Geologic unit	Thickness range (feet)	Comments
Quaternary flood deposits	0-100	Localized in and near coulees and scablands
Quaternary fine unit	0-120	Predominantly loess
Priest Rapids Member (WB)	0-400	Absent in southwest corner of County
Roza Member (WB)	0-300	Absent from western 1/3 of County
Sentinel Gap, Frenchman Springs Mbr (WB)	0-150	Absent from northern and eastern part of County
Sand Hollow, Frenchman Springs Mbr (WB)	0-120	Only present in south-central and southwestern part of County
Ginkgo, Frenchman Springs Mbr (WB)	0-50	Only present in southwestern most corner of County
Sentinel Bluffs Member (GRB)	0-800	Underlies almost all of County
Umtanum Member (GRB)	0-300	Absent beneath northern half of County
Ortley Member (GRB)	0-600	Absent beneath northern half of County
Grouse Creek Member (GRB)	0-400	Absent in northeastern and northwestern corners of County
Wapshilla Ridge Member (GRB)	0-500	Underlies most of County
Undifferentiated Grande Ronde Basalt	0->2,000	Only beneath southern half of County
Pre-basalt basement	>20,000	Underlies all of County

WB – Wanapum Basalt; GRB – Grande Ronde Basalt

Table 1. Summary of the main geologic units underlying project area.

Feature		Hydraulic Conductivity Ranges		Reference	Comments
		ft/day	m/day (approx. conversion)		
Flow Tops	Kh	1×10^{-6} to 1,000	3×10^{-7} to 3×10^{2}	USDOE, 1988	Average = 0.1 ft/day
	Kv	3×10^{-9} to 3×10^{-3}	9×10^{-10} to 9×10^{-4}	USDOE,1988	
		1×10^{-5} to 1×10^{-1}	3×10^{-6} to 3×10^{-2}	Sabol and Downey, 1997	Measured near Lind, Washington
Flow Interiors	Kh	1×10^{-9} to 1×10^{-3}	3×10^{-10} to 3×10^{-4}	USDOE, 1988	Approximately 5 orders of magnitude less than flow tops
	Kv	3×10^{-9} to 3×10^{-3}	9×10^{-10} to 9×10^{-4}	USDOE,1988	
		1×10^{-5} to 1×10^{-1}	3×10^{-6} to 3×10^{-2}	Sabol and Downey, 1997	Measured near Lind, Washington
Flow Tops	Kh	7×10^{-3} to 1,892	2×10^{-3} to 6×10^{2}	Whiteman et al. (1994)	Vertically Averaged for Saddle Mountains Basalt
	Kh	7×10^{-3} to 5,244	2×10^{-3} to 2×10^{3}		Vertically Averaged for Wanapum Basalt
	Kh	5×10^{-3} to 2,522	5×10^{-3} to 6×10^{2}		Vertically Averaged for Grande Ronde Basalt
Ellensburg Formation Interbeds	Kh	1×10^{-6} to 1	3×10^{-7} to 3×10^{-1}	USDOE, 1988	Average for various interbeds = 0.01 to 0.1 feet/day
	Kh	1×10^{-6} to 100 feet/day	3×10^{-7} to 3×10^{1}	Sabol and Downey, 1997	Measured for interbeds in Pasco Basin

Kh = horizontal hydraulic conductivity
Kv = vertical hydraulic conductivity

Table 2 - Summary of hydraulic conductivity values typical for CRBG interflow structures and sedimentary interbeds.

