	1186.90	1644.98	501.39
06-02-84-07W6	5	CAD	3054.00	-964.00	1248.84	1920.16	585.26
07-09-78-01W6	5	CAD	3373.00	-1341.00	1406.18	1906.53	581.11
08-34-71-24W5	2	CAD	4583.00	-2093.00	1740.00	1925.48	586.89
04-06-73-04W6	2	CAD	5396.00	-3088.00	2166.15	1914.66	583.59
05-28-87-04W6	3	CAD	3491.00	-670.00	1068.37	1797.37	547.84
03-24-81-05W6	1	CAD	2981.00	-1049.00	1283.00	1914.05	583.40
10-13-79-10W6	2	CAD	4743.00	-2085.00	1820.61	2119.64	646.07
04-06-81-06W6	3	CAD	3538.38	-1540.35	1491.48	1904.18	580.39
10-28-80-24W5	2	CAD	2582.00	-675.00	1092.23	1847.47	563.11
15-04-83-12W6	1	CAD	3787.73	-1810.37	1657.64	2017.90	615.06
07-31-79-10W6	3	CAD	4732.00	-2108.00	1758.48	1953.15	595.32
11-24-80-12W6	2	CAD	4363.52	-2194.88	1795.23	1951.15	594.71
09-35-77-25W5	3	CAD	3135.00	-1262.00	1354.46	1866.08	538.78
11-34-78-04W6	4	CAD	3513.00	-1581.00	1514.71	1917.18	584.36
15-28-84-11W6	4	CAD	3588.00	-1550.00	1540.17	2006.97	611.73
10-27-82-06W6	1	CAD	3253.25	-1219.79	1335.02	1863.40	567.96
11-21-79-05W6	6	CAD	3374.00	-1453.00	1488.63	1984.94	605.01
06-25-77-06W6	2	CAD	4229.00	-2064.30	1737.64	1948.73	593.97
11-26-75-23W5	1	CAD	3332.00	-1456.00	1446.70	1885.11	574.58
15-09-74-01W6	2	CAD	4335.00	-2266.00	1830.31	1961.04	597.73
06-18-72-06W6	5	CAD	5785.00	-3576.00	2422.00	2017.53	614.94
10-32-84-07W6	4	CAD	3016.00	-911.00	1245.92	1966.41	599.36
11-19-75-04W6	6	CAD	5048.00	-2365.00	1855.88	1921.10	585.55
10-34-86-03W6	1	CAD	3405.43	-692.50	1107.03	1864.15	568.19
10-26-80-11W6	5	CAD	4384.00	-2079.00	1768.15	2004.49	610.97
06-23-77-07W6	5	CAD	4731.00	-2134.00	1762.00	1935.28	589.87
06-04-68-04W6	1	CAD	6927.00	-4541.00	2821.00	1974.01	601.68
07-21-82-06W6	3	CAD	3261.00	-1188.00	1310.67	1838.95	560.51
10-18-76-04W6	3	CAD	4711.00	-2270.00	1805.83	1900.51	579.27

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
08-30-79-05W6	3	CAD	3439.96	-1503.61	1458.11	1863.85	568.10
03-02-82-10W6	7	CAD	4071.52	-1677.49	1552.20	1907.27	581.34
11-07-77-25W5	6	CAD	3205.38	-1311.02	1375.26	1865.10	568.48
07-30-79-02W6	9	CAD	3130.00	-1244.00	1384.73	1953.99	595.58
11-12-79-07W6	2	CAD	3756.00	-1696.00	1565.22	1918.83	584.86
06-13-74-06W6	4	CAD	5441.00	-2886.00	2116.21	2001.32	610.00
10-17-75-10W6	4	CAD	5910.00	-3236.00	2246.10	1951.30	594.76
01-28-81-11W6	2	CAD	4000.13	-1897.77	1703.18	2035.67	520.47
12-17-66-26W5	3	CAD	6837.00	-4217.00	2643.00	1886.93	575.14
06-30-75-04W6	4	CAD	4972.00	-2285.00	1835.41	1953.82	595.53
10-09-81-10W6	2	CAD	4406.00	-1869.00	1651.80	1945.78	593.07
10-35-72-24W5	3	CAD	4516.00	-1995.00	1674.92	1873.18	570.94
04-28-74-02W6	6	CAD	4354.00	-2262.00	1822.71	1947.49	593.60
06-29-77-06W6	5	CAD	4527.56	-2153.87	1778.16	1952.74	595.19
07-20-82-05W6	4	CAD	3066.00	-1059.00	1281.79	1901.25	579.50
10-07-73-26W5	4	CAD	4724.00	-2335.00	1852.27	1942.76	592.15
16-29-78-11W6	2	CAD	5013.12	-2342.52	1869.10	1974.11	601.71
06-36-78-07W6	1	CAD	4016.08	-1884.19	1680.70	1997.33	608.79
10-02-76-02W6	2	CAD	3619.00	-1679.00	1570.00	1946.87	593.40
10-02-66-24W5	1	CAD	6748.00	-3806.00	2504.54	1978.16	602.94
10-21-68-04W6	8	CAD	6570.00	-4374.00	2766.90	2016.07	614.50
11-21-82-12W6	2	CAD	3891.08	-1897.97	1695.93	2018.73	615.31
16-25-79-08W6	1	CAD	4026.16	-1862.77	1648.06	1943.37	592.34
11-18-77-08W6	5	CAD	5552.00	-2401.00	1870.00	1917.71	584.52
10-12-74-06W6	1	CAD	5440.00	-2895.00	2118.94	1998.63	609.18
08-12-80-10W6	4	CAD	4534.12	-2015.09	1708.97	1931.72	588.79
10-27-80-13W6	4	CAD	4110.00	-2020.00	1764.00	2053.90	626.03
10-17-82-24W5	1	CAD	2647.00	-671.00	1042.43	1736.46	529.27
06-30-75-03W6	1	CAD	4555.12	-2326.77	1850.84	1947.69	593.66
11-07-74-03W6	2	CAD	4760.00	-2505.00	1907.41	1900.10	579.15
10-05-75-23W5	2	CAD	3631.00	-1660.00	1526.50	1865.40	568.58
10-08-81-13W6	2	CAD	4057.00	-1968.00	1716.49	1996.18	608.44
08-15-81-09W6	4	CAD	3701.11	-1436.35	1505.51	2040.58	621.97
16-07-80-08W6	4	CAD	4194.56	-1822.51	1664.50	2021.60	616.18

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-15-81-11W6	4	CAD	4100.00	-1959.00	1742.33	2064.86	629.37
12-24-77-09W6	3	CAD	5516.00	-2387.00	1877.83	1949.79	594.30
14-34-80-06W6	3	CAD	3454.73	-1484.91	1465.10	1898.69	578.72
06-13-78-02W6	4	CAD	3166.01	-1262.14	1358.60	1875.50	571.65
07-27-79-01W6	2	CAD	3118.00	-1256.00	1404.13	1986.79	605.57
07-27-77-26W5	3	CAD	3285.00	-1347.00	1398.10	1881.87	573.59
03-26-72-24W5	2	CAD	4587.00	-2064.00	1729.00	1929.07	587.98
10-32-82-07W6	2	CAD	3524.00	-1258.00	1398.84	1972.58	601.24
04-10-86-12W6	2	CAD	3530.00	-1281.00	1408.00	1970.73	600.68
11-28-82-03W6	3	CAD	3196.00	-986.00	1234.82	1865.78	568.69
11-02-82-07W6	2	CAD	3289.00	-1204.00	1358.55	1933.53	589.34
06-27-83-12W6	1	CAD	3642.00	-1542.00	1545.05	2026.24	617.60
10-21-83-06W6	5	CAD	3074.00	-1010.00	1265.19	1911.92	582.75
02-31-83-01W6	3	CAD	3038.00	-819.00	1137.44	1807.88	551.04
10-24-78-08W6	6	CAD	4397.00	-2001.00	1736.94	2010.41	612.77
10-03-80-12W6	3	CAD	4497.00	-2218.00	1827.08	2001.58	610.08
06-31-77-10W6	3	CAD	5329.00	-2523.00	1973.00	2033.58	619.84
01-14-82-12W6	2	CAD	3994.00	-1933.00	1721.00	2041.60	622.28
10-34-82-08W6	1	CAD	3494.00	-1234.00	1389.94	1976.02	602.29
11-26-82-01W6	2	CAD	2945.00	-776.00	1113.80	1796.29	547.51
07-10-77-12W6	2	CAD	5427.00	-2807.00	2054.63	1938.10	590.73
06-21-67-23W5	5	CAD	5687.00	-3202.00	2223.23	1932.48	589.02
07-13-83-24W5	8	CAD	2624.67	-532.15	943.00	1645.68	501.60
06-36-83-13W6	2	CAD	3789.37	-1612.86	1562.80	1996.38	608.50
16-21-78-08W6	1	CAD	4496.49	-2106.40	1777.08	1997.71	608.90
10-22-84-12W6	7	CAD	3794.00	-1515.00	1541.19	2044.33	623.11
06-17-75-04W6	2	CAD	4836.00	-2328.00	1838.70	1918.42	584.73
11-17-88-24W5	2	CAD	2375.00	-200.00	830.52	1718.06	523.66
10-26-78-25W5	2	CAD	2926.00	-1054.00	1267.80	1873.94	571.18
06-25-78-08W6	5	CAD	4340.09	-1978.38	1713.70	1979.36	603.31
16-28-77-08W6	1	CAD	5465.88	-2268.70	1814.30	1921.37	585.63
01-33-81-10W6	2	CAD	3955.00	-1668.00	1589.20	2002.21	610.27
06-03-78-08W6	4	CAD	4708.00	-2145.01	1761.50	1923.12	586.17
06-24-76-08W6	2	CAD	5022.97	-2510.50	1937.28	1963.59	598.50

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
13-16-73-24W5	2	CAD	4332.35	-1904.20	1642.80	1889.80	576.01
05-29-75-02W6	1	CAD	4074.81	-2003.94	1679.20	1874.12	571.23
11-15-82-07W6	3	CAD	3310.00	-1181.00	1340.29	1914.36	583.50
10-33-85-11W6	4	CAD	3300.00	-1143.00	1385.20	2056.08	626.69
11-21-83-23W5	2	CAD	2490.00	-457.00	920.77	1669.49	508.86
06-25-76-12W6	6	CAD	5820.21	-2905.84	2105.01	1955.61	596.07
06-35-78-07W6	1	CAD	4028.87	-1860.89	1656.61	1965.00	598.93
11-15-68-02W6	6	CAD	6247.00	-3974.00	2552.47	1920.85	585.48
06-32-73-13W6	6	CAD	6994.00	-4238.00	2680.30	1952.07	594.99
04-08-74-05W6	7	CAD	5457.00	-2902.00	2113.54	1979.15	603.25
06-11-68-08W6	5	CAD	8118.00	-5457.00	3153.68	1826.33	556.66
16-07-82-11W6	3	CAD	3966.54	-1894.69	1684.51	1995.63	608.27
06-11-73-08W6	1	CAD	5803.81	-3582.35	2403.77	1969.08	600.18
06-26-77-06W6	5	CAD	4306.11	-2091.21	1762.50	1979.23	603.27
06-23-77-10W6	3	CAD	5230.00	-2502.00	1940.52	1979.57	603.37
10-30-62-25W5	3	CAD	8098.00	-5049.00	3069.70	2040.38	621.91
11-25-77-08W6	3	CAD	4885.17	-2238.19	1822.65	1971.16	600.81
07-23-83-11W6	6	CAD	3736.00	-1679.00	1600.61	2017.56	614.95
07-21-78-06W6	2	CAD	4197.84	-1925.53	1704.80	2011.65	613.15
10-23-65-24W5	3	CAD	6736.00	-3900.00	2527.00	1936.03	590.10
07-33-80-13W6	5	CAD	4106.00	-2035.00	1744.00	1992.71	607.38
10-23-83-09W6	2	CAD	3426.00	-1170.00	1356.00	1961.64	597.91
08-19-75-08W6	1	CAD	5760.47	-2912.04	2128.10	2002.74	610.44
01-17-81-08W6	1	CAD	3734.00	-1581.00	1541.00	1977.89	602.86
06-26-64-23W5	5	CAD	6917.00	-3926.00	2538.00	1935.43	589.92
16-19-77-11W6	3	CAD	5101.71	-2589.24	1944.50	1901.52	579.58
06-27-75-03W6	3	CAD	4294.95	-2152.23	1761.63	1916.20	584.06
08-28-84-12W6	1	CAD	3879.32	-1525.32	1540.01	2031.29	619.14
11-01-64-05W6	1	CAD	8986.22	-6054.13	3484.40	1992.98	607.46
13-21-78-09W6	2	CAD	4701.44	-2217.19	1806.30	1954.40	595.70
02-27-79-13W6	2	CAD	4368.44	-2234.91	1824.84	1979.50	603.35
14-07-76-11W6	1	CAD	5935.76	-3095.54	2202.10	1990.14	606.60
15-28-77-13W6	4	CAD	5534.78	-2702.43	2035.70	1998.96	609.28
06-14-76-09W6	1	CAD	5623.04	-2634.19	1992.40	1967.20	599.60

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
07-30-78-04W6	4	CAD	3507.00	-1579.00	1520.70	1933.01	589.18
06-20-79-08W6	1	CAD	4205.91	-1906.04	1658.35	1923.87	586.39
10-05-84-11W6	4	CAD	3280.00	-1624.00	1576.00	2015.72	614.39
12-33-78-07W6	2	CAD	4089.57	-1897.64	1672.92	1965.92	599.21
14-19-78-06W6	1	CAD	4138.00	-1905.00	1666.05	1942.69	592.13
16-31-76-05W6	3	CAD	4390.72	-2224.38	1786.40	1901.26	579.50
02-11-76-04W6	3	CAD	4767.06	-2247.70	1798.00	1904.72	580.56
14-23-76-04W6	3	CAD	4389.77	-2159.45	1776.90	1944.25	592.61
10-29-80-13W6	4	CAD	4074.00	-1994.00	1743.96	2033.62	619.85
06-01-85-11W6	4	CAD	3369.09	-1282.15	1442.26	2048.70	624.45
06-31-77-12W6	2	CAD	5072.00	-2604.00	1968.00	1941.03	591.63
06-21-76-05W6	2	CAD	4451.18	-2278.94	1839.70	1969.79	600.39
10-02-79-24W5	5	CAD	2763.00	-942.00	1209.00	1850.15	563.93
16-21-72-06W6	3	CAD	5728.02	-3508.56	2392.85	2017.65	614.98
11-11-76-08W6	4	CAD	5425.00	-2609.00	2000.00	2009.94	612.63
06-21-83-09W6	1	CAD	3533.14	-1269.36	1424.25	2019.90	615.67
07-26-78-10W6	6	CAD	4862.20	-2289.04	1820.51	1915.37	583.81
16-06-76-07W6	1	CAD	5144.03	-2555.45	1996.95	2056.44	626.80
07-03-74-23W5	3	CAD	3946.00	-1703.00	1537.00	1846.65	562.86
08-09-78-06W6	4	CAD	4206.04	-2036.42	1731.80	1963.12	598.36
15-10-84-12W6	2	CAD	3713.91	-1518.37	1546.00	2052.07	625.47
08-09-77-04W6	2	CAD	4264.89	-1992.91	1697.60	1927.64	587.55
07-25-62-27W5	3	CAD	8690.00	-5230.00	3100.86	1931.34	588.67
12-33-78-07W6	1	CAD	4122.38	-1930.45	1634.79	1845.05	562.37
10-08-83-10W6	2	CAD	3715.00	-1660.00	1574.00	1975.10	602.01
06-25-80-12W6	3	CAD	4319.20	-2163.32	1763.30	1908.97	581.85
14-06-77-07W6	5	CAD	5265.75	-2374.67	1875.70	1957.20	596.55
16-24-77-12W6	2	CAD	5134.52	-2572.18	1954.96	1942.74	592.15
11-11-68-03W6	3	CAD	6527.00	-4183.00	2675.14	1995.15	608.12
14-16-77-05W6	3	CAD	4203.08	-2093.83	1753.10	1954.90	595.85
09-36-78-12W6	2	CAD	4829.40	-2305.12	1905.00	2094.42	638.38
06-05-78-08W6	1	CAD	4861.38	-2273.13	1790.98	1863.08	567.87
06-02-85-02W6	3	CAD	3108.00	-753.00	1094.00	1773.56	540.58
07-25-75-08W6	2	CAD	5623.36	-2660.76	1993.50	1943.17	592.28

