DESIGN PHILOSOPHY

5.1.1 APPROACH

ConocoPhillips is committed to protecting the health and safety of its employees, contractors and the public. The plan for the Parsons Lake field is sustainable development – a balance of economic, environmental and social factors – based on industry's leading standards for personnel safety and environmental protection.

All facilities will be designed, constructed, installed and commissioned according to applicable federal and territorial regulations. These regulations include the:

- Canada Oil and Gas Installation Regulations
- Canada Oil and Gas Production and Conservation Regulations

Although not directly applicable, aspects of the Onshore Pipeline Regulations have also been used for the design of the south pad to north pad flow line.

The design will follow acceptable engineering practices for northern regions to ensure safe and reliable operation. The facilities are designed to handle high volumes of natural gas, but will be relatively simple in design and operation, and use proven technology.

Decisions on design have been and will continue to be made on the basis of the five design factors first set out in Section 1.5.

5.1.2 DESIGN CODES AND STANDARDS

The codes and standards used for the Parsons Lake field development include, among others, those produced by or found in the:

- American Petroleum Institute (API)
- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing of Materials (ASTM)
- Canadian Institute of Steel Construction
- Canadian Standards Association (CSA)
- Government of Northwest Territories
- Institute of Electrical and Electronic Engineers (IEEE)
- Instrument Society of America (ISA)

5.1.2 DESIGN CODES AND STANDARDS (cont'd)

- National Building Code of Canada
- NWT Air Quality Code of Practice Upstream Oil and Gas Industry Consultation Draft

Selected guidelines issued by the Alberta Energy and Utilities Board (EUB) will also be used.

5.2.1 SITE DESCRIPTION

The north pad of the Parsons Lake field development will include the gas conditioning facility, the power generation equipment and the north production wells for the Parsons Lake field. It will be located at about 68.99° North, 133.57° West at the northeast corner of Parsons Lake, on a previous well site location (D-20). The design of the north pad will incorporate as much of the previously disturbed area as is technically feasible. For example, a floating dock for float plane access will be located where the previous gravel landing, used in drilling D-20, was situated.

The south pad of the Parsons Lake field development will be small, with minimal facilities and the south production wells. It will be located at about 68.88°North, 133.72° West at the south end of Parsons Lake, on a previous well location (L-43). The design of the south pad will also incorporate as much of the previously disturbed area as is technically feasible.

The south pad design includes an above-ground flow line to transport production from the south pad to the north pad. The flow line will parallel and be in the same right-of-way as the Parsons Lake lateral, which forms part of the Mackenzie Gas Project gathering system.

Locations for potential satellite wells have not been established, as none are currently planned. ConocoPhillips is maintaining the satellite-well concept in its development plan, because satellite wells might be required later in the development as reservoir performance and exploration data is gathered. If they are required to maximize resource recovery, they would likely be located closer to the north pad than to the south pad and would be designed with minimal facilities.

A Hercules aircraft-capable all-weather gravel airstrip will be constructed near the north pad and connected to it by an all-weather gravel access road. A short all-weather access road will also be constructed from the main production pad to the floating dock located on the northeast edge of Parsons Lake, following a historical access route.

5.2.2 CLIMATE, METEOROLOGY AND AIR QUALITY

With the long winters and short summers, daylight hours vary significantly during the year. Total darkness prevails for about 40 days in December and

5.2.2 CLIMATE, METEOROLOGY AND AIR QUALITY (cont'd)

January. The coldest month of the year is normally January, and the warmest month is July.

Data from both Inuvik and Tuktoyaktuk was considered, because Parsons Lake is about halfway between the two towns. The high ambient temperature used for design was 19.2ºC. This temperature is the mean of the average daily high temperature in July for both Inuvik and Tuktoyaktuk, and it will be used to design aerial cooling equipment. The minimum design temperature used was -45ºC, the coldest expected daily average temperature. It will be used to determine metallurgical requirements.

Wind data for Inuvik and Tuktoyaktuk indicated that the prevalent wind direction was from the east. Therefore, the facilities layout design was based on an easterly wind direction.