Cert./Permit/Application	Priority Date	Quantity	Purpose
IRRIGATION			
S3-01622C	5/16/1938	13,450 cfs 2,910,00 AF/yr	Irrigation of 590,000 acres, hydroelectric, recreation, municipal, industrial
C-9252	12/24/1941	40 cfs	Irrigation of 1,319 acres, Block 2
S3-00019C	4/22/1943	212 cfs 70,000 AF/yr (1)	Partial irrigation of 160,000 acres
C-10703	10/27/1958	80 cfs 23,121 AF/yr	Irrigation of 3,303 acres, Block 3
R3-00013P	4/22/1943	200,000 AF (2) Plus storage of project waste, seepage & return flow	Supplemental supply; irrigation of 234,000 acres
S3-25062C	10/27/1958	8.5 cfs 23,121 AF/yr	Irrigation of 350 acres, Block 3
S3-28586P	5/16/1938	1,140 cfs 214,000 AF/yr	Irrigation, hydroelectric, recreation, municipal, industrial
CBP Withdrawal	5/16/1938	10,410 cfs	Reserved for remainder of CBP
Withdrawal	6/16/1975	120 cfs	Block 1
HYDROPOWER			
C-11543	5/16/1938	75,000 cfs continuously	Hydropower left and right bank of Grand Coulee Dam
C-11793	5/16/1938	6,400,000 AF	Live storage, FDR irrigation – hydropower
C-11794	8/12/1970	3,162,000 AF	Dead storage FDR
S3-26257C	5/9/1975	22,000 cfs continuously	Hydropower – 3rd power plant – increased capacity
S3-26258C	10/16/1969	184,000 cfs continuously	Hydropower – 3rd power plant – 6 units
S3-27615C	10/16/1969	7,400 cfs continuously	Hydropower – 4 pump turbine units
S3-01606C	10/16/1969	21,700 cfs continuously	Hydropower – increased capapcity left and right bank – Grand Coulee (18,000 cfs), two pump turbines (3,700 cfs)
S3-01622C (old permit #15994)	5/16/1938	13,450 cfs continuously March - October	Low head power generation
R3-00013P	4/22/1943	200,000 AF	Low head power generation

Notes: (1) From Lind Coulee
(2) Natural flows from Rocky Ford, Upper Crab Creek, tributaries to Moses Lake, and Potholes Reservoir.

Table 3. USBOR water rights. (from: Reclamation – Managing Water in the West, Odessa Subarea Special Study Columbia Basin Project – Plan of Study, USBOR, February 2006)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr(1)	Apr(2)	May	June	July	Aug(1)	Aug(2)	Sept	Total
Average	1773	413	1791	4078	2254	1719	1319	241	2149	2602	1478	61	21	1040	20936
Maximum	4693	3082	7443	10999	7484	5846	4269	2216	8134	15620	7671	1453	1062	5103	54485
Minimum	938	0	0	0	0	0	0	0	0	0	0	0	0	0	2276
Driest 10-year Avg. (37-46)	1582	0	758	2557	559	1033	689	63	1217	483	340	0	0	597	---
Wettest 10-year Avg. (67-76)	1510	401	2217	5950	4251	2294	1787	335	3407	3885	3144	211	106	1375	---

Notes: 1) Data was provided by Reclamation (Appendix B of the Columbia River Water Availability Analysis – Preliminary Work Product dated September 5, 2006. 2) Data represents volume of water available for diversion in excess of downstream flow objectives under current operations. Available to divert just downstream of Priest Rapids Reservoir.

Table 4. Columbia River Water Available for Diversion (KAF) – 1929 to 1978 (Ecology, May 2007)

Drainage	Available Info	Conveyance Distance/ Issues	Land Owner/ Stream Channel Issues	Hydrogeology /Water Rights	Recreation and Habitat (Lakes)
Bluestem Creek					
Canniwai Creek					
Coal Creek					
Crab Creek					
Duck Creek					
Goose Creek					
Lake Creek					
Marlin Hollow					
Rock Creek					
Sinking Creek					
Wilson Creek					

Table 5. Color coded rankings of the drainages assessed in this report. Green is favorable for the proposed project, red is not favorable for the proposed project, and yellow is neutral.

	Moonshine Pipeline Route	Hawk Creek Pipeline Route	Lincoln Pipeline Route
Pipeline Length (ft)	62,000	74,000	77,000
Start Elevation (ft)	1,320	1,240	1,200
Highest Elevation (ft)	2,480	2,500	2,360
Total Static Head (ft)	1,160	1,260	1,160
10 CFS Pilot Study – 24-inch Pipeline			
Pipeline Headloss (ft)	81.5	97.3	100.6
Velocity (ft/sec)	3.2	3.2	3.2
Total Dynamic Head (ft)	1,242	1,357	1,261
100 CFS Full Build Out – 57-inch Equivalent Pipeline			
Pipeline Headloss (ft)	85.8	102.4	106
Velocity (ft/sec)	5.6	5.6	5.6
Total Dynamic Head (ft)	1,246	1,362	1,266
100 CFS Full Build Out – 60-inch Pipeline			
Pipeline Headloss (ft)	66.9	79.8	82.6
Velocity (ft/sec) Pilot / Full Build	0.50 / 5.1	0.50 / 5.1	0.50 / 5.1
Total Dynamic Head (ft)	1,226	1,340	1,243

Table 6. Summary of potential pipeline