WELL LOCATION	DST #	FORMATION NAME	RECORDER DEPTH (ft)	RECORDER ELEVATION	ASSIGNED P MAX psi	HEAD (ft) CALCULATED	HEAD (m)
14-33-74-03W6	1	CAD	4993.12	-2339.90	1870.81	1980.68	603.71
06-36-75-07W6	2	CAD	5255.91	-2574.15	1957.82	1947.37	593.56
07-17-83-10W6	3	CAD	3555.00	-1632.00	1567.48	1988.05	605.96
06-36-75-07W6		CAD	5255.91	-2574.15	1957.82	1947.37	593.56
07-08-77-07W6	2	CAD	5088.00	-2316.00	1837.00	1926.49	587.20
14-17-81-02W6	4	CAD	3185.07	-1127.33	1291.21	1854.68	565.31
10-29-81-10W6	2	CAD	4006.00	-1759.00	1625.52	1995.09	608.10
10-27-77-09W6	3	CAD	5252.63	-2253.94	1841.82	1999.69	609.50
07-19-69-25W5	3	CAD	5598.00	-3063.00	2164.74	1936.40	590.21
09-20-77-26W5	2	CAD	3471.13	-1337.60	1407.17	1912.22	582.84
11-21-76-09W6	2	CAD	5656.17	-2551.84	2025.09	2125.04	647.71
06-08-83-25W5	2	CAD	2920.00	-714.00	1069.00	1754.82	534.87
07-29-77-07W6	2	CAD	4704.72	-2180.77	1782.88	1936.74	590.32
10-25-75-05W6	4	CAD	6292.00	-3628.00	2389.00	1889.32	575.87

APPENDIX II

WATER CHEMISTRY DATA

APPENDIX II

WATER CHEMISTRY

Water chemistry data were obtained from the Alberta Energy Resources Conservation Board (ERCB) standard water analyses microfiche files. A tremendous quantity of data is available as the ERCB requires producing companies to submit copies of water analyses for all sampled wells. There are, however, no industry standards for water sample collection, analytical techniques or reporting methods. The result is a highly variable data base which must be carefully screened and qualified before the information may be used.

Standard water analyses commonly report concentrations of the major ions (sodium, calcium, magnesium, bicarbonate, sulphate, chloride), total dissolved solids (TDS), and occasionally a few other ions such as potassium, iodide or carbonate. Other information includes water density, resistivity and pH.

Formation water samples may be collected from drill stem tests or surface facilities such as well heads, treaters, separators, or holding tanks. It is common for water samples to be contaminated by drilling muds, acid washes, cement filtrates or waters from other than the zone of interest. Samples may also be affected by water injection into the reservoir, in which case the well history may be useful in determining the type and extent of fluid contamination. Surface samples are usually the most seriously contaminated and should generally be avoided. Samples recovered in the fluid column close to the tested interval ("top of tool" or "bottom" samples) are less likely to be contaminated by drilling fluid (Hitchon, 1984). Identification of contaminated samples and removal of analyses not representative of formation waters is necessary before any data interpretation is attempted.

The initial sorting process involved removing samples from the data base when the following conditions applied:

1) the analysis was incomplete

2) a poor ionic balance, i.e., if the sum of the cations (in meq/l) did not equal the sum of the anions indicating a probable error or omission made in the analysis

3) the sample was taken from multiple test intervals, i.e., it was not possible to identify the origin of the water.

Hitchon (1987; pers. comm., 1988) suggested several other culling criteria which have been used in this study, namely:

4) when hydroxide or carbonate is reported. Most oilfield brines contain no hydroxyl ions and most of them contain no carbonate ions (but they do contain bicarbonate ions). In the qualification of standard oilfield water analyses, therefore, the presence of hydroxide or carbonate is usually taken as an indication of mud filtrate contamination and that sample is not considered as a representative formation water.

5) when pH is < 5.0 or >10.0. Most oilfield brines do not contain acidity. New wells or reworked wells often are acidified or "acidized" with a strong mineral acid or a combination of mineral and organic acids. This treatment causes the produced water to contain a certain amount of acidity until all of the acid is neutralized or diluted. Because of the large quantities of acids used in some treatments, it may take months for the produced water to return to normal, i.e., uncontaminated formation water. Thus low pH samples must be evaluated carefully. The pH range of most formation waters should be between 6.5 and 8.5.

There are also several important points to remember when considering the validity of any water analysis. Tests reported prior to 1955 have computed sodium values (sodium calculated stoichiometrically as the difference between the sum of the anions and the sum of the cations), which are subject to great errors. Potassium values were also typically incorporated into the reported sodium value. This situation changed as analytical techniques improved.

Under optimum conditions, the analytical results for major constituents of water have an accuracy of +/- 2-10%. For concentrations above 1000 mg/l TDS, the accuracy improves (usually < 5%). A range of values may be obtained by different laboratories, so care must be used when comparing data.

The next step in the qualification process comes after initial contour mapping of the data. Maps identify anomalous data points or significant contour flexures which should be investigated for contaminated or erroneous data. In this study, the TDS contents of waters from individual formations were mapped separately to provide an overview of the water chemistry in each formation (Figures 2.23, 2.24, 2.27, 2.28, 2.29). Areal salinity mapping is a useful indicator of the movement of meteoric water into the subsurface. Considerable confidence may be placed in regional compositional trends from the final data base, especially when regional patterns and composition gradients correspond closely with those predicted by the hydraulic head distribution/flow pattern mapping.

In this study, over 6900 water test results were reviewed on the ERCB microfiche. Initial culling discarded over 80% of those analyses. Rigorous qualification and checking of the remaining data led to the removal of more analyses, resulting in a working database consisting of approximately 5% of the initial available data. These data are listed on the following pages by formation, in stratigraphic order beginning with the Paddy Member of the Peace River Formation and ending with the Cadomin Formation.

REFERENCES

Hitchon, B., 1984: Graphical and statistical treatment of standard formation water analyses; Proc. of First Canadian/American Conference on Hydrogeology: Practical applications of ground water geochemistry. Banff, Alberta, June 22-26, NWWA, Dublin, Ohio, pp. 225-236.

Hitchon, B., 1987: Dynamic basin analysis: an integrated approach with large data bases; in: Goff, J.C. and B.P.J. Williams (Eds.), 1987, Fluid flow in sedimentary basins and aquifers; Geological Society Special Publication No. 34, pp. 31-44.

PADDY WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-11-35-065-04W6	3961.0	35.0	15.0	4304.0	3322.0	11677.0	0.681	1.08659
00-03-26-074-06W6	8276.0	239.0	111.0	13000.0	948.0	22661.0	0.292	1.57081
00-03-03-074-07W6	8798.0	185.0	64.0	13630.0	802.0	23520.0	0.266	1.54922
00-06-33-074-07W6	8597.0	280.0	190.0	13800.0	891.0	23840.0	0.273	1.60521
00-07-26-074-09W6	7619.0	189.0	43.0	11620.0	983.0	20483.0	0.34	1.52513
00-06-23-075-22W5	8142.0	244.0	122.0	13074.0	445.0	22039.0	NA	1.60575
00-10-18-075-04W6	8341.0	440.0	267.0	14000.0	732.0	23780.0	NA	1.67846
00-06-16-075-06W6	8009.0	212.0	68.0	12100.0	1390.0	21806.0	0.334	1.5108
00-10-21-075-06W6	8629.0	236.0	70.0	13500.0	710.0	23171.0	0.303	1.56449
00-11-02-076-23W5	8090.0	225.0	97.0	13090.0	495.0	22038.0	0.29	1.61805
00-11-19-076-07W6	6816.0	184.0	126.0	10630.0	982.0	18746.0	0.344	1.55957
00-08-12-076-08W6	7050.0	300.0	185.0	10900.0	920.0	19478.0	0.321	1.5461
00-16-16-076-09W6	7990.0	400.0	219.0	12800.0	781.0	22273.0	0.277	1.602
00-10-19-076-09W6	8436.0	184.0	53.0	13050.0	659.0	22467.0	0.29	1.54694
00-06-27-076-09W6	8246.0	260.0	42.0	12870.0	720.0	22156.0	0.738	1.56076
00-06-03-076-12W6	6959.0	100.0	176.0	10710.0	1149.0	19237.0	0.322	1.53901
00-06-23-077-07W6	8103.0	174.0	80.0	12260.0	1279.0	21940.0	0.291	1.51302
00-08-02-077-08W6	7813.0	240.0	73.0	13000.0	793.0	21933.0	0.264	1.66389
00-14-05-077-09W6	8164.0	220.0	61.0	12750.0	680.0	21895.0	0.324	1.56173
00-06-08-077-11W6	8497.0	219.0	66.0	13050.0	1050.0	22918.0	0.297	1.53584
00-16-23-077-11W6	7888.0	219.0	62.0	12044.0	1113.0	21380.0	0.34	1.52688
00-07-32-077-11W6	8469.0	168.0	105.0	13100.0	925.0	22805.0	0.31	1.54682
00-06-33-077-11W6	8286.0	214.0	99.0	12900.0	908.00	22432.0	0.320	1.55684
00-07-10-077-12W6	8115.0	252.0	61.0	12660.0	805.0	21910.0	0.31	1.56007
00-10-28-078-10W6	8152.0	232.0	70.0	12590.0	1020.0	22072.0	0.291	1.5444
00-07-30-078-04W6	8652.0	312.0	68.0	13800.0	490.0	23338.0	0.306	1.5950
00-06-23-078-01W6	9133.0	193.0	101.0	14500.0	356.0	24304.0	0.285	1.5876
00-12-24-077-09W6	8416.0	152.0	62.0	12920.0	781.0	22410.0	0.286	1.5351
00-15-34-077-01W6	8750.0	230.0	131.0	14050.0	342.0	23538.0	NA	1.6057

PADDY WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-14-15-075-22W5	7950.0	263.0	115.0	12800.0	428.0	21556.0	NA	1.6100
00-12-20-078-06W6	7494.0	129.0	120.0	11790.0	245.0	20049.0	NA	1.57326
00-10-35-078-08W6	8491.0	281.0	91.0	13400.0	775.0	23050.0	0.306	1.57814
00-10-23-078-10W6	7861.0	240.0	66.0	12260.0	780.0	21247.0	0.292	1.5596
00-06-07-078-11W6	7490.0	412.0	175.0	12140.0	905.0	21223.0	0.326	1.62083
00-07-21-079-08W6	8120.0	158.0	107.0	12675.0	749.0	21821.0	0.262	1.56096
00-07-01-079-09W6	8255.0	234.0	94.0	13020.0	638.0	22337.0	0.304	1.57723
00-11-23-079-10W6	8044.0	255.0	81.0	12620.0	816.0	21819.0	0.327	1.56887
00-07-29-079-10W6	8049.0	245.0	64.0	12420.0	1050.0	21835.0	0.343	1.54305
00-10-16-080-01W6	6926.0	238.0	82.0	11010.0	386.0	18853.0	0.34	1.58966
00-07-07-080-05W6	8643.0	323.0	116.0	13857.0	649.0	23588.0	0.275	1.60326
00-10-26-080-10W6	7434.0	200.0	68.0	11523.0	830.0	20073.0	0.393	1.55004
00-10-36-080-11W6	7972.0	208.0	53.0	12233.0	1010.0	21476.0	0.399	1.5345

CADOTTE WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-05-18-062-25W5	4345.0	50.0	24.0	5575.0	2501.0	12540.0	0.544	1.28308
00-09-09-062-26W5	4984.0	57.0	14.0	5825.0	3420.0	14320.0	0.485	1.16874
00-02-03-064-26W5	3767.0	33.0	8.0	3850.0	3430.0	11154.0	0.766	1.02203
00-11-35-065-04W6	3961.0	35.0	15.0	4304.0	3322.0	11677.0	0.681	1.08659
00-11-07-066-04W6	5016.0	39.0	11.0	6380.0	5232.0	13993.0	0.512	1.27193
00-10-26-066-05W6	7220.0	88.0	29.0	10300.0	1830.0	19482.0	0.376	1.42659
00-10-28-066-05W6	6711.0	73.0	26.0	9530.0	1730.0	18098.0	0.439	1.42006
00-07-13-066-09W6	4862.0	131.0	26.0	6650.0	2020.0	13715.0	0.499	1.36775
00-01-29-068-26W5	9176.0	181.0	85.0	14207.0	885.0	24541.0	0.385	1.54828
00-04-08-068-01W6	7440.0	117.0	68.0	10923.0	1250.0	20107.0	0.34	1.46815
00-11-06-068-02W6	7713.0	117.0	54.0	11420.0	1440.0	20744.0	0.36	1.48062
00-10-30-068-06W6	6465.0	97.0	18.0	9220.0	1753.0	17649.0	0.373	1.42614
00-06-34-068-07W6	6185.0	127.0	51.0	8811.0	1890.0	17064.0	0.378	1.42458
00-07-33-068-11W6	6045.0	89.0	38.0	7886.0	2908.0	16987.0	0.426	1.30455
00-01-02-069-22W5	10647.0	226.0	126.0	16283.0	1513.0	28825.0	NA	1.52935
00-06-06-069-23W5	7429.0	109.0	66.0	11150.0	1190.0	19947.0	0.37	1.50087
00-05-17-070-23W5	NA	501.0	NA	15880.0	674.0	NA	0.251	NA
00-06-06-070-25W5	7304.0	202.0	37.0	11100.0	1055.0	19716.0	0.37	1.51972
00-06-23-070-10W6	6474.0	96.0	36.0	9460.0	1154.0	17397.0	0.345	1.46123
00-04-04-071-23W5	8948.0	213.0	70.0	14000.0	655.0	23889.0	0.312	1.5646
00-07-34-071-24W5	7142.0	189.0	81.0	11131.0	760.0	19316.0	0.31	1.55853
00-06-29-071-03W6	8786.0	225.0	102.0	12900.0	2280.0	24324.0	0.312	1.46824
00-07-13-071-12W6	7003.0	216.0	112.0	11050.0	848.0	19282.0	0.317	1.5779
00-11-16-071-12W6	7707.0	320.0	66.0	11780.0	1464.0	21359.0	0.315	1.52848
00-11-21-071-12W6	6600.0	130.0	50.0	10600.0	1620.0	18231.0	0.4	1.60606
00-06-29-072-13W6	8534.0	341.0	118.0	13570.0	956.0	23590.0	0.3317	1.59011
00-06-33-073-05W6	9154.0	309.0	128.0	14718.0	576.0	24885.0	0.29	1.60782
00-04-14-073-07W6	8344.0	199.0	60.0	12852.0	895.0	22377.0	0.43	1.54027
00-07-33-073-10W6	7740.0	153.0	41.0	11620.0	1196.0	20765.0	0.345	1.50129