Snow depth for the Parsons Lake area was based on:

- a snow depth survey done by the Inuvialuit Environmental and Geotechnical Group for ConocoPhillips in 2003
- publicly available snow depth measurements

Snow depth is an important parameter in establishing the appropriate height for above-ground flow lines. A minimum flow line design height of 2.2 m above ground level was selected, taking into account snow depth, caribou height and snowmobile height. Detailed design will establish the exact heights, considering factors such as projected potential increases in snow depth.

All other climate and meteorological data used for the Parsons Lake design was based on Inuvik data.

The climate of northern Canada has been undergoing change. The Inuvialuit Settlement Region, where Parsons Lake is located, has experienced an increase in annual average temperature of 1.5°C and an increase in average annual precipitation of 5.2 mm in the last 30 years. Potential future climate projections were modelled using models approved by the Intergovernmental Panel on Climate Change (IPCC). These projections were considered in the design of the Parsons Lake facilities and pipelines. For further information on climate, see EIS Volume 5: Biophysical Impact Assessment.

5.2.3 HYDROLOGY

The principal hydrological processes in the region are:

- snowmelt
- surface runoff
- stream flow

- lake hydrology

5.2.3.1 Snowmelt and Surface Runoff

Snowmelt occurs from May to July, with the volume of the snow accumulation governing the magnitude of the flows. While the ground is frozen, it restricts infiltration of water. As soon as the active layer begins to thaw, the ground capacity to transmit water increases. Therefore, the freshet flows recede rapidly to base flow.

5.2.3.2 Stream Flow

The minimum flows are usually from early July to late September, before autumn rainfall produces a notably increased flow. Streams usually start freezing in mid-September and are completely frozen by November. As the north pad is about 45 m above sea level, there is no evidence that the site has been flooded. Similarly, the south pad is not expected to flood.

5.2.3.3 Lake Hydrology

Bathymetric surveys of Parsons Lake and all other lakes proposed for water withdrawal have been carried out. ConocoPhillips provided funding to the Department of Fisheries and Oceans for research on the Husky Lakes system, which included establishing a water gauging station on Keg Lake, downstream of Parsons Lake. The need for lake and stream gauging stations will be assessed when the requirements for long-term monitoring for the Parsons Lake field are addressed.

Parsons Lake is the preferred source of industrial and domestic water for the Parsons Lake field development, and will also be used for float plane access. The route for the south to north pad flow line will involve some creek crossings, the only large one being the Zed Creek crossing. This crossing will be elevated at least 2.2 m above the bank height. The possible satellite wells would also include above-ground flow lines to transport their production to the north pad. No locations for these potential wells, flow lines or crossings have been selected, as the need for satellite wells has not yet been established. The Parsons Lake design is otherwise based on all facilities being located at least 100 m from all significant waterbodies.

5.2.4 HYDROGEOLOGY

The Parsons Lake field is within the zone of continuous permafrost. Permafrost thickness to the north and east of the lake ranges from 354 to 378 m. The active layer is more than 30 cm thick in organic peats and silts, and up to 1 m in sparsely-vegetated glaciofluvial gravels and sands. Taliks or zones of unfrozen groundwater are expected to exist under deeper lakes in the area, such as Parsons Lake.

5.2.4 HYDROGEOLOGY (cont'd)

Geotechnical drilling in 2004 on the north pad location and adjacent areas identified the presence of massive ground ice throughout the north pad area, which will be considered in foundation design.

5.2.5 TERRAIN

Surface deposits in the Parsons Lake field are primarily hummocky glacial moraine composed of silty clay, although the local texture ranges widely, from clay to gravel. Depressions are typically post-glacial lacustrine silt and clay, organic-rich bogs or post-glacial lakes. Retrogressive thaw slides exist along the shores and banks of lakes, streams and river channels.

Hummocks or kettles on the east side of Parsons Lake are mainly glaciofluvial sand and gravel. South of Parsons Lake, lacustrine sediments exist in depressions and channels. Pingos and low and high-centre ice-wedge polygons are present in the moraine and lacustrine deposits around Parsons Lake. The two key factors that contribute to the existing stability of landforms in the Parsons Lake area are permafrost and drainage. These factors were considered in facility designs.