CADOTTE WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-10-12-074-05W6	8142.0	293.0	225.0	13490.0	451.0	22643.0	0.266	1.65684
00-04-13-074-11W6	8978.0	177.0	68.0	13632.0	1220.0	24091.0	0.332	1.51838
00-06-32-075-25W5	7980.0	217.0	123.0	12700.0	575.0	21620.0	0.385	1.59148
00-10-25-075-05W6	8287.0	461.0	87.00	13626.0	351.0	22830.0	0.280	1.6442
00-10-08-075-07W6	8091.0	184.0	68.0	12360.0	1098.0	21812.0	0.31	1.52762
00-06-22-075-07W6	8441.0	235.0	426.0	13759.0	1545.0	24428.0	0.6	1.63002
00-11-33-075-07W6	7785.0	305.0	91.0	12118.0	1015.0	21449.0	0.35	1.55658
00-10-09-075-08W6	NA	376.0	NA	14118.0	797.0	NA	0.241	NA
00-11-35-075-08W6	8480.0	169.0	80.0	12903.0	1185.0	22843.0	0.35	1.52158
00-10-28-075-10W6	NA	427.0	NA	12964.0	995.0	NA	0.308	NA
00-06-03-076-08W6	8363.0	218.0	86.0	13000.0	880.0	22574.0	0.326	1.55447
00-11-04-076-08W6	9153.0	229.0	74.0	14168.0	885.0	24578.0	0.36	1.54791
00-07-09-076-08W6	9144.0	182.0	63.0	13940.0	993.0	24445.0	0.31	1.5245
00-10-13-076-09W6	8160.0	340.0	207.0	13040.0	836.0	22624.0	0.302	1.59804
00-06-27-076-09W6	8589.0	259.0	57.0	13300.0	955.0	23185.0	0.674	1.54849
00-12-20-077-03W6	8360.0	306.0	88.9	13500.0	275.0	22574.4	NA	1.61483
00-14-18-077-04W6	NA	390.0	NA	12660.0	300.0	NA	NA	NA
00-05-35-077-04W6	NA	640.0	NA	13920.0	300.0	NA	0.6	NA
00-06-23-077-07W6	8745.0	369.0	44.0	13329.0	1601.0	24088.0	0.3	1.52419
00-03-26-077-07W6	7308.0	162.0	100.0	10790.0	1098.0	19568.0	0.313	1.47646
00-11-18-077-08W6	8503.0	256.0	61.0	13250.0	781.0	22908.0	0.294	1.55827
00-11-16-077-10W6	8994.0	275.0	108.0	14250.0	655.0	24332.0	0.28	1.58439
00-10-31-077-11W6	7075.0	198.0	42.0	10658.0	1162.0	19201.0	0.302	1.50643
00-07-32-077-11W6	7943.0	185.0	91.0	11936.0	1556.0	21711.0	0.285	1.50271
00-06-33-077-11W6	8023.0	137.0	68.0	12142.0	1137.0	21317.0	0.285	1.5134
00-11-34-077-12W6	7944.0	189.0	69.0	12200.0	975.0	21407.0	0.344	1.53575
00-10-35-078-02W6	6946.0	222.0	80.0	11000.0	543.0	18824.0	0.356	1.58364
00-07-07-078-12W6	7323.0	207.0	52.0	11133.0	1108.0	19893.0	0.3741	1.52028
00-10-09-078-13W6	7071.0	228.0	37.0	10800.0	989.0	19207.0	0.3507	1.52737
00-06-11-078-13W6	NA	247.0	NA	11300.0	950.0	NA	2.77	NA

CADOTTE WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-01-12-078-13W6	NA	304.0	NA	10710.0	800.0	NA	0.77	NA
00-13-12-078-13W6	7416.0	225.0	41.0	11406.0	881.0	20046.0	0.3507	1.53803
00-01-12-079-22W5	7150.0	224.0	94.0	11500.0	377.0	19345.0	NA	1.60839
00-10-20-079-22W5	7770.0	213.0	137.0	12550.0	330.0	21023.0	NA	1.61519
00-07-10-079-02W6	6415.0	320.0	194.0	10000.0	366.0	18464.0	NA	1.55885
00-11-24-079-09W6	NA	547.0	NA	13548.0	1389.0	NA	0.269	NA
00-07-24-079-11W6	7210.0	210.0	NA	10740.0	1280.0	19460.0	NA	1.4896
00-10-30-080-10W6	NA	343.0	NA	11068.0	906.0	NA	0.352	NA
00-10-33-081-23W5	7028.0	181.0	97.0	11200.0	360.0	18912.0	0.365	1.59363
00-07-13-081-05W6	6858.0	244.0	100.0	10740.0	900.0	18895.0	0.384	1.56605

NOTIKEWIN WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-11-04-066-23W5	3642.0	256.0	33.0	5580.0	880.0	10493.0	0.735	1.53213
00-14-18-077-04W6	NA	537.0	NA	13680.0	200.0	NA	NA	NA
00-05-35-077-04W6	NA	477.0	NA	12820.0	200.0	NA	0.63	NA
00-16-25-078-01W6	8480.0	190.0	117.0	13500.0	258.0	NA	NA	1.59198
00-12-20-078-06W6	8393.0	243.0	151.0	13559.0	150.0	22718.0	NA	1.61551
00-01-12-079-22W5	9200.0	260.0	118.0	14800.0	320.0	24698.0	NA	1.6087
00-03-28-079-22W5	9294.0	17.0	16.0	14170.0	402.0	23899.0	NA	1.52464
00-06-17-080-01W6	8197.0	276.0	114.0	13273.0	255.0	22174.0	0.311	1.61925
00-09-04-081-05W6	5891.0	157.0	78.0	8600.0	781.0	15628.0	0.328	1.45985
00-03-27-082-06W6	5874.0	123.0	62.0	9082.0	630.0	15781.0	NA	1.54614
00-13-15-089-09W6	9358.0	525.0	151.0	15380.0	680.0	26134.0	0.283	1.64351

BLUESKY WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-03-23-066-26W5	21386.0	289.0	145.0	33150.0	1270.0	56265.0	0.22	1.55008
00-10-26-066-05W6	24879.0	741.0	182.0	38450.0	1280.0	66565.0	0.131	1.54548
00-15-08-067-22W5	18426.0	235.0	78.0	27620.0	2463.0	48822.0	0.139	1.49897
00-06-17-067-22W5	15996.0	827.0	197.0	26200.0	860.0	44096.0	0.218	1.63791
00-11-15-067-23W5	15785.0	456.0	431.0	25818.0	960.0	43484.0	0.18	1.6356
00-06-21-067-23W5	16041.0	673.0	168.0	25780.0	1110.0	43772.0	0.151	1.60713
00-06-35-067-24W5	13855.0	637.0	116.0	22228.0	1020.0	37865.0	0.183	1.60433
00-07-32-068-22W5	15479.0	476.0	139.0	24150.0	1660.0	41917.0	0.203	1.56018
00-11-25-068-23W5	13630.0	549.0	190.0	21800.0	1274.0	37453.0	0.207	1.59941
00-10-04-068-24W5	15337.0	753.0	187.0	23540.0	3265.0	43213.0	0.17	1.53485
00-01-29-068-26W5	19581.0	331.0	171.0	30159.0	1905.0	52160.0	0.24	1.54022
00-11-11-068-03W6	13361.0	436.0	158.0	21000.0	1440.0	36401.0	0.209	1.57174
00-07-05-069-21W5	17775.0	470.0	207.0	27567.0	2200.0	48229.0	0.189	1.55089
00-01-02-069-22W5	16155.0	481.0	171.0	24963.0	2178.0	43985.0	NA	1.54522
00-09-16-069-22W5	15851.0	292.0	215.0	23336.0	3850.0	43557.0	0.182	1.47221
00-06-06-069-23W5	12910.0	502.0	264.0	20950.0	1060.0	35693.0	0.228	1.62277
00-03-35-069-23W5	15410.0	326.0	117.0	23700.0	1679.0	41246.0	0.19	1.53796
00-06-13-069-25W5	14240.0	609.0	209.0	23125.0	903.0	39089.0	0.172	1.62395
00-07-19-069-25W5	18270.0	229.0	164.0	27804.0	2135.0	48614.0	0.173	1.52184
00-13-06-070-23W5	15196.0	322.0	218.0	23276.0	2325.0	41347.0	0.207	1.53172
00-06-29-071-03W6	11874.0	600.0	114.0	19350.0	600.0	32554.0	0.22	1.62961
00-04-34-072-23W5	15513.0	236.0	194.0	23400.0	2590.0	41941.0	0.178	1.50841
00-10-02-072-25W5	10336.0	305.0	129.0	16036.0	1386.0	28206.0	0.252	1.55147
00-10-07-073-26W5	10129.0	601.0	219.0	16875.0	770.0	28599.0	0.229	1.66601
00-02-02-073-01W6	9862.0	572.0	230.0	16385.0	865.0	27914.0	0.31	1.66143
00-10-23-074-01W6	8671.0	308.0	112.0	13500.0	1265.0	23871.0	0.33	1.55691
00-06-22-075-22W5	11554.0	184.0	97.0	16550.0	3220.0	31617.0	0.224	1.4324
00-10-05-075-23W5	11661.0	174.0	172.0	16060.0	4673.0	32894.0	0.228	1.37724
00-11-09-078-23W5	10423.0	154.0	117.0	15385.0	2200.0	28315.0	0.3	1.47606

BLUESKY WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-10-18-078-23W5	9683.0	400.0	680.0	15638.0	3408.0	29809.0	0.22	1.615
00-10-26-078-25W5	7786.0	15.0	42.0	11306.0	1444.0	20601.0	0.332	1.45209
00-07-28-078-01W6	7323.0	171.0	43.0	10419.0	2210.0	20183.0	0.36	1.42278
00-12-18-079-24W5	6976.0	109.0	44.0	10740.0	3510.0	21384.0	0.348	1.53956
00-07-01-079-25W5	8829.0	70.0	40.0	11830.0	3475.0	24256.0	0.315	1.3399
00-07-27-079-01W6	6730.0	58.0	37.0	8855.0	2917.0	18653.0	0.379	1.31575
00-06-18-079-05W6	9420.0	380.0	136.0	15125.0	798.0	25874.0	0.231	1.60563
00-11-20-080-23W5	9660.0	88.0	50.0	13300.0	3271.0	26371.0	0.288	1.37681
00-05-31-080-25W5	6692.0	73.0	43.0	9060.0	2597.0	18477.0	0.356	1.35386
00-10-11-080-03W6	8071.0	120.0	97.0	11000.0	3294.0	22623.0	NA	1.3629
00-10-26-080-11W6	7167.0	178.0	38.0	10634.0	1235.0	19417.0	0.34	1.48374
00-10-16-081-23W5	7454.0	44.0	38.0	8370.0	5660.0	21600.0	0.413	1.12289
00-06-36-081-25W5	6872.0	65.0	43.0	9165.0	2862.0	19022.0	0.368	1.33367
00-16-23-081-13W6	6826.0	46.0	28.0	9130.0	2684.0	18784.0	0.369	1.33753
00-07-19-082-02W6	9539.0	211.0	84.0	14060.0	2175.0	26079.0	0.287	1.47395
00-07-21-082-06W6	5980.0	86.0	45.0	7323.0	3743.0	17184.0	0.4	1.22458
00-07-08-082-11W6	7548.0	106.0	53.0	10600.0	2345.0	20681.0	0.315	1.40435
00-06-14-082-11W6	7333.0	164.0	52.0	10560.0	2040.0	20157.0	0.457	1.44007
00-10-20-082-12W6	5014.0	640.0	97.0	8768.0	673.0	15192.0	0.29	1.7487
00-11-32-082-12W6	5836.0	59.0	28.0	7112.0	3530.0	16596.0	0.502	1.21864
00-11-21-083-23W5	6408.0	112.0	39.0	7420.0	4709.0	18739.0	0.405	1.15793
00-10-03-083-10W6	5189.0	90.0	27.0	6840.0	2391.0	14552.0	0.455	1.31817
00-08-06-083-10W6	5322.0	72.0	31.0	7590.0	2111.0	15233.0	0.454	1.42616
00-07-17-083-10W6	6633.0	88.0	38.0	8265.0	3806.0	18847.0	0.39	1.24604
00-11-31-084-24W5	5410.0	41.0	26.0	5450.0	5212.0	16157.0	0.488	1.00739
00-10-28-084-04W6	10690.0	70.0	57.0	14500.0	3920.0	29239.0	0.264	1.35641
00-10-35-084-10W6	11786.0	526.0	238.0	19183.0	1049.0	32787.0	0.185	1.62761
00-11-19-085-05W6	8432.0	276.0	56.0	12363.0	2221.0	23355.0	0.3	1.4662
00-12-20-085-08W6	12141.0	487.0	141.0	19500.0	855.0	33129.0	0.262	1.60613
00-11-36-086-26W5	11468.0	223.0	222.0	17300.0	2403.0	31662.0	0.242	1.50855

BLUESKY WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-06-16-087-25W5	14813.0	322.0	197.0	22900.0	1855.0	40108.0	0.21	1.54594
00-06-30-087-01W6	9090.0	323.0	190.0	13500.0	2800.0	25929.0	0.335	1.48515
00-10-15-087-02W6	9365.0	149.0	100.0	13416.0	2730.0	25760.0	0.246	1.43193
00-13-26-088-02W6	9918.0	123.0	129.0	13846.0	3506.0	27522.0	3.25	1.39605
00-10-11-089-03W6	16033.0	463.0	262.0	25450.0	1370.0	43568.0	0.158	1.58735
00-09-18-089-04W6	18927.0	689.0	447.0	30600.0	1877.0	52575.0	0.14	1.61674
00-10-33-089-11W6	11038.0	457.0	141.0	17535.0	1200.0	30389.0	0.236	1.5886
00-13-16-090-22W5	14684.0	711.0	76.0	20931.0	5350.0	41871.0	0.305	1.42543
00-08-28-090-22W5	13095.0	694.0	66.0	21441.0	305.0	35601.0	0.225	1.63734
00-10-27-090-11W6	19117.0	740.0	296.0	31153.0	870.0	52179.0	0.17	1.6296
00-10-02-090-12W6	16075.0	621.0	220.0	26000.0	913.0	43835.0	0.17	1.61742
00-06-14-091-23W5	6670.0	224.0	119.0	10153.0	1444.0	18656.0	0.379	1.52219
00-10-03-091-11W6	22383.0	961.0	729.0	37500.0	1390.0	63021.0	0.134	1.67538

GETHING WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-07-26-060-21W5	11661.0	646.0	106.0	18600.0	857.0	32335.0	0.237	1.59506
00-14-03-061-22W5	13177.0	371.0	331.0	21342.0	1025.0	36258.0	0.394	1.61964
00-10-22-062-22W5	12206.0	613.0	152.0	19822.0	NA	33693.0	0.195	1.62396
00-07-34-065-03W6	21177.0	631.0	183.0	33250.0	1430.0	56990.0	0.125	1.5701
00-10-09-066-23W5	16693.0	989.0	457.0	28400.0	701.0	47273.0	0.17	1.70131
00-11-15-067-23W5	18172.0	456.0	182.0	28301.0	1800.0	48922.0	0.16	1.5574
00-06-21-067-23W5	19956.0	465.0	78.0	30780.0	1790.0	53084.0	0.126	1.54239
00-10-11-068-24W5	20925.0	375.0	85.0	32500.0	1170.0	55067.0	0.144	1.55317
00-06-16-068-24W5	20034.0	440.0	134.0	30750.0	2270.0	53632.0	0.155	1.53489
00-06-26-068-25W5	22023.0	361.0	111.0	33620.0	2200.0	58359.0	0.137	1.52659
00-12-11-069-22W5	14893.0	472.0	81.0	22796.0	2030.0	40351.0	0.155	1.53065
00-07-19-069-25W5	21053.0	416.0	95.0	32000.0	2534.0	56119.0	0.148	1.51997
00-10-13-070-22W5	17127.0	551.0	145.0	26300.0	2575.0	46721.0	0.184	1.53559
00-03-03-070-23W5	14482.0	615.0	316.0	23529.0	1380.0	40332.0	0.171	1.62471
00-06-18-070-24W5	14943.0	288.0	240.0	23000.0	2130.0	40630.0	0.196	1.53918
00-06-03-070-25W5	17965.0	330.0	134.0	27250.0	2460.0	48147.0	0.173	1.51684
00-02-04-070-01W6	16383.0	369.0	142.0	25423.0	1555.0	43872.0	0.223	1.55179
00-11-14-070-01W6	18752.0	288.0	122.0	28900.0	1490.0	49585.0	0.146	1.54117
00-11-16-071-23W5	15536.0	350.0	232.0	24048.0	2050.0	42229.0	0.21	1.54789
00-05-06-072-23W5	10163.0	521.0	57.0	16192.0	945.0	27899.0	0.268	1.59323
00-02-05-072-23W5	13643.0	207.0	151.0	20927.0	1570.0	36500.0	NA	1.5339
00-06-04-073-03W6	11140.0	208.0	73.0	20160.0	1842.0	33581.0	0.203	1.8097
00-10-31-073-03W6	15557.0	173.0	57.0	23452.0	1723.0	40965.0	0.155	1.50749
00-11-26-074-09W6	8711.0	44.0	27.0	10850.0	3867.0	24266.0	0.293	1.24555
00-14-20-075-04W6	8570.0	110.0	33.0	12040.0	2211.0	23045.0	0.275	1.4049
00-04-19-076-23W5	10870.0	229.0	129.0	16439.0	1893.0	29560.0	0.243	1.51233
00-04-35-077-22W5	11797.0	185.0	145.0	17762.0	1975.0	31920.0	0.198	1.50564
00-10-10-077-26W5	7361.0	128.0	68.0	10250.0	2391.0	20387.0	0.309	1.39247
00-07-27-077-26W5	8694.0	159.0	74.0	12904.0	1703.0	23543.0	0.302	1.48424

GETHING WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-11-25-077-11W6	6527.0	200.0	53.0	9830.0	1226.0	17930.0	0.349	1.50605
00-12-11-078-22W5	11359.0	63.0	121.0	16445.0	2600.0	30618.0	0.36	1.44775
00-10-20-079-22W5	11900.0	83.0	82.0	13800.0	9400.0	35281.0	NA	1.15966
00-01-12-079-22W5	11250.0	170.0	115.0	16750.0	2140.0	30425.0	NA	1.48889
00-04-12-079-23W5	9085.0	85.0	70.0	12860.0	2562.0	24687.0	0.264	1.41552
00-11-28-080-22W5	7426.0	29.0	30.0	8100.0	6063.0	21698.0	0.335	1.09076
00-06-01-080-23W5	8769.0	117.0	52.0	11750.0	3645.0	24353.0	0.32	1.33995
00-06-23-080-23W5	9223.0	84.0	70.0	13125.0	2459.0	24998.0	0.26	1.42307
00-05-31-080-25W5	6446.0	56.0	27.0	8100.0	3459.0	18102.0	0.389	1.25659
00-07-35-080-10W6	6240.0	101.0	29.0	8500.0	1900.0	17255.0	0.5	1.36218
00-11-01-080-11W6	7961.0	158.0	52.0	12000.0	1218.0	21393.0	0.329	1.50735
00-06-36-081-25W5	7618.0	151.0	76.0	11980.0	366.0	20253.0	0.308	1.57259
00-10-11-081-01W6	5497.0	64.0	41.0	7280.0	2420.0	15335.0	0.546	1.32436
00-11-26-081-01W6	5683.0	39.0	28.0	6550.0	4050.0	16363.0	0.419	1.15256
00-15-14-082-25W5	6368.0	46.0	47.0	8410.0	2800.0	17720.0	0.378	1.32067
00-03-27-082-06W6	4600.0	111.0	61.0	5988.0	2440.0	13281.0	NA	1.30174
00-11-07-083-22W5	8452.0	84.0	42.0	10630.0	4560.0	23806.0	0.374	1.25769
00-07-16-083-23W5	8251.0	56.0	19.0	10450.0	4054.0	22930.0	0.298	1.26651
00-11-21-083-23W5	7345.0	86.0	23.0	7800.0	6393.0	21689.0	0.375	1.06195
00-11-15-084-09W6	9731.0	272.0	87.0	14750.0	1680.0	26545.0	0.256	1.51577
00-14-13-085-12W6	9837.0	297.0	102.0	15030.0	1660.0	26928.0	0.267	1.5279
00-11-13-086-26W5	7004.0	48.0	48.0	7860.0	5412.0	20402.0	0.376	1.12222
00-10-23-086-01W6	13393.0	348.0	237.0	20620.0	2265.0	36889.0	0.195	1.53961
00-14-25-086-01W6	14386.0	468.0	381.0	23500.0	1003.0	39802.0	0.181	1.63353
00-10-36-086-01W6	13050.0	318.0	193.0	19750.0	2518.0	35885.0	0.227	1.51341
00-10-27-086-09W6	12538.0	701.0	207.0	20750.0	740.0	34941.0	0.213	1.65497
00-11-31-086-09W6	11189.0	364.0	171.0	17560.0	1430.0	30728.0	0.234	1.5694
00-07-06-087-25W5	12355.0	242.0	305.0	19260.0	1884.0	34073.0	0.197	1.55888
00-11-08-087-25W5	4046.0	62.0	80.0	5925.0	1039.0	11224.0	0.545	1.46441
00-06-09-087-25W5	11248.0	172.0	185.0	17200.0	1684.0	30509.0	0.222	1.52916

GETHING WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-10-27-087-01W6	9373.0	244.0	138.0	13984.0	2050.0	25940.0	0.302	1.49195
00-11-14-087-02W6	8665.0	42.0	51.0	11460.0	3633.0	23874.0	0.288	1.32256
00-10-15-087-02W6	7504.0	46.0	21.0	8290.0	5880.0	21752.0	0.324	1.10474
00-03-32-087-03W6	12848.0	212.0	221.0	19050.0	2810.0	35352.0	0.208	1.48272
00-02-28-087-04W6	8769.0	335.0	143.0	13350.0	2030.0	24635.0	0.367	1.52241
00-08-25-087-07W6	11478.0	580.0	176.0	18431.0	NA	31854.0	0.214	1.60577
00-10-27-088-22W5	13391.0	184.0	213.0	19000.0	4433.0	37254.0	0.211	1.41886
00-05-11-088-01W6	13100.0	392.0	228.0	20800.0	1390.0	35910.0	0.19	1.58779
00-11-35-088-07W6	14174.0	165.0	129.0	20367.0	3695.0	38535.0	0.17	1.43693
00-10-08-089-25W5	11863.0	445.0	296.0	19091.0	1391.0	33141.0	0.2	1.60929
00-09-18-089-04W6	10823.0	356.0	221.0	17288.0	989.0	29823.0	0.22	1.59734
00-10-29-089-07W6	28819.0	881.0	452.0	45500.0	3037.0	78776.0	0.098	1.57882
00-06-36-090-25W5	12561.0	340.0	164.0	19500.0	1420.0	34162.0	0.228	1.55242
00-07-03-090-10W6	8285.0	300.0	66.0	12440.0	1416.0	22832.0	0.286	1.50151

CADOMIN WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-12-01-065-02W6	23759.0	501.0	73.0	37000.0	1270.0	62616.0	0.154	1.5573
00-02-12-089-08W6	32363.0	831.0	313.0	51034.0	1679.0	86585.0	0.086	1.5769
00-10-20-067-05W6	27645.0	1017.0	238.0	44504.0	1090.0	74494.0	0.12	1.60984
00-06-26-068-02W6	20988.0	170.0	127.0	32090.0	1611.0	54991.0	0.134	1.52897
00-11-09-068-04W6	25026.0	625.0	131.0	39400.0	1160.0	66365.0	0.123	1.57436
00-10-21-068-04W6	21454.0	633.0	228.0	34200.0	1125.0	57672.0	0.14	1.59411
00-11-35-068-07W6	30652.0	1437.0	540.0	50761.0	1051.0	84448.0	0.177	1.65604
00-06-25-071-10W6	23355.0	875.0	363.0	37800.0	1115.0	63757.0	0.11	1.6185
00-11-33-072-06W6	21089.0	497.0	127.0	33030.0	1081.0	55989.0	0.126	1.56622
00-04-06-073-04W6	20602.0	376.0	92.0	32000.0	1220.0	54294.0	0.128	1.55325
00-10-30-073-09W6	19049.0	1201.0	24.0	30300.0	1950.0	52722.0	0.142	1.59063
00-15-09-074-01W6	1720.0	9.0	5.0	671.0	3348.0	5841.0	1.73	0.39011
00-10-23-074-01W6	3998.0	35.0	3.0	1900.0	7450.0	13394.0	0.88	0.47523
00-07-24-074-02W6	4868.0	8.0	1.0	3049.0	7590.0	15596.0	0.55	0.62633
00-04-08-074-06W6	18966.0	373.0	95.0	29256.0	1562.0	50273.0	0.12	1.54255
00-06-22-074-06W6	19771.0	451.0	109.0	30553.0	1810.0	52707.0	0.136	1.54534
00-04-13-074-11W6	21089.0	654.0	236.0	33548.0	1391.0	56922.0	0.139	1.59078
00-05-29-075-02W6	3220.0	38.0	12.0	1535.0	6068.0	10945.0	0.847	0.47670
00-11-36-075-05W6	4825.0	26.0	10.0	3605.0	6700.0	15189.0	0.575	0.74715
00-10-21-075-07W6	22300.0	681.0	225.0	35300.0	1635.0	60253.0	0.116	1.58296
00-10-30-063-24W5	23613.0	545.0	129.0	37000.0	1311.0	62600.0	0.136	1.56693
00-10-28-063-26W5	23048.0	598.0	91.0	36187.0	1152.0	61076.0	0.106	1.57007
00-10-35-063-26W5	25220.0	328.0	153.0	39250.0	1165.0	66120.0	0.13	1.5563
00-10-30-062-25W5	23979.0	532.0	140.0	37600.0	1245.0	63515.0	0.131	1.56804
00-04-12-063-25W5	19711.0	640.0	91.0	30995.0	1352.0	52793.0	0.13	1.57247
00-10-08-063-25W5	24172.0	434.0	88.0	37850.0	1141.0	64108.0	0.136	1.56586
00-04-11-063-26W5	25699.0	793.0	162.0	40303.0	1196.0	68261.0	0.194	1.56827
00-10-35-064-03W6	26251.0	773.0	211.0	42700.0	1176.0	71115.0	NA	1.62661
00-13-11-081-17W6	1912.0	63.0	47.0	1437.0	3000.0	4957.0	NA	0.75156

CADOMIN WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-13-17-081-17W6	2042.0	58.0	32.0	1306.0	3488.0	6941.0	1.23	0.63956
00-11-23-081-22W6	2113.0	47.0	47.0	1716.0	2908.0	6943.0	0.129	0.81211
00-05-27-082-19W6	1817.0	84.0	53.0	1350.0	3010.0	6325.0	0.9	0.74298
00-08-29-083-15W6	2220.0	44.0	18.0	1740.0	2970.0	7162.0	1.12	0.78378
00-06-23-083-17W6	1853.0	66.0	35.0	1420.0	2830.0	6219.0	1.13	0.76632
00-01-09-083-18W6	1696.0	107.0	62.0	1317.0	2850.0	6047.0	1.2	0.77653
00-01-09-083-18W6	1772.0	99.0	72.0	1317.0	3090.0	6386.0	1.2	0.74322
00-14-20-084-13W6	2959.0	49.0	49.0	1700.0	5270.0	7410.0	1.07	0.57451
00-14-07-084-16W6	2070.0	24.0	NA	1260.0	2973.0	6506.0	1.32	0.60869
00-14-07-084-16W6	2890.0	30.0	13.0	1990.0	4142.0	9106.0	0.953	0.68858
00-14-07-084-16W6	2900.0	66.0	12.0	1990.0	4290.0	9282.0	0.942	0.68620
00-14-07-084-16W6	2830.0	46.0	6.0	2100.0	3932.0	8953.0	0.944	0.74204
00-11-23-085-15W6	3332.0	39.0	12.0	2795.0	3730.0	10288.0	0.948	0.83883
00-16-18-085-16W6	2318.0	51.0	17.0	1888.0	2710.0	7326.0	1.17	0.81449
00-11-34-085-19W6	3442.0	72.0	7.0	3156.0	3940.0	10630.0	0.699	0.91690
00-08-17-085-23W6	3210.0	69.0	27.0	3279.0	3211.0	9800.0	0.777	1.02149
00-16-30-086-13W6	2456.0	88.0	39.0	10925.0	3380.0	21745.0	0.353	4.44829
00-04-23-086-21W6	2642.0	28.0	7.0	2326.0	3042.0	8114.0	0.7	0.88039
00-07-05-086-24W6	2723.0	70.0	18.0	2640.0	2490.0	8333.0	0.823	0.96951
00-11-28-087-17W6	12798.0	368.0	152.0	20096.0	1240.0	34050.0	0.216	1.57025
00-06-23-087-25W6	4500.0	68.0	78.0	4620.0	4480.0	13823.0	0.55	1.02667
00-04-34-059-24W5	22390.0	2083.0	218.0	38480.0	620.0	63822.0	0.13	1.71862
00-10-36-059-24W5	24532.0	2672.0	334.0	43268.0	439.0	71245.0	0.11	1.76374
00-10-20-060-23W5	24614.0	1639.0	406.0	41500.0	900.0	69099.0	0.13	1.68603
00-06-33-060-23W5	23880.0	1826.0	430.0	41000.0	540.0	67684.0	0.115	1.71692
00-07-36-061-24W5	25180.0	1477.0	175.0	41600.0	610.0	69056.0	0.112	1.6521
00-06-05-063-22W5	20747.0	861.0	195.0	33486.0	1000.0	56314.0	0.137	1.61402
00-06-24-063-22W5	21203.0	1844.0	398.0	36650.0	815.0	60925.0	0.138	1.72853
00-06-27-063-23W5	23073.0	350.0	114.0	35700.0	1430.0	60681.0	0.136	1.54726
00-10-09-063-26W5	23471.0	562.0	341.0	37750.0	730.0	62471.0	0.131	1.60837

CADOMIN WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-11-34-065-22W5	20409.0	448.0	129.0	31900.0	1288.0	54176.0	0.133	1.56304
00-07-24-074-13W6	28375.0	1218.0	487.0	46600.0	1254.0	77955.0	0.123	1.64229
00-07-10-075-07W6	13715.0	335.0	74.0	21003.0	1610.0	36758.0	0.186	1.53139
00-10-32-076-20W5	18469.0	408.0	272.0	28755.0	2050.0	49959.0	0.15	1.55693
00-10-02-076-02W6	4493.0	38.0	3.0	2545.0	7625.0	14742.0	0.638	0.56643
00-14-23-076-04W6	2900.0	12.0	3.0	1200.0	5456.0	9589.0	1.01	0.41379
00-15-35-076-07W6	3341.0	32.0	2.0	2032.0	5449.0	10921.0	0.788	0.60820
00-16-06-076-07W6	10900.0	232.0	83.0	16380.0	2208.0	29908.0	0.218	1.50275
00-11-04-076-08W6	5862.0	7.0	7.0	5819.0	5500.0	17270.0	0.55	0.99266
00-11-23-076-09W6	4158.0	18.0	9.0	3515.0	5035.0	12771.0	0.79	0.84535
00-14-07-076-11W6	2510.0	18.0	13.0	1500.0	4274.0	6253.0	1.12	0.59761
00-06-10-077-05W6	2770.0	50.0	28.0	1400.0	4587.0	6525.0	0.85	0.50541
00-06-15-077-05W6	2540.0	20.0	7.0	1160.0	5209.0	8959.0	0.953	0.45669
00-16-21-077-06W6	2500.0	26.0	9.0	1155.0	4539.0	8358.0	0.917	0.462
00-07-31-077-07W6	2425.0	19.0	4.0	1095.0	4451.0	8167.0	1.15	0.45154
00-06-23-077-10W6	2437.0	16.0	6.0	1225.0	4432.0	8119.0	1.119	0.50266
00-07-32-077-11W6	2156.0	37.0	3.0	1148.0	3604.0	7158.0	1.27	0.53246
00-07-10-077-12W6	3851.0	10.0	2.0	2320.0	6222.0	12440.0	0.748	0.60244
00-06-18-077-12W6	5549.0	18.0	6.0	4660.0	6710.0	17008.0	0.503	0.83979
00-07-30-078-04W6	2646.0	32.0	7.0	680.0	5980.0	9347.0	1.13	0.25699
00-14-19-078-06W6	1484.0	28.0	7.0	346.0	3460.0	5327.0	2.02	0.23315
00-10-35-078-08W6	2665.0	22.0	5.0	950.0	5500.0	9163.0	1.25	0.35647
00-06-21-078-10W6	2111.0	24.0	2.0	960.0	4000.0	7122.0	1.5	0.45476
00-10-23-078-10W6	2203.0	26.0	1.0	898.0	4320.0	7497.0	1.28	0.40762
00-10-27-078-12W6	2534.0	15.0	7.0	1343.0	4490.0	8391.0	1.19	0.52999
00-06-30-079-03W6	3381.0	36.0	5.0	1692.0	6154.0	11298.0	0.84	0.50044
00-14-33-079-06W6	3050.0	42.0	16.0	920.0	6155.0	10476.0	0.986	0.30163
00-06-29-079-07W6	2722.0	45.0	3.0	849.0	6198.0	10051.0	1.02	0.31190
00-11-17-079-10W6	2890.0	30.0	0.0	1030.0	6000.0	9950.0	NA	0.35640
00-11-07-080-06W6	2781.0	23.0	14.0	780.0	6164.0	9770.0	0.928	0.28047