Detailed topographic information was obtained for the north pad in August 2003. ConocoPhillips conducted a LiDAR aerial survey to determine topographical features of this area for drainage assessment and site selection. This data was used to configure the north pad.

Conversely, public topographic information was used to configure the south pad. A LiDAR aerial survey was not done on the south pad because it will not be constructed until 7 to 10 years after the north pad construction has started.

Topographic data was not used to configure the satellite wells, as the need for and location of satellite wells have not yet been established.

Additional topographic surveys will be conducted near Parsons Lake and near the potential locations of the airstrip and winter ice roads, to finalize access plans and designs.

5.2.6 VEGETATION

The Parsons Lake field is located in an area of upland tundra, adjacent to the North Storm Hills. This is an area of undulating terrain studded with numerous lakes. Dwarf shrub heath and medium shrub covers most of the upland. The saxifrage heath vegetation type occurs on the crests and steep slopes of gravel deposits and rock outcrops. One rare plant species was documented on gravel deposits in the Parsons Lake field development area. As gravel deposits are uncommon on the tundra, the presence of additional rare plant sites and species within the development area is possible. Detailed rare plant surveys will be conducted immediately before construction starts.

5.2.7 WATER QUALITY AND FISHERIES

A considerable amount of historical information on water quality and fisheries is available for the Parsons Lake area. In addition, composite water and sediment quality samples were collected from Parsons Lake, five unnamed lakes and Zed Creek in 2002. Field water quality parameters were measured in an additional 18 other waterbodies in 2002 and 2003. Historical water quality data is available for Parsons Lake, Zed Creek, Hans Creek, East Hans Lake, West Hans Lake and three unnamed lakes. For further information on water quality, see EIS Volume 3: Biophysical Setting.

All pad designs will include measures to control siltation for site runoff. Water crossings will also be designed and reclaimed to minimize siltation, and secondary containment will be included in facility design, to ensure that site runoff does not contaminate adjacent waterbodies.

A reconnaissance survey of 16 lakes and streams potentially crossed by pipelines was conducted in 2002, to assess their suitability to support fish year-round and to select lakes for detailed fish and fish habitat investigations. Of the fish species identified in Parsons Lake and surrounding waterbodies and streams, seven have been identified in the Inuvik Inuvialuit Community Conservation Plans as species important to local communities for subsistence. Because Parsons Lake is shallow, it does not have a highly productive fishery and local residents do not commonly fish there. However, the downstream Husky Lakes are highly rated for sport and subsistence fishing.

5.2.8 WILDLIFE

Resource Wildlife and Economic Development has historical and current data on the movements of radio and satellite-collared caribou and grizzly bear in the Parsons Lake area. Surveys of bird populations in the Parsons Lake area were conducted during 2001 and 2002. In addition, pellet counts and incidental wildlife observations collected during the Ecological Land Classification mapping program, and during the waterfowl and other field programs, were recorded.

Only a few wildlife species, such as arctic fox, red fox, lemmings, muskrat, ptarmigan and caribou, are present in winter, because of the harsh weather. During the winter, most wildlife use is limited to shrubby vegetation types that offer security and thermal protection. Domestic reindeer and caribou depend on terrestrial lichens as a food source, and use windswept areas in the winter. Within the Parsons Lake field development area, the upland vegetation types support the highest percentage of lichen ground cover. The Cape Bathurst and Bluenose West caribou herds use the Parsons Lake field development area for most of the winter, providing prey for wolves and scavenging opportunities for wolverines. Caribou are an important subsistence wildlife species that is commonly harvested in the Parsons Lake field development area during fall, winter and spring.

During summer, numerous other seasonal wildlife use a wide variety of habitats in the area. Moose depend on browse as a food staple, particularly in winter

5.2.8 WILDLIFE (cont'd)

where their distribution is heavily influenced by the availability of moderately productive shrub and low tree strata. In the Parsons Lake field development area, suitable habitat for grizzly bear are the saxifrage heath, dwarf shrub heath and medium shrub vegetation types. Grizzly bear denning habitat occurs on south-facing aspects in sandy and fine gravel, such as along river and lakeshores and in other glaciofluvial landforms.