CADOMIN WATER CHEMISTRY FILE (continued)

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-06-14-080-06W6	3772.0	19.0	17.0	920.0	8564.0	13292.0	0.82	0.24390
00-06-33-080-06W6	3654.0	21.0	10.0	797.0	8400.0	12910.0	0.959	0.21811
00-14-24-080-07W6	2980.0	40.0	8.0	810.0	6771.0	10689.0	0.817	0.27181
00-11-23-080-09W6	2450.0	40.0	1.0	900.0	4707.0	8238.0	1.25	0.36734
00-10-26-080-10W6	3006.0	30.0	9.0	912.0	6310.0	10450.0	0.934	0.30339
00-14-26-080-12W6	2940.0	15.0	10.0	1150.0	5819.0	10067.0	0.98	0.39115
00-07-33-080-13W6	2055.0	35.0	10.0	962.0	3950.0	7015.0	1.44	0.46812
00-11-01-081-04W6	3864.0	30.0	16.0	2000.0	6980.0	12892.0	0.803	0.51759
00-10-05-081-05W6	2834.0	32.0	5.0	735.0	6370.0	NA	1.1	0.25935
00-07-17-081-08W6	2525.0	26.0	22.0	880.0	5280.0	8807.0	1.15	0.34851
00-01-33-081-10W6	2845.0	45.0	15.0	962.0	5980.0	9944.0	0.84	0.33813
00-10-32-082-07W6	3896.0	42.0	6.0	817.0	9013.0	13832.0	0.886	0.20970
00-06-10-082-08W6	2860.0	81.0	2.0	1000.0	6051.0	10224.0	1.06	0.34965
00-03-33-082-10W6	2571.0	32.0	7.0	1130.0	4985.0	8746.0	1.94	0.43951
00-07-27-083-01W6	3307.0	181.0	70.0	2180.0	6340.0	12369.0	0.809	0.65920
00-11-06-083-08W6	3233.0	24.0	9.0	1410.0	6225.0	10936.0	0.971	0.43612
00-10-19-083-08W6	3353.0	32.0	9.0	1481.0	6480.0	11355.0	0.814	0.44169
00-10-08-083-09W6	2975.0	42.0	16.0	1408.0	5675.0	10118.0	0.91	0.47327
00-10-23-083-09W6	2992.0	34.0	17.0	1865.0	4899.0	9823.0	0.867	0.62332
00-07-17-083-10W6	4138.0	12.0	9.0	1519.0	8369.0	14102.0	0.71	0.36708
00-06-02-084-07W6	2829.0	32.0	5.0	1127.0	5680.0	9673.0	0.059	0.39837
00-16-01-084-09W6	3273.0	43.0	22.0	1460.0	6352.0	11255.0	0.883	0.44607
00-08-03-084-12W6	3190.0	59.0	0.0	1580.0	5338.0	10203.0	0.885	0.49529
00-08-28-084-12W6	3856.0	29.0	11.0	2290.0	6169.0	12666.0	0.816	0.59388
00-07-11-085-03W6	3884.0	36.0	10.0	2450.0	5951.0	12563.0	0.703	0.63079
00-11-19-085-11W6	5835.0	38.0	12.0	5010.0	6960.0	17916.0	0.475	0.85861
00-08-19-085-12W6	3962.0	32.0	15.0	3675.0	4621.0	12406.0	0.635	0.92756
00-16-25-085-13W6	4400.0	20.0	31.0	4130.0	5431.0	14155.0	0.596	0.93863
00-06-16-089-07W6	33000.0	1241.0	447.0	53300.0	1531.0	89809.0	0.098	1.61515
00-13-15-089-09W6	24534.0	676.0	245.0	38900.0	1380.0	65807.0	0.132	1.58556

NIKANASSIN WATER CHEMISTRY FILE

LOC	Na	Ca	Mg	Cl	HCO3	TDS	RW	ClNa
00-06-02-068-04W6	16558.0	231.0	73.0	24250.0	878.0	44051.0	0.284	1.46455
00-06-14-069-08W6	11201.0	446.0	121.0	18200.0	344.0	30339.0	0.251	1.62486
00-06-14-069-08W6	18620.0	777.0	229.0	30500.0	417.0	50572.0	0.155	1.63802
00-06-11-073-08W6	21551.0	809.0	279.0	35000.0	1039.0	58546.0	0.122	1.62405
00-14-14-073-09W6	21707.0	621.0	97.0	34000.0	1686.0	58259.0	0.127	1.56631
00-14-17-073-09W6	13434.0	517.0	66.0	21850.0	1448.0	36664.0	0.193	1.62647
00-10-30-073-09W6	19049.0	1201.0	24.0	30300.0	1950.0	52722.0	0.142	1.59063
00-06-06-074-09W6	18496.0	390.0	131.0	28350.0	2336.0	49882.0	0.155	1.53276
00-01-20-074-11W6	23000.0	638.0	260.0	36000.0	1347.0	61386.0	0.225	1.56522
00-08-05-075-08W6	9348.0	51.0	26.0	12280.0	3943.0	25765.0	0.268	1.31365
00-15-34-077-01W6	8350.0	118.0	77.0	11900.0	2380.0	22825.0	NA	1.42515
00-11-05-068-06W6	29964.0	1032.0	360.0	48800.0	498.0	80662.0	0.109	1.62862
00-11-05-068-06W6	29634.0	1216.0	404.0	48500.0	923.0	80683.0	0.109	1.63663

APPENDIX III

WATER CLASSIFICATION SYSTEMS

APPENDIX III

WATER CLASSIFICATION SYSTEMS

Formation waters may be classified by a variety of systems based upon the relative concentrations of dissolved chemical constituents. The objective of classification systems is to provide a basis for grouping chemically related waters. The ions most commonly used in classification systems are the six major ions normally determined by standard water analyses, namely, sodium, calcium, magnesium, chloride, bicarbonate and sulphate.

Palmer (1911) described five basic characteristics of waters based on the properties of salinity and alkalinity. Basically, salinity is a measure of the salts of strong acids and alkalinity is a measure of the salts of weak acids. The relative concentrations of the major ions determine the salinity and alkalinity which Palmer (1911) divided into:

(1) primary salinity - strong acid radicals (sulphate, chloride) combined with the primary bases (sodium, potassium). The salinity is not to exceed twice the sum of the reacting values of the alkali ions.

(Reacting values are simply a way of describing the electrochemical composition of the ions in a water sample. Ion concentrations in milligrams per litre (mg/l) are converted to equivalents per million (epm), or milligram equivalents per litre (meq/l), by dividing by the equivalent weight of a particular ion. Equivalent weight equals the molecular weight divided by the ion valence).

(2) Secondary salinity - strong acids combined with alkaline earth secondary bases (calcium, magnesium). The excess of salinity over primary salinity is not to exceed twice the reacting values of the ions of the alkaline earth group.

(3) Tertiary salinity - this is any salinity in excess of the primary and secondary salinity.

(4) Primary alkalinity - weak acids (carbonate, bicarbonate, sulphide) combined with primary bases. The excess of twice the sum of the reacting values of the alkalies over salinity.

(5) Secondary alkalinity - weak acids combined with secondary bases. The excess of twice the sum of the reacting values of the ions of the alkaline earth group over secondary salinity.

The Palmer system divides water into five classes based on the numerical relationship between anions and cations. To use this system, ionic concentrations must be expressed in percent reacting values. These percentage values are determined by summing the milligram equivalents of all the ions, dividing the milligram equivalents of a given ion by that sum and multiplying by 100. Three ion groups are then calculated,

a - alkalies (sodium, potassium)

b- alkaline earths (calcium, magnesium)

d- hydrogen (strong acid anions).

These groups determine the five Palmer classes as follows:

<u>Class 1:</u> $d < a$
$2d$ = primary salinity
$2(a - d)$ = primary alkalinity
$2b$ = secondary alkalinity

<u>Class 2:</u> $d = a$
$2a$ or $2d$ = primary salinity
$2b$ = secondary alkalinity

<u>Class 3:</u> $d > a$: $d < (a + b)$
$2a$ = primary salinity
$2(d - a)$ = secondary salinity
$2(a + b - d)$ = secondary alkalinity

<u>Class 4:</u> $d = (a + b)$
$2a$ = primary salinity
$2b$ = secondary salinity

Class 5: $d > (a + b)$
$2a$ = primary salinity
$2b$ = secondary salinity
$2(d - a - b)$ = tertiary salinity

Palmer (1911) described the first three classes to be various surface waters, class 4 to represent sea water and brines, and class 5 to include mine drainage waters and water of volcanic origin.

Sulin (1946) proposed a classification system to categorize waters into genetic types, groups and subgroups, based upon various ratios of dissolved salts in water. The Sulin system incorporated the Palmer classes to help express the salinity and alkalinity properties of the waters, i.e., the dissolved constituents, in a detailed manner.

Natural waters were divided into four basin environments to define genetic water "types".

Type 1: continental or terrestrial conditions which promote the formation of sulphate waters, "sulphate-sodium type"

Type 2: continental conditions which promote the formation of sodium-bicarbonate waters, "bicarbonate-sodium type"

Type 3: marine conditions, "chloride-magnesium type"

Type 4: deep subsurface conditions, "chloride-calcium type" waters.

Calculations to determine water type are based on ionic concentrations which must be expressed in percent reacting values. The ratio Na/Cl is used to determine whether a water should be classified primarily as meteoric or marine. Two other ion ratios are then calculated: if $(Na\text{-}Cl)/SO_4$ is greater than one, it indicates a bicarbonate-sodium type water, while if it is less than one, it is the sulphate-sodium type. Similarly, if the ratio (Cl-Na)/Mg is less than one, it is indicative of chloride-magnesium waters, while if greater than one, indicates the chloride-calcium type. These conditions are summarized in Table AIII-1.

TABLE AIII-1

Coefficients characterizing Sulin's genetic water types

Type of water	Na^+/Cl^-	$(Na^+ - Cl^-)/SO_4^{-2}$	$(Cl^- - Na^+)/Mg^{+2}$
Chloride-calcium	< 1	< 0	> 1
Chloride-magnesium	< 1	< 0	< 1
Bicarbonate-sodium	> 1	> 1	< 0
Sulfate-sodium	> 1	< 1	< 0

The water types are subdivided into groups and subgroups. Basically groups indicate the predominant anion present and subgroups indicate the predominant cation. The Palmer classification system is used to express the dissolved constituents in classes as follows:

A_1 - primary alkalinity predominates

A_2 - secondary alkalinity predominates

A_3 - tertiary alkalinity predominates

S_1 - primary salinity predominates

S_2 - secondary salinity predominates

S_3 - tertiary salinity predominates

The complete detailed system of types, groups, subgroups and classes is shown in Table AIII-2.

The combination of the two classification schemes provides useful insight into the origin and distribution of subsurface waters and has been adopted for use in this study. It is interesting to note that Sulin (1946) determined that hydrocarbon accumulations are most commonly associated with water types in the following order: Type 4 > Type 2 > Type 3 > Type 1. Mapping the water types can thus be of interest in hydrocarbon exploration.

The following pages list the calculated Sulin ratios and the resultant classification of water type, as well as the Palmer ion groups and resultant Palmer class. The data are listed by formation in stratigraphic order beginning with the Paddy Member of the Peace River Formation and ending with the Cadomin Formation.

Maps of Sulin-Palmer water types are provided in Chapter 2 (Figures 2.25, 2.26, 2.31, 2.32, 2.33).

TABLE AIII-2

Sulin's method of water characterization

$Na/Cl > 1$

Sulfate-sodium type: $\frac{(Na^+ - Cl^-)}{SO_4^{-2}} < 1$

- Bicarbonate group
  - class A_2
    - calcium subgroup
    - magnesium subgroup
- Sulfate group
  - class S_1
    - calcium subgroup
    - magnesium subgroup
    - sodium subgroup
  - class S_2
    - calcium subgroup
    - magnesium subgroup
- Chloride group
  - class S_1
    - calcium subgroup
    - magnesium subgroup
    - sodium subgroup

Bicarbonate-sodium type: $\frac{(Na^+ - Cl^-)}{SO_4^{-2}} > 1$

- Bicarbonate group
  - class A_1
    - sodium subgroup
  - class A_2
    - calcium subgroup
    - magnesium subgroup
    - sodium subgroup
  - class S_1
    - sodium subgroup
- Sulfate group
  - class S_1
    - sodium subgroup
- Chloride group
  - class S_1
    - sodium subgroup

$Na/Cl < 1$

Chloride-magnesium type: $\frac{(Cl^- - Na^+)}{Mg^{+2}} < 1$

- Bicarbonate group
  - class A_2
    - calcium subgroup
    - magnesium subgroup
- Sulfate group
  - class S_1
    - calcium subgroup
    - magnesium subgroup
  - class S_2
    - calcium subgroup
    - magnesium subgroup
- Chloride group
  - class S_1
    - calcium subgroup
    - magnesium subgroup
    - sodium subgroup
  - class S_2
    - calcium subgroup
    - magnesium subgroup

Chloride-calcium type: $\frac{(Cl^- - Na^+)}{Mg^{+2}} > 1$

- Bicarbonate group
  - class A_2
    - calcium subgroup
    - magnesium subgroup
- Sulfate group
  - class S_1
    - calcium subgroup
    - magnesium subgroup
  - class S_2
    - calcium subgroup
    - magnesium subgroup
- Chloride group
  - class S_1
    - calcium subgroup
    - magnesium subgroup
    - sodium subgroup
  - class S_2
    - calcium subgroup
    - magnesium subgroup

(Ostroff, 1967)

REFERENCES

Ostroff, A.G., 1967: Comparison of some formation water classification systems; Amer. Assoc. of Pet. Geol. Bull., Vol. 51, No. 3, pp. 404-416.

Palmer, C., 1911: The geochemical interpretation of water analyses: U.S. Geol. Survey Bulletin, 479, 31 pp.

Sulin, V.A., 1946: Waters of petroleum formations in the system of natural waters; Moscow, Gostoptekhizdat, pp. 35-96.

LOCATION	FORM	Na/Cl	(Cl-Na)/Mg	(Na-Cl)/SO4	SULIN CLASSIFICATION	a=Na+K	b=Ca+Mg	d=SO4+Cl	CLASS
11-35-65-04W6	PADDY	1.42	-41.24	244.51	bicarbonate-sodium	49.15	0.85	34.54	1
03-26-74-06W6	PADDY	0.98	0.72	-12.67	chloride-magnesium	47.25	2.75	47.07	3
03-03-74-07W6	PADDY	1.00	0.32	-5.00	chloride-magnesium	48.18	1.82	48.35	3
06-33-74-07W6	PADDY	0.96	0.97	-17.82	chloride-magnesium	46.34	3.66	48.20	3
07-26-74-09W6	PADDY	1.01	-1.06	6.20	bicarbonate-sodium	48.12	1.88	47.66	1
06-23-75-22W5	PADDY	0.96	1.46	-58.72	chloride-calcium	47.05	2.95	49.03	3
10-18-75-04W6	PADDY	0.92	1.45	ERR	chloride-calcium	44.60	5.40	48.53	3
06-06-75-06W6	PADDY	1.05	-2.37	85.28	bicarbonate-sodium	47.95	2.05	45.73	1
06-16-75-06W6	PADDY	1.02	-1.28	12.74	bicarbonate-sodium	47.78	2.22	46.88	1
10-21-75-06W6	PADDY	0.99	0.93	-9.91	chloride-magnesium	47.77	2.23	48.52	3
06-06-75-07W6	PADDY	1.00	-0.20	0.43	sulphate-sodium	47.94	2.06	47.86	1
11-02-76-23W5	PADDY	0.97	1.51	-147.12	chloride-calcium	47.42	2.58	48.93	3
11-19-76-07W6	PADDY	0.99	0.32	-19.78	chloride-magnesium	46.91	3.09	47.45	3
08-12-76-08W6	PADDY	0.96	0.85	-6.06	chloride-magnesium	45.53	4.47	47.68	3
16-16-76-09W6	PADDY	0.94	1.33	-18.08	chloride-calcium	45.08	4.92	48.29	3
10-19-76-09W6	PADDY	1.00	0.23	-0.57	chloride-magnesium	48.22	1.78	48.58	3
06-27-76-09W6	PADDY	0.99	1.23	-11.37	chloride-calcium	47.81	2.19	48.43	3
01-25-76-10W6	PADDY	1.01	-0.83	1.32	bicarbonate-sodium	47.89	2.11	47.74	1
07-25-76-10W6	PADDY	1.02	-1.89	0.77	sulphate-sodium	48.05	1.95	48.18	3
06-03-76-12W6	PADDY	1.00	-0.05	0.30	sulphate-sodium	46.99	3.01	47.09	3
06-23-77-07W6	PADDY	1.02	-1.00	7.22	bicarbonate-sodium	47.92	2.08	47.15	1
08-02-77-08W6	PADDY	0.98	0.92	-21.63	chloride-magnesium	47.49	2.51	48.29	3
16-05-77-09W6	PADDY	0.99	0.88	-10.66	chloride-magnesium	47.84	2.16	48.50	3
06-08-77-11W6	PADDY	1.00	-0.29	2.13	bicarbonate-sodium	47.88	2.12	47.77	1
16-23-77-11W6	PADDY	1.01	-0.65	2.97	bicarbonate-sodium	47.77	2.23	47.46	1
11-28-77-11W6	PADDY	1.01	-0.86	ERR	unk	48.57	1.43	48.29	1
07-32-77-11W6	PADDY	1.00	0.17	-3.44	chloride-magnesium	47.79	2.21	48.03	3
06-33-77-11W6	PADDY	1.05	-1.68	7.19	bicarbonate-sodium	47.52	2.48	45.69	1
07-35-77-11W6	PADDY	1.01	-0.65	3.09	bicarbonate-sodium	47.66	2.34	47.19	1
07-10-77-12W6	PADDY	0.99	0.81	-11.45	chloride-magnesium	47.63	2.37	48.22	3
12-20-78-06W6	PADDY	0.98	0.67	-1.18	chloride-magnesium	47.62	2.38	49.41	3
10-35-78-08W6	PADDY	0.98	1.14	-34.28	chloride-calcium	47.25	2.75	48.38	3
06-21-78-10W6	PADDY	1.01	-0.98	5.01	bicarbonate-sodium	48.02	1.98	47.52	1
10-23-78-10W6	PADDY	0.99	0.70	-6.56	chloride-magnesium	47.58	2.42	48.22	3
06-07-78-11W6	PADDY	0.94	1.32	-11.97	chloride-calcium	45.16	4.84	47.93	3
06-18-79-08W6	PADDY	0.99	0.57	-10.15	chloride-magnesium	47.91	2.09	48.50	3
07-21-79-08W6	PADDY	0.99	0.47	-16.70	chloride-magnesium	47.74	2.26	48.34	3
07-01-79-09W6	PADDY	0.98	1.04	-5.39	chloride-calcium	47.44	2.56	48.62	3
11-23-79-10W6	PADDY	0.98	0.89	-95.43	chloride-magnesium	47.37	2.63	48.19	3
11-23-79-10W6	PADDY	0.96	1.80	-28.41	chloride-calcium	46.90	3.10	49.06	3
07-29-79-10W6	PADDY	1.00	0.03	-0.97	chloride-magnesium	47.62	2.38	47.66	3
06-31-79-10W6	PADDY	1.01	-1.57	7.49	bicarbonate-sodium	47.60	2.40	47.17	1
10-16-80-01W6	PADDY	0.97	1.36	-2.42	chloride-calcium	47.10	2.90	49.01	3
07-07-80-05W6	PADDY	0.96	1.57	ERR	chloride-calcium	46.81	3.19	48.68	3
10-26-80-10W6	PADDY	1.00	0.29	-4.27	chloride-magnesium	47.70	2.30	47.99	3
10-36-80-11W6	PADDY	1.01	-0.41	ERR	unk	47.96	2.04	47.71	1
08-01-81-04W6	PADDY	1.00	-0.16	0.10	sulphate-sodium	47.16	2.84	48.86	3
10-14-82-04W6	PADDY	0.99	0.59	-3.88	chloride-magnesium	48.31	1.69	49.17	3

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
05-18-62-25W5	CDT	1.23	-17.99	69.95	bicarbonate-sodium	48.85	1.15	39.69	1
09-09-62-26W5	CDT	1.32	-45.55	126.02	bicarbonate-sodium	49.10	0.90	37.31	1
02-03-64-26W5	CDT	1.36	-65.92	28.67	bicarbonate-sodium	49.31	0.69	36.71	1
06-10-64-02W6	CDT	1.60	-492.30	8.51	bicarbonate-sodium	48.89	1.11	32.61	1
06-10-64-02W6	CDT	1.50	-125.44	8.70	bicarbonate-sodium	49.35	0.65	34.66	1
11-35-65-04W6	CDT	1.42	-41.24	244.51	bicarbonate-sodium	49.15	0.85	34.54	1
11-07-66-04W6	CDT	1.21	-44.78	177.02	bicarbonate-sodium	49.26	0.74	40.76	1
11-07-66-04W6	CDT	1.46	-75.45	492.34	bicarbonate-sodium	49.36	0.64	33.87	1
10-26-66-05W6	CDT	1.08	-9.86	75.34	bicarbonate-sodium	48.94	1.06	45.33	1
10-28-66-05W6	CDT	1.09	-10.82	39.72	bicarbonate-sodium	49.03	0.97	45.24	1
07-13-66-09W6	CDT	1.13	-11.19	287.38	bicarbonate-sodium	48.03	1.97	42.50	1
07-13-66-09W6	CDT	1.14	-14.69	667.83	bicarbonate-sodium	47.97	2.03	41.88	1
10-32-67-04W6	CDT	1.20	-27.29	87.31	bicarbonate-sodium	49.17	0.83	41.08	1
01-29-68-26W5	CDT	1.00	0.20	-9.50	chloride-magnesium	48.07	1.93	48.25	3
04-08-68-01W6	CDT	1.05	-2.77	2.61	bicarbonate-sodium	48.29	1.71	46.94	1
11-06-68-02W6	CDT	1.04	-3.00	ERR	unk	48.51	1.49	46.59	1
10-30-68-06W6	CDT	1.08	-14.31	37.72	bicarbonate-sodium	48.91	1.09	45.04	1
06-34-68-07W6	CDT	1.08	-4.87	ERR	unk	48.12	1.88	44.46	1
07-33-68-11W6	CDT	1.18	-12.96	92.70	bicarbonate-sodium	48.60	1.40	41.19	1
01-02-69-22W5	CDT	1.01	-0.36	6.05	bicarbonate-sodium	47.77	2.23	47.44	1
06-06-69-23W5	CDT	1.03	-1.60	139.19	bicarbonate-sodium	48.37	1.63	47.08	1
06-06-70-25W5	CDT	1.01	-1.49	.12	bicarbonate-sodium	48.02	1.98	47.39	1
06-23-70-10W6	CDT	1.06	-5.01	4.03	bicarbonate-sodium	48.66	1.34	46.73	1
04-04-71-23W5	CDT	0.99	0.07	-89.59	chloride-magnesium	47.98	2.02	48.68	3
07-34-71-24W5	CDT	0.99	0.51	-12.44	chloride-magnesium	47.54	2.46	48.09	3
06-29-71-03W6	CDT	1.05	-2.19	28.49	bicarbonate-sodium	47.56	2.44	45.35	1
07-13-71-12W6	CDT	0.98	0.76	-33.60	chloride-magnesium	46.93	3.07	47.87	3
07-13-71-12W6	CDT	0.99	0.45	-6.89	chloride-magnesium	46.53	3.47	46.98	3
07-13-71-12W6	CDT	1.00	-0.14	1.86	bicarbonate-sodium	47.40	2.60	47.18	1
11-16-71-12W6	CDT	1.01	-0.56	6.92	bicarbonate-sodium	47.00	3.00	46.64	1
11-21-71-12W6	CDT	1.05	-3.05	218.50	bicarbonate-sodium	48.23	1.77	45.92	1
06-29-72-13W6	CDT	0.97	1.18	-17.73	chloride-calcium	46.65	3.35	48.04	3
06-29-72-13W6	CDT	0.97	1.82	-12.13	chloride-calcium	46.28	3.72	47.59	3
06-29-72-13W6	CDT	0.97	1.52	-26.94	chloride-calcium	46.39	3.61	47.79	3
06-33-73-05W6	CDT	0.96	1.57	ERR	chloride-calcium	46.94	3.06	48.89	3
06-33-73-05W6	CDT	0.96	1.22	ERR	chloride-calcium	46.96	3.04	48.75	3
04-14-73-07W6	CDT	1.00	-0.07	0.65	sulphate-sodium	48.03	1.97	48.06	3
07-33-73-10W6	CDT	1.03	-2.65	26.79	bicarbonate-sodium	48.42	1.58	47.18	1
10-12-74-05W6	CDT	0.93	1.42	-105.15	chloride-calcium	45.73	4.27	49.05	3
04-13-74-11W6	CDT	1.02	-1.06	17.72	bicarbonate-sodium	48.22	1.78	47.53	1
06-32-75-25W5	CDT	0.97	1.09	-21.16	chloride-calcium	47.15	2.85	48.72	3
10-25-75-05W6	CDT	0.93	2.83	-688.82	chloride-calcium	46.05	3.95	49.44	3
10-25-75-05W6	CDT	0.94	3.36	-64.11	chloride-calcium	46.14	3.86	49.26	3
10-25-75-05W6	CDT	0.94	2.57	-66.37	chloride-calcium	46.22	3.78	49.47	3
10-25-75-05W6	CDT	0.93	2.88	-192.26	chloride-calcium	46.07	3.93	49.35	3
10-08-75-07W6	CDT	1.01	-0.61	16.43	bicarbonate-sodium	47.99	2.01	47.55	1
06-22-75-07W6	CDT	0.95	0.60	-45.84	chloride-magnesium	44.35	5.65	46.94	3
11-33-75-07W6	CDT	0.99	0.44	-1.16	chloride-magnesium	46.86	3.14	47.70	3
11-35-75-08W6	CDT	1.01	-0.75	9.13	bicarbonate-sodium	48.04	1.96	47.47	1
06-03-76-08W6	CDT	0.99	0.42	-5.28	chloride-magnesium	47.65	2.35	48.11	3
11-04-76-08W6	CDT	1.00	0.26	-1.09	chloride-magnesium	47.89	2.11	48.26	3

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
07-09-76-08W6	CDT	1.01	-0.50	1.13	bicarbonate-sodium	48.06	1.94	48.03	1
10-13-76-09W6	CDT	0.94	1.21	-121.60	chloride-calcium	43.64	4.36	48.21	3
06-27-76-09W6	CDT	1.00	0.31	-2.78	chloride-magnesium	47.75	2.25	48.00	3
06-23-77-07W6	CDT	1.01	-1.17	ERR	unk	47.26	2.74	46.76	1
03-26-77-07W6	CDT	1.01	-0.35	1.86	bicarbonate-sodium	47.57	2.43	47.22	1
11-18-77-08W6	CDT	0.99	0.76	-3.16	chloride-magnesium	47.71	2.29	48.35	3
11-16-77-10W6	CDT	0.90	3.54	-35.67	chloride-calcium	44.96	5.04	49.95	3
11-16-77-10W6	CDT	0.97	1.22	-10.40	chloride-calcium	47.27	2.73	48.70	3
11-16-77-10W6	CDT	0.98	1.05	-9.07	chloride-calcium	47.38	2.62	48.65	3
11-16-77-10W6	CDT	1.00	-0.00	ERR	unk	47.61	2.39	47.61	2
10-31-77-11W6	CDT	1.02	-2.05	5.16	bicarbonate-sodium	47.92	2.08	47.03	1
07-32-77-11W6	CDT	1.03	-1.17	ERR	unk	47.69	2.31	46.48	1
06-33-77-11W6	CDT	1.02	-1.15	30.81	bicarbonate-sodium	48.28	1.72	47.42	1
11-34-77-12W6	CDT	1.00	-0.26	2.39	bicarbonate-sodium	47.91	2.09	47.70	1
11-34-77-12W6	CDT	1.02	-60.03	80.26	bicarbonate-sodium	48.32	1.68	47.58	1
10-35-78-02W6	CDT	0.97	1.23	-11.76	chloride-calcium	47.24	2.76	48.61	3
07-07-78-12W6	CDT	1.01	-0.80	18.21	bicarbonate-sodium	47.81	2.19	47.27	1
10-09-78-13W6	CDT	1.01	-0.68	8.31	bicarbonate-sodium	47.76	2.24	47.48	1
13-12-78-13W6	CDT	1.00	-0.01	0.14	sulphate-sodium	47.83	2.17	47.85	3
01-12-79-22W5	CDT	0.96	1.65	ERR	chloride-calcium	47.13	2.87	49.07	3
10-20-79-22W5	CDT	0.95	1.62	-33.45	chloride-calcium	46.96	3.04	49.25	3
07-10-79-02W6	CDT	0.99	0.11	-0.37	chloride-magnesium	44.87	5.13	49.04	3
07-24-79-11W6	CDT	1.04	ERR	26.20	bicarbonate-sodium	48.38	1.62	46.77	1
10-33-81-23W5	CDT	0.97	1.27	-10.61	chloride-calcium	47.36	2.64	49.09	3
07-13-81-05W6	CDT	0.98	0.55	-4.13	chloride-magnesium	46.80	3.20	47.60	3

LOCATION	FORM	Na/Cl	(Cl-Na)/Mg	(Na-Cl)/SO4	SULIN CLASSIFICATION	a=Na+K	b=Ca+Mg	d=SO4+Cl	CLASS
11-04-66-23W5	WOT	1.01	-0.39	0.30	sulphate-sodium	45.53	4.45	45.85	3
16-25-78-01W6	WOT	0.96	1.46	-16.74	chloride-calcium	47.54	2.46	49.65	3
12-20-78-06W6	WOT	0.95	1.61	-3.78	chloride-calcium	46.85	3.15	49.68	3
01-12-79-22W5	WOT	0.96	1.80	ERR	chloride-calcium	47.32	2.68	49.38	3
03-28-79-22W5	WOT	1.01	-3.36	ERR	unk	49.73	0.27	49.19	1
06-17-80-01W6	WOT	0.96	1.75	-13.42	chloride-calcium	47.12	2.88	49.65	3
09-04-81-05W6	WOT	1.00	-0.01	0.04	sulphate-sodium	47.38	2.62	47.51	3
03-27-82-06W6	WOT	0.98	0.99	-23.75	chloride-magnesium	47.89	2.11	48.88	3
13-15-89-09W6	WOT	0.93	2.53	-37.40	chloride-calcium	45.67	4.33	49.29	3