A total of 54 species of birds were identified during surveys of the Parsons Lake area. The most abundantly recorded species were Pacific loon, tundra swan, canvasback, scaup, scoters, long-tailed duck and Arctic Tern. The Parsons Lake area is used for moulting and brood-rearing by many waterfowl during late summer, especially scaup and scoters. Northern pintail, scaup, surf and white-winged scoters, and long-tailed duck, all designated species of concern, were seen regularly during surveys. Local residents indicate that the Parsons Lake area is an important subsistence harvest area for waterfowl.

The design of Parsons Lake facilities has responded to wildlife concerns in a number of ways. For example, the minimum height of the south to north pad flow line has been set to accommodate the passage of caribou beneath it. Noise mitigative measures and minimal flaring requirements are also, in part, responses to these concerns. Facilities and infrastructure locations have also taken wildlife concerns into account. Other mitigation of potential impacts on wildlife, as well as wildlife monitoring programs, are being designed in accordance with the environmental protection plans in EIS Volume 7: Environmental Management. Preliminary and detailed engineering will continue to consider wildlife as part of the environmental factor in design evaluation.

5.3.1 AREA AND FACILITIES

The Parsons Lake field development will be in the morainic hills and pitted outwash plains of the Pleistocene Coastlands region. The average elevation of hills in the area of Parsons Lake is about 45 m above sea level.

The seismic ratings for Parsons Lake are low. According to the National Building Code of Canada, they are Za 1, Zv 2 and V 0.10.

A detailed geotechnical investigation of the north pad site was completed in 2004. The south pad design was based on boreholes drilled in the Parsons Lake area in the late 1970s. These boreholes are assumed to be representative of the physical characteristics of the soil at the proposed south pad site.

Most heated buildings will be supported on adfreeze-type steel pipe piles and elevated above the surface of a gravel pad..

All pads and the airstrip will have about 1.5 m of gravel placed directly on top of the tundra. A layer of rigid insulation or geotextile might be incorporated to provide additional protection for the permafrost in some areas. The gravel will be thick enough to provide thermal stability and protection against contact pressure on the tundra, caused by the vehicular and construction equipment traffic on the pad.

5.3.2 SURFICIAL GEOLOGY AND GEOMORPHOLOGY

Surficial geology consists of a thin layer of peat overlying silt, sand and interbedded gravel with a high ice content. Underlying this are glacial and post-glacial sediments of varying origins. The geomorphology of these deposits is the result of glacial processes, leaving behind a terrain of gentle hills and lakes. The thickness of the active layer is between 0.6 and 0.8 m. The underlying permafrost is between 354 and 378 m thick.

5.3.3 FOUNDATION DESIGN

5.3.3.1 Permafrost

Thermal degradation or thawing of permafrost can lead to settlement and loss of bearing capacity.

5.3.3.1 Permafrost (cont'd)

The foundation design for Parsons Lake facilities will be governed by criteria to:

- prevent thermal degradation of the permafrost
- provide adequate support for structures

5.3.3.2 Geotechnical Considerations

Geotechnical considerations affect the type of foundation design that can be used for Parsons Lake facilities. The two basic foundation options are:

- shallow foundations supported by gravel pads
- elevated structures supported by piles

The facilities design is based on pile-supported elevated structures. The piles will be adfreeze-type steel pipe piles, and will elevate the buildings about 1.5 m from the surface of the gravel pad. This will provide free air flow between the gravel and heat sources and will allow heat from the buildings to dissipate without affecting the permafrost. Some of the facilities, including storage buildings, might be supported by insulated slab on grade foundations, with active or passive refrigeration.

5.4.1 FLOW STREAMS AND DESIGN RATES

The Parsons Lake facilities will process sweet natural gas from the north and south pads for delivery to the Mackenzie gathering system.

The well drilling schedule is shown in Section 3.1, Reservoir Data. The average annual flow rates are shown in Section 4.2, Reservoir Simulation.

The wellhead temperature profile varies with tubing size and production rate. Table 5-1 provides the temperature profile across the tubing sizes expected to be used at Parsons Lake.