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
07-27-79-01W6	BLSKY	1.17	36.91	-14.13	bicarbonate-sodium	49.01	0.99	42.00	1
06-18-79-05W6	BLSKY	0.96	-53.70	1.50	chloride-calcium	46.57	3.43	48.51	3
11-20-80-23W5	BLSKY	1.12	1084.17	-10.97	bicarbonate-sodium	49.01	0.99	43.75	1
05-31-80-25W5	BLSKY	1.14	142.61	-10.07	bicarbonate-sodium	48.80	1.20	42.87	1
10-11-80-03W6	BLSKY	1.13	47.88	-5.12	bicarbonate-sodium	48.09	1.91	42.61	1
10-26-80-11W6	BLSKY	1.04	3.40	-3.73	bicarbonate-sodium	48.15	1.85	46.87	1
06-28-80-11W6	BLSKY	1.04	1.05	-2.71	bicarbonate-sodium	47.82	2.18	47.76	1
10-16-81-23W5	BLSKY	1.37	124.53	-28.19	bicarbonate-sodium	49.19	0.81	35.93	1
06-36-81-25W5	BLSKY	1.16	129.48	-11.43	bicarbonate-sodium	48.89	1.11	42.33	1
16-23-81-13W6	BLSKY	1.16	49.50	-17.40	bicarbonate-sodium	49.24	0.76	42.73	1
07-19-82-02W6	BLSKY	1.05	88.43	-2.66	bicarbonate-sodium	47.98	2.02	45.88	1
07-21-82-06W6	BLSKY	1.26	367.10	-16.43	bicarbonate-sodium	48.31	1.69	38.36	1
07-08-82-11W6	BLSKY	1.10	48.67	-6.74	bicarbonate-sodium	48.37	1.63	44.32	1
06-14-82-11W6	BLSKY	1.07	126.91	-4.94	bicarbonate-sodium	48.12	1.88	44.96	1
10-20-82-12W6	BLSKY	0.88	ERR	3.62	chloride-calcium	42.26	7.74	47.87	3
11-32-82-12W6	BLSKY	1.27	82.51	-23.11	bicarbonate-sodium	48.99	1.01	38.84	1
11-21-83-23W5	BLSKY	1.33	65.40	-21.64	bicarbonate-sodium	48.47	1.53	36.38	1
10-03-83-10W6	BLSKY	1.17	104.99	-14.76	bicarbonate-sodium	48.56	1.44	41.57	1
08-06-83-10W6	BLSKY	1.14	19.77	-11.03	bicarbonate-sodium	48.71	1.29	43.09	1
07-17-83-10W6	BLSKY	1.24	156.02	-17.67	bicarbonate-sodium	48.73	1.27	39.46	1
11-31-84-24W5	BLSKY	1.53	217.78	-38.16	bicarbonate-sodium	49.13	0.87	32.17	1
10-28-84-04W6	BLSKY	1.14	1347.37	-11.96	bicarbonate-sodium	49.14	0.86	43.21	1
10-35-84-10W6	BLSKY	0.95	-274.06	1.46	chloride-calcium	45.90	4.10	48.46	3
11-19-85-05W6	BLSKY	1.05	124.61	-3.04	bicarbonate-sodium	47.61	2.39	45.28	1
14-30-85-07W6	BLSKY	0.89	-23.94	1.32	chloride-calcium	43.01	6.99	48.34	3
12-20-85-08W6	BLSKY	0.96	-209.39	1.88	chloride-calcium	46.82	3.18	48.76	3
11-36-86-26W5	BLSKY	1.02	11.42	-0.60	bicarbonate-sodium	47.22	2.78	46.27	1
10-23-86-01W6	BLSKY	1.00	0.83	-0.03	sulphate-sodium	46.99	3.01	47.00	3
11-05-87-25W5	BLSKY	1.03	111.80	-1.20	bicarbonate-sodium	47.63	2.37	46.08	1
06-16-87-25W5	BLSKY	1.00	-3.31	0.09	chloride-magnesium	47.61	2.39	47.73	3
06-07-87-01W6	BLSKY	1.02	175.59	-0.62	bicarbonate-sodium	47.49	2.51	46.73	1
10-13-87-01W6	BLSKY	0.99	-43.50	0.22	chloride-magnesium	46.91	3.09	47.28	3
06-30-87-01W6	BLSKY	1.04	27.11	-0.94	bicarbonate-sodium	46.28	3.72	44.63	1
10-15-87-02W6	BLSKY	1.08	233.76	-3.55	bicarbonate-sodium	48.15	1.85	44.71	1
12-22-87-02W6	BLSKY	1.08	33.92	-2.79	bicarbonate-sodium	47.57	2.43	43.97	1
06-17-88-02W6	BLSKY	1.05	34.24	-1.93	bicarbonate-sodium	48.07	1.93	45.88	1
13-26-88-02W6	BLSKY	1.10	ERR	-3.84	unk	48.13	1.87	43.59	1
10-11-89-03W6	BLSKY	0.97	-52.15	1.01	chloride-calcium	46.99	3.01	48.48	3
09-18-89-04W6	BLSKY	0.95	-54.47	1.08	chloride-calcium	46.02	3.98	48.28	3
10-33-89-11W6	BLSKY	0.97	-38.36	1.24	chloride-calcium	46.66	3.34	48.09	3
13-16-90-22W5	BLSKY	1.08	19.54	-7.74	bicarbonate-sodium	46.93	3.07	43.56	1
08-28-90-22W5	BLSKY	0.94	ERR	6.46	chloride-calcium	46.71	3.29	49.59	3
10-27-90-11W6	BLSKY	0.95	-752.18	1.93	chloride-calcium	46.57	3.43	49.20	3
10-02-90-12W6	BLSKY	0.95	-272.30	1.88	chloride-calcium	46.72	3.28	49.00	3
06-14-91-23W5	BLSKY	1.01	3.82	-0.37	bicarbonate-sodium	46.63	3.37	46.20	1
10-03-91-11W6	BLSKY	0.92	-69.54	1.40	chloride-calcium	45.01	4.99	48.95	3

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
03-23-66-26W5	BLSKY	0.99	-9.63	0.42	chloride-magnesium	48.62	1.38	48.91	3
10-26-66-05W6	BLSKY	0.97	-42.22	1.99	chloride-calcium	47.71	2.29	49.05	3
15-08-67-22W5	BLSKY	1.03	ERR	-3.46	unk	48.89	1.11	47.54	1
06-17-67-22W5	BLSKY	0.94	-129.28	2.66	chloride-calcium	46.18	3.82	49.06	3
11-15-67-23W5	BLSKY	0.94	-59.01	1.18	chloride-calcium	46.09	3.91	48.94	3
06-21-67-23W5	BLSKY	0.96	ERR	2.11	chloride-calcium	46.82	3.18	48.78	3
06-35-67-24W5	BLSKY	0.96	-146.75	2.56	chloride-calcium	46.79	3.21	48.70	3
07-32-68-22W5	BLSKY	0.99	-28.54	0.68	chloride-magnesium	47.52	2.48	48.08	3
11-25-68-23W5	BLSKY	0.96	-105.43	1.40	chloride-calcium	46.62	3.38	48.36	3
10-04-68-24W5	BLSKY	1.00	1.19	-0.21	bicarbonate-sodium	46.32	3.68	46.29	1
01-29-68-26W5	BLSKY	1.00	3.35	-0.06	bicarbonate-sodium	48.27	1.73	48.23	1
11-11-68-03W6	BLSKY	0.98	-88.39	0.85	chloride-magnesium	47.18	2.82	48.08	3
07-05-69-21W5	BLSKY	0.99	-20.33	0.25	chloride-magnesium	47.51	2.49	47.78	3
01-02-69-22W5	BLSKY	1.00	-2.07	0.11	chloride-magnesium	47.43	2.57	47.59	3
09-16-69-22W5	BLSKY	1.05	116.05	-1.76	bicarbonate-sodium	47.77	2.23	45.63	1
13-18-69-22W5	BLSKY	1.00	ERR	-0.01	unk	47.21	2.79	47.19	1
06-06-69-23W5	BLSKY	0.95	-200.82	1.35	chloride-calcium	46.16	3.84	48.57	3
03-35-69-23W5	BLSKY	1.00	6.55	-0.20	bicarbonate-sodium	48.14	1.86	48.02	1
06-13-69-25W5	BLSKY	0.95	-524.15	1.90	chloride-calcium	46.63	3.57	48.89	3
07-19-69-25W5	BLSKY	1.01	41.31	-0.76	bicarbonate-sodium	48.48	1.52	47.87	1
13-06-70-23W5	BLSKY	1.01	20.72	-0.24	bicarbonate-sodium	47.55	2.45	47.26	1
06-29-71-03W6	BLSKY	0.95	-87.56	3.11	chloride-calcium	46.46	3.54	49.12	3
04-34-72-23W5	BLSKY	1.02	89.27	-0.93	bicarbonate-sodium	48.03	1.97	46.98	1
10-02-72-22W5	BLSKY	0.99	-9.69	0.27	chloride-magnesium	47.28	2.72	47.61	3
10-07-73-26W5	BLSKY	0.93	-339.11	1.96	chloride-calcium	45.09	4.91	48.71	3
02-02-73-01W6	BLSKY	0.93	ERR	1.76	chloride-calcium	45.02	4.98	48.51	3
10-23-74-01W6	BLSKY	0.99	-11.36	0.38	chloride-magnesium	46.94	3.06	47.62	3
11-12-75-22W5	BLSKY	1.05	347.03	-3.62	bicarbonate-sodium	48.60	1.40	46.13	1
06-21-75-22W5	BLSKY	1.02	15.41	-1.12	bicarbonate-sodium	48.08	1.92	47.08	1
06-22-75-22W5	BLSKY	1.08	143.52	-4.49	bicarbonate-sodium	48.35	1.65	44.92	1
10-05-75-23W5	BLSKY	1.12	ERR	-3.80	unk	47.85	2.15	42.77	1
11-09-78-23W5	BLSKY	1.04	26.00	-2.02	bicarbonate-sodium	48.16	1.84	46.17	1
10-18-78-23W5	BLSKY	0.95	ERR	0.36	chloride-magnesium	42.36	7.64	44.38	3
10-26-78-25W5	BLSKY	1.06	117.86	-5.68	bicarbonate-sodium	49.39	0.61	46.55	1
07-28-78-01W6	BLSKY	1.08	69.25	-6.93	bicarbonate-sodium	48.17	1.83	44.52	1
12-18-79-24W5	BLSKY	1.16	453.21	-11.29	bicarbonate-sodium	48.55	1.45	42.02	1
07-01-79-25W5	BLSKY	1.15	201.81	-15.31	bicarbonate-sodium	49.13	0.87	42.72	1

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
10-04-68-24W5	GETH	1.06	28.98	-5.15	bicarbonate-sodium	48.36	1.64	45.86	1
06-16-68-24W5	GETH	1.02	244.74	-3.70	bicarbonate-sodium	48.83	1.17	47.75	1
06-26-68-23W5	GETH	1.01	10.72	-1.07	bicarbonate-sodium	48.62	1.38	48.17	1
12-11-69-22W5	GETH	1.01	2.86	-0.71	bicarbonate-sodium	47.77	2.23	47.55	1
07-19-69-23W5	GETH	1.01	30.61	-1.71	bicarbonate-sodium	48.49	1.51	47.80	1
10-13-70-22W5	GETH	1.00	6.78	-0.27	bicarbonate-sodium	47.49	2.51	47.31	1
03-03-70-23W5	GETH	0.95	-162.63	1.30	chloride-calcium	45.87	4.13	48.35	3
06-18-70-24W5	GETH	1.00	2.29	-0.07	bicarbonate-sodium	47.51	2.49	47.45	1
06-03-70-25W5	GETH	1.02	77.95	-1.18	bicarbonate-sodium	48.30	1.70	47.51	1
02-04-70-01W6	GETH	0.99	ERR	0.39	chloride-magnesium	47.97	2.03	48.28	3
11-14-70-01W6	GETH	1.00	1.00	-0.07	bicarbonate-sodium	48.55	1.45	48.55	2
11-16-71-23W5	GETH	1.00	-9.90	0.14	chloride-magnesium	47.43	2.37	47.64	3
05-06-72-23W5	GETH	0.97	-33.75	3.15	chloride-calcium	46.75	3.25	48.36	3
02-05-72-23W5	GETH	1.01	72.59	-0.24	bicarbonate-sodium	48.15	1.85	47.91	1
06-04-73-03W6	GETH	1.02	5.25	-1.80	bicarbonate-sodium	48.36	1.64	47.49	1
10-31-73-03W6	GETH	1.02	239.87	-3.19	bicarbonate-sodium	49.03	0.97	47.95	1
11-26-74-09W6	GETH	1.24	4.91	-33.21	bicarbonate-sodium	49.42	0.58	41.76	1
06-23-75-22W5	GETH	1.05	19.39	-2.12	bicarbonate-sodium	47.69	2.31	45.42	1
14-20-75-04W6	GETH	1.08	44.58	-10.72	bicarbonate-sodium	48.92	1.08	45.19	1
04-19-76-23W5	GETH	1.02	ERR	-0.85	unk	47.77	2.23	46.86	1
04-35-77-22W5	GETH	1.02	42.50	-0.97	bicarbonate-sodium	48.02	1.98	46.07	1
10-10-77-26W5	GETH	1.11	7.91	-5.56	bicarbonate-sodium	48.20	1.80	44.10	1
07-27-77-26W5	GETH	1.04	75.14	-2.31	bicarbonate-sodium	48.21	1.79	46.44	1
11-25-77-11W6	GETH	1.03	6.82	-1.65	bicarbonate-sodium	47.60	2.40	46.64	1
11-34-77-12W6	GETH	0.97	-201.14	1.68	chloride-calcium	47.06	2.94	48.62	3
12-11-78-22W5	GETH	1.06	48.25	-3.03	bicarbonate-sodium	48.71	1.29	45.80	1
10-20-79-22W5	GETH	1.37	420.87	-20.63	bicarbonate-sodium	48.97	1.03	35.83	1
01-12-79-22W5	GETH	1.04	ERR	-1.81	unk	48.23	1.77	46.55	1
04-12-79-23W5	GETH	1.09	62.45	-5.64	bicarbonate-sodium	48.77	1.23	44.82	1
11-28-80-22W5	GETH	1.42	374.03	-38.60	bicarbonate-sodium	49.40	0.60	34.85	1
06-01-80-23W5	GETH	1.14	108.02	-7.01	bicarbonate-sodium	48.06	1.94	42.37	1
06-23-80-23W5	GETH	1.08	41.49	-5.40	bicarbonate-sodium	48.79	1.21	45.10	1
05-31-80-25W5	GETH	1.23	178.29	-23.38	bicarbonate-sodium	49.12	0.88	40.07	1
07-35-80-10W6	GETH	1.14	3.59	-13.70	bicarbonate-sodium	48.67	1.33	44.44	1
11-01-80-11W6	GETH	1.02	94.62	-1.84	bicarbonate-sodium	48.30	1.70	47.22	1
06-36-81-25W5	GETH	0.98	-4.94	1.04	chloride-calcium	48.00	2.00	49.13	3
05-15-81-26W5	GETH	1.24	118.31	-17.11	bicarbonate-sodium	48.97	1.03	39.61	1
10-11-81-01W6	GETH	1.16	49.17	-10.01	bicarbonate-sodium	48.66	1.34	41.93	1
11-26-81-01W6	GETH	1.34	230.55	-27.09	bicarbonate-sodium	49.15	0.85	36.80	1
15-14-82-25W5	GETH	1.17	66.78	-10.40	bicarbonate-sodium	48.91	1.09	41.91	1
03-27-82-06W6	GETH	1.18	18.45	-6.20	bicarbonate-sodium	47.49	2.51	40.51	1
11-07-83-22W5	GETH	1.23	85.80	-19.64	bicarbonate-sodium	48.98	1.02	40.05	1
07-16-83-23W5	GETH	1.22	30.82	-41.04	bicarbonate-sodium	49.40	0.60	40.86	1
11-21-83-23W5	GETH	1.45	111.13	-52.56	bicarbonate-sodium	-49.05	0.95	33.92	1
11-15-84-09W6	GETH	1.02	14.06	-1.02	bicarbonate-sodium	47.67	2.33	46.90	1
14-13-85-12W6	GETH	1.01	96.76	-0.48	bicarbonate-sodium	47.43	2.57	46.99	1
11-13-86-26W5	GETH	1.37	132.86	-21.01	bicarbonate-sodium	48.98	1.02	35.74	1
10-23-86-01W6	GETH	1.00	1.51	-0.04	bicarbonate-sodium	47.02	2.98	47.00	1
14-25-86-01W6	GETH	0.94	-27.73	1.18	chloride-calcium	45.98	4.02	48.79	3
10-36-86-01W6	GETH	1.02	9.16	-0.67	bicarbonate-sodium	47.35	2.65	46.56	1
10-27-86-09W6	GETH	0.93	-382.29	2.34	chloride-calcium	45.65	4.35	48.99	3
11-31-86-09W6	GETH	0.98	-29.21	0.60	chloride-magnesium	46.89	3.11	47.74	3
07-06-87-25W5	GETH	0.99	-10.22	0.23	chloride-magnesium	46.77	3.23	47.31	3
11-08-87-25W5	GETH	1.05	5.90	-1.34	bicarbonate-sodium	47.39	2.61	45.41	1