Table 5-1: Wellhead Temperature Profile

Single Well Flow Rate		Wellhead Temperature by Tubing Size (ºC)	
(Mm^3/d)	MMscf/d	178 mm (7 inch)	114 mm (4.5 inch)
0.142	5	53	21
0.283	10	54	30
0.566	20	57	47
1.699	60	63	60
2.832	100	67	N/A
4.242	150	67	N/A
5.664	200	64	N/A

5.4.1.1 Design Rate

Delivering 8.5 Mm^3/d (300 MMcf/d) of gas from the Parsons Lake field to the Northwest Territories–Alberta boundary will require a gas production rate at the Parsons Lake wellhead of about 9.0 Mm^3/d (324 MMcf/d). The design wellhead production rate must exceed the boundary delivery rate to make up for fuel used at various points in the system, and for shrinkage that occurs when the NGL is removed at the Inuvik area facility.

The Parsons Lake facilities will be designed to take advantage of spare capacity that might arise periodically on the gathering and pipeline systems, to:

- make up for periods of reduced production resulting from maintenance activities

5.4.1.1 Design Rate (cont'd)

- accommodate the potential for higher fuel requirements if the pipeline system is expanded in the future

Table 5-2 shows the Parsons Lake design gas flow rates.

Table 5-2: Parsons Lake Design Gas Flow Rates

Location	Design Rate	
	(Mm^3/d)	(MMcf/d)
Parsons Lake wellhead	10.0	355
Parsons Lake north pad outlet	9.8	345

5.4.1.2 Wellhead Pressure

The expected wellhead pressure (see Figure 5-1) was selected based on the ability to provide sufficient project life with a single stage of compression. Additional compression is not in the development plan at this time, but its inclusion might be evaluated in the future after more reservoir and production data is available.

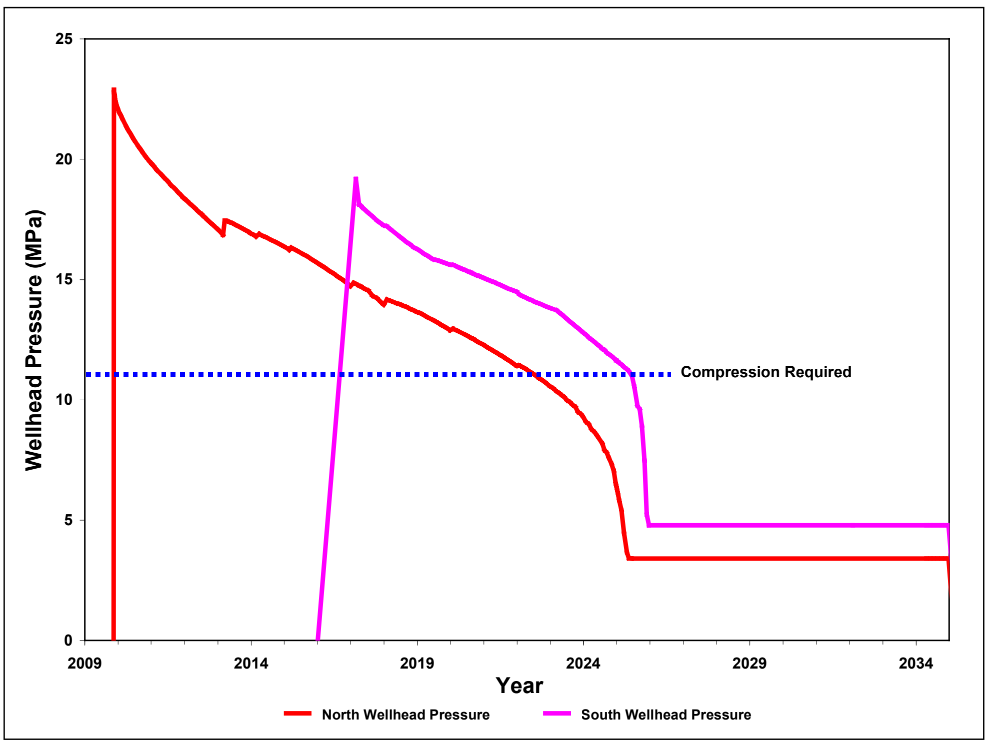

Figure 5-1: Wellhead Pressure

The wellhead pressure at the south pad will likely be 1.4 MPa higher than the wellhead pressure at the north pad. This is because the south pad must overcome the pressure drop in the flow line to the north pad before using the compression equipment at the north pad.

5.4.1.3 Flow Line

The flow line from the south pad to the north pad will be above ground because production from the south pad contains water and will require heat for hydrate inhibition.

5.4.1.4 Waste Disposal Well

The Parsons Lake field development includes one waste disposal well, which will be located at the north pad. The design water flow rate and pressure for the waste disposal well are:

- water flow rate:
  - expected – 95 m^3/d (598 bbl/d)
  - design – 240 m^3/d (1,510 bbl/d)
- water pressure:
  - normal – 700 kPa (102 psi)
  - design – 9,800 kPa (1,421 psi)

Sufficient space will be available on the north pad for additional injection wells and equipment, if required.

5.4.1.5 Satellite Wells

In all cases, potential satellite well flow streams and design rates are assumed to be equal to an individual well on the north pad.

5.4.2 PRODUCTION STREAM PROPERTIES

The facilities design for the Parsons Lake field development is based, in part, on assumptions regarding the composition and properties of substances produced from the wells.

5.4.2.1 Fluid Properties

Gas compositions observed during historic well tests are shown in Section 3.1, Reservoir Data. The gas composition for any potential satellite wells is assumed to be the same. The analysis for the water produced from Parsons Lake wells is also provided in Section 3.1.

5.4.2.2 Carbon Dioxide Content

Parsons Lake gas contains about 3% carbon dioxide (CO_2) in the north field and about 5% CO_2 in the south field. The combined stream, which will leave the

5.4.2.2 Carbon Dioxide Content (cont'd)

north pad gas conditioning facility, will initially contain 3% CO_2. This concentration is expected to gradually increase to about 4% CO_2 by the end of the field's producing life.

Parsons Lake gas will be blended with other gas in the gathering system to meet the 2% CO_2 content specification at the outlet of the Inuvik area facility. As a result, the current Parsons Lake design does not include CO_2 removal facilities.

5.4.2.3 Hydrogen Sulphide Content

As no measurable hydrogen sulphide (H_2S) has been detected in the gas (<1 ppm), the Parsons Lake design will be for sweet natural gas.

5.4.2.4 Wax Content

ConocoPhillips has assessed the composition of the condensate and has determined that wax deposition is unlikely to occur. As a precaution, injection points for a wax inhibitor chemical will be included in the refrigeration facilities at the north pad.

5.4.2.5 Sand Production

ConocoPhillips has assessed the potential for sand production and has determined that it is unlikely to occur. As a precaution, the inlet and test separators will have connections for future sand jetting and removal equipment.

5.4.3 PRODUCT AND DELIVERY SPECIFICATIONS

Product and delivery specifications for the Parsons Lake gas conditioning facility are determined by the requirements of the gathering system. Products at the outlet of the gas conditioning facility must be below the maximum requirements listed in Table 5-3.

Table 5-3: Product and Delivery Specifications

Parameter	Design Maximum
Normal facility outlet pressure	10.6 MPa
Design outlet pressure	12.2 MPa
Maximum design outlet temperature	-1°C
Water content – gas	6 mg/m^3
Water content – NGLs	10 ppmw
Carbon dioxide (at the Inuvik area facility outlet)	2%
Hydrogen sulphide	3 mg/m^3

5.4.4 OTHER CRITERIA

Other functional criteria used in the design of the Parsons Lake facilities were:

- reservoir subsidence – ConocoPhillips has assessed the likelihood of surface subsidence caused by withdrawing gas from the reservoir. No measurable subsidence is expected because of the nature of the reservoir, its depth (3 km subsurface), and other indicators.

- well permafrost thaw subsidence – A combination of wellbore insulation and thermosiphons will be used to ensure that the surface permafrost remains frozen at all times during production operations. No measurable subsidence is expected.