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
06-09-87-25W5	GETH	1.01	10.10	-0.28	bicarbonate-sodium	47.68	2.32	47.31	1
10-27-87-01W6	GETH	1.03	4.20	-1.16	bicarbonate-sodium	47.27	2.73	46.10	1
11-16-87-02W6	GETH	1.17	113.54	-16.42	bicarbonate-sodium	49.26	0.74	42.23	1
10-15-87-02W6	GETH	1.40	404.24	-53.57	bicarbonate-sodium	49.39	0.61	35.42	1
09-19-87-02W6	GETH	1.14	43.56	-6.55	bicarbonate-sodium	47.89	2.11	42.04	1
03-32-87-03W6	GETH	1.04	5.11	-1.18	bicarbonate-sodium	47.55	2.45	46.08	1
02-28-87-04W6	GETH	1.01	29.70	-0.42	bicarbonate-sodium	46.53	3.47	45.94	1
08-25-87-07W6	GETH	0.95	-1.74	1.91	chloride-calcium	46.00	4.00	50.00	4
10-27-88-22W5	GETH	1.09	67.87	-2.66	bicarbonate-sodium	47.81	2.19	44.04	1
05-11-88-01W6	GETH	0.97	ERR	0.83	chloride-magnesium	46.85	3.15	48.13	3
11-35-88-07W6	GETH	1.07	401.75	-3.94	bicarbonate-sodium	48.52	1.48	45.23	1
10-08-89-25W5	GETH	0.96	-19.75	0.93	chloride-magnesium	45.86	4.14	47.97	3
09-18-89-04W6	GETH	0.97	-5.50	0.92	chloride-magnesium	46.45	3.55	48.40	3
06-16-89-07W6	GETH	0.98	-38.50	0.94	chloride-magnesium	47.32	2.68	48.56	3
10-29-89-07W6	GETH	0.98	-16.34	0.80	chloride-magnesium	46.96	3.04	48.14	3
02-12-89-08W6	GETH	0.98	-4.22	1.25	chloride-calcium	47.72	2.28	49.07	3
06-36-90-25W5	GETH	0.99	-0.95	0.26	chloride-magnesium	47.36	2.64	47.98	3
07-03-90-10W6	GETH	1.03	1.41	-1.76	bicarbonate-sodium	47.32	2.68	46.95	1
10-22-62-22W5	GETH	0.93	-287.12	3.43	chloride-calcium	46.25	3.75	50.00	4
07-25-62-24W5	GETH	1.17	2.01	-9.75	bicarbonate-sodium	47.96	2.04	44.48	1
07-34-65-03W6	GETH	0.98	-2.48	1.09	chloride-calcium	47.60	2.40	48.79	3
10-09-66-23W5	GETH	0.91	-108.88	1.99	chloride-calcium	44.65	5.35	49.29	3
11-15-67-23W5	GETH	0.99	-34.91	0.53	chloride-magnesium	47.72	2.28	48.22	3
06-21-67-23W5	GETH	1.00	0.06	-0.00	sulphate-sodium	48.35	1.65	48.37	3
10-11-68-24W5	GETH	0.99	-25.17	0.90	chloride-magnesium	48.63	1.37	48.98	3
06-15-68-24W5	GETH	1.00	51.58	-0.39	bicarbonate-sodium	48 18	1.82	47.94	1

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
12-01-65-02W6	CAD	0.99	-36.69	1.65	chloride-calcium	48.54	1.46	49.02	3
10-20-67-05W6	CAD	0.96	ERR	2.68	chloride-calcium	47.24	2.76	49.30	3
06-26-68-02W6	CAD	1.01	72.79	-0.73	bicarbonate-sodium	48.98	1.02	48.58	1
11-09-68-04W6	CAD	0.98	ERR	2.13	chloride-calcium	48.14	1.86	49.16	3
10-21-68-04W6	CAD	0.97	-46.92	1.67	chloride-calcium	47.44	2.56	49.06	3
11-35-68-07W6	CAD	0.93	-677.63	2.22	chloride-calcium	45.99	4.01	49.41	3
06-25-71-10W6	CAD	0.95	-9.66	1.68	chloride-calcium	46.63	3.37	49.16	3
11-33-72-06W6	CAD	0.98	-4.11	1.35	chloride-calcium	48.15	1.85	49.07	3
04-06-73-04W6	CAD	0.99	-75.19	0.83	chloride-magnesium	48.57	1.43	48.02	3
10-30-73-09W6	CAD	0.97	-6.27	13.08	chloride-calcium	46.52	3.48	48.21	3
15-09-74-01W6	CAD	3.95	30.48	-135.81	bicarbonate-sodium	49.43	0.57	13.72	1
10-23-74-01W6	CAD	3.24	722.14	-487.31	bicarbonate-sodium	49.43	0.57	15.29	1
07-24-74-03W6	CAD	2.46	75.40	-1527.28	bicarbonate-sodium	49.89	0.11	20.67	1
04-08-74-06W6	CAD	1.00	-0.89	0.05	chloride-magnesium	48.45	1.55	48.50	3
06-22-74-06W6	CAD	1.00	-4.47	0.17	chloride-magnesium	48.23	1.77	48.34	3
04-13-74-11W6	CAD	0.97	-350.20	1.30	chloride-calcium	47.32	2.68	48.82	3
05-29-75-02W6	CAD	3.25	108.85	-98.21	bicarbonate-sodium	48.99	1.01	15.38	1
11-36-75-05W6	CAD	2.06	225.89	-131.46	bicarbonate-sodium	49.50	0.50	24.10	1
10-21-75-07W6	CAD	0.97	-101.93	1.37	chloride-calcium	47.43	2.57	48.69	3
10-30-63-24W5	CAD	0.98	-391.29	1.53	chloride-calcium	48.22	1.78	48.99	3
10-28-63-26W5	CAD	0.98	ERR	2.46	chloride-calcium	48.21	1.79	49.09	3
10-35-63-26W5	CAD	0.99	-117.56	0.78	chloride-magnesium	48.71	1.29	49.15	3
10-30-62-25W5	CAD	0.98	-43.68	1.50	chloride-calcium	48.24	1.76	49.06	3
04-12-63-25W5	CAD	0.98	-206.19	2.29	chloride-calcium	47.80	2.20	48.76	3
10-08-63-25W5	CAD	0.99	ERR	1.42	chloride-calcium	48.66	1.34	49.14	3
04-11-63-26W5	CAD	0.97	ERR	2.48	chloride-calcium	47.74	2.26	49.15	3
10-35-64-03W6	CAD	0.97	-453.83	2.13	chloride-calcium	47.67	2.33	49.21	3
14-20-84-13W6	CAD	2.70	43.61	-20.12	bicarbonate-sodium	47.60	2.40	18.29	1
16-30-86-13W6	CAD	1.14	3.56	-4.02	bicarbonate-sodium	46.68	3.32	42.62	1
10-20-60-23W5	CAD	0.91	-119.66	2.98	chloride-calcium	45.14	4.86	49.38	3
06-33-60-23W5	CAD	0.90	-705.59	3.32	chloride-calcium	44.57	5.43	49.62	3
07-36-61-24W5	CAD	0.93	-267.06	5.40	chloride-calcium	46.28	3.72	49.58	3
06-05-63-22W5	CAD	0.96	-80.89	2.62	chloride-calcium	46.93	3.07	49.15	3
06-24-63-22W5	CAD	0.89	-445.12	3.30	chloride-calcium	44.04	5.96	49.36	3
06-27-63-23W5	CAD	1.00	-10.72	0.33	chloride-magnesium	48.70	1.30	48.86	3
10-09-63-26W5	CAD	0.96	-83.84	1.55	chloride-calcium	47.40	2.60	49.44	3
11-34-65-22W5	CAD	0.99	-284.08	1.11	chloride-calcium	48.21	1.79	48.85	3
07-24-74-13W6	CAD	0.94	-182.73	1.99	chloride-calcium	46.22	3.78	49.23	3
07-10-75-07W6	CAD	1.01	9.20	-0.66	bicarbonate-sodium	48.16	1.84	47.87	1
10-32-76-20W5	CAD	0.99	-86.21	0.40	chloride-magnesium	47.47	2.53	48.01	3
10-02-76-02W6	CAD	2.72	156.25	-500.83	bicarbonate-sodium	49.46	0.54	18.37	1
14-23-76-04W6	CAD	3.62	710.27	-340.88	bicarbonate-sodium	49.67	0.33	13.77	1
15-35-76-07W6	CAD	2.54	94.44	-535.88	bicarbonate-sodium	49.40	0.60	19.74	1
16-06-76-07W6	CAD	1.04	14.15	-2.72	bicarbonate-sodium	48.13	1.87	46.38	1
11-04-76-08W6	CAD	1.55	58.14	-157.64	bicarbonate-sodium	49.82	0.18	32.38	1
11-23-76-09W6	CAD	1.82	108.92	-110.28	bicarbonate-sodium	49.55	0.45	27.38	1
14-07-76-11W6	CAD	2.65	44.00	-63.48	bicarbonate-sodium	49.11	0.89	19.26	1
06-10-77-05W6	CAD	2.79	1134.30	-33.58	bicarbonate-sodium	48.08	1.92	17.24	1
06-15-77-05W6	CAD	3.56	2011.47	-137.93	bicarbonate-sodium	49.30	0.70	13.87	1
16-21-77-06W6	CAD	3.26	66.62	-101.74	bicarbonate-sodium	49.08	0.92	15.58	1

LOCATION	FORM	Na/Cl	(Na-Cl)/SO4	(Cl-Na)/Mg	SULIN CLASSIFICATION	a=Na	b=Ca+Mg	d=SO4+Cl	CLASS
07-31-77-07W6	CAD	3.43	22.79	-226.95	bicarbonate-sodium	49.40	0.60	15.95	1
06-23-77-10W6	CAD	3.07	1143.31	-144.69	bicarbonate-sodium	49.40	0.60	16.16	1
07-32-77-11W6	CAD	2.89	14.03	-248.65	bicarbonate-sodium	48.91	1.09	19.18	1
07-10-77-12W6	CAD	2.36	140.04	-620.13	bicarbonate-sodium	49.80	0.20	19.68	1
06-18-77-12W6	CAD	1.84	82.69	-222.63	bicarbonate-sodium	49.71	0.29	27.33	1
07-30-78-04W6	CAD	6.00	2302.63	-166.51	bicarbonate-sodium	49.07	0.93	8.20	1
14-19-78-06W6	CAD	6.61	1315.52	-95.12	bicarbonate-sodium	48.52	1.48	7.37	1
10-35-78-08W6	CAD	4.32	203.73	-216.59	bicarbonate-sodium	49.36	0.64	11.60	1
06-21-78-10W6	CAD	3.39	124.34	-393.36	bicarbonate-sodium	49.27	0.73	14.81	1
10-23-78-10W6	CAD	3.78	69.05	-856.53	bicarbonate-sodium	49.29	0.71	13.56	1
10-27-78-12W6	CAD	2.91	1736.52	-125.57	bicarbonate-sodium	49.41	0.59	17.01	1
06-30-79-03W6	CAD	3.08	158.95	-241.40	bicarbonate-sodium	49.26	0.74	16.20	1
14-33-79-06W6	CAD	4.98	18.23	-80.52	bicarbonate-sodium	48.75	1.25	11.03	1
06-29-79-07W6	CAD	5.32	23.20	-389.40	bicarbonate-sodium	48.97	1.03	10.93	1
11-17-79-10W6	CAD	4.33	ERR	ERR	unk	49.41	0.59	11.40	1
11-07-80-06W6	CAD	5.49	593.76	-85.90	bicarbonate-sodium	49.07	0.93	9.00	1
06-14-80-06W6	CAD	6.32	ERR	-98.73	unk	49.29	0.71	7.80	1
06-33-80-06W6	CAD	7.07	233.06	-165.82	bicarbonate-sodium	49.42	0.58	7.17	1
14-26-80-07W6	CAD	5.79	87.67	-162.92	bicarbonate-sodium	49.00	1.00	8.92	1
11-23-80-09W6	CAD	4.07	28.76	-976.59	bicarbonate-sodium	49.04	0.96	13.35	1
10-26-80-10W6	CAD	5.08	27.56	-141.81	bicarbonate-sodium	49.16	0.84	11.11	1
14-26-80-12W6	CAD	3.07	37.62	-116.27	bicarbonate-sodium	49.39	0.61	13.42	1
07-33-80-13W6	CAD	3.29	906.38	-75.65	bicarbonate-sodium	48.60	1.40	14.79	1
11-01-81-04W6	CAD	2.98	2680.85	-84.80	bicarbonate-sodium	49.18	0.82	16.52	1
10-05-81-05W6	CAD	5.94	984.64	-249.21	bicarbonate-sodium	49.20	0.80	8.32	1
07-17-81-08W6	CAD	4.42	55.15	-46.95	bicarbonate-sodium	48.62	1.38	11.68	1
01-33-81-10W6	CAD	4.56	47.81	-78.26	bicarbonate-sodium	48.63	1.37	11.46	1
10-32-82-07W6	CAD	7.35	121.19	-206.55	bicarbonate-sodium	49.25	0.75	7.05	1
06-10-82-08W6	CAD	4.52	22.49	-388.66	bicarbonate-sodium	48.36	1.64	12.38	1
03-33-82-10W6	CAD	3.51	182.90	-138.82	bicarbonate-sodium	49.05	0.95	14.17	1
07-27-83-01W6	CAD	2.47	47.61	-14.85	bicarbonate-sodium	45.34	4.66	18.95	1
11-06-83-08W6	CAD	3.53	138.35	-136.17	bicarbonate-sodium	49.32	0.68	16.21	1
10-19-83-08W6	CAD	3.49	ERR	-140.45	unk	49.21	0.79	16.12	1
10-08-83-09W6	CAD	3.26	1435.54	-68.12	bicarbonate-sodium	48.72	1.28	14.98	1
10-23-83-09W6	CAD	2.47	232.75	-55.43	bicarbonate-sodium	48.84	1.16	19.87	1
07-17-83-10W6	CAD	4.20	119.62	-185.13	bicarbonate-sodium	49.63	0.37	12.14	1
06-02-84-07W6	CAD	3.87	ERR	-221.71	unk	49.20	0.80	12.73	1
16-01-84-09W6	CAD	3.47	61.12	-55.99	bicarbonate-sodium	48.65	1.35	14.58	1
08-03-84-12W6	CAD	2.90	1018.58	ERR	bicarbonate-sodium	48.96	1.04	16.90	1
08-28-84-12W6	CAD	2.61	18.90	-114.41	bicarbonate-sodium	49.31	0.69	20.48	1
07-11-85-03W6	CAD	2.44	20.65	-121.28	bicarbonate-sodium	49.24	0.76	21.56	1
11-19-85-11W6	CAD	1.80	88.55	-113.90	bicarbonate-sodium	49.44	0.56	27.78	1
08-19-85-12W6	CAD	1.72	48.26	-58.32	bicarbonate-sodium	49.19	0.81	29.07	1
16-25-85-13W6	CAD	1.75	36.60	-32.21	bicarbonate-sodium	49.09	0.91	28.59	1
06-16-89-07W6	CAD	0.96	-11.20	1.84	chloride-calcium	46.78	3.22	49.18	3
13-15-89-09W6	CAD	0.97	-19.88	1.48	chloride-calcium	47.60	2.40	48.99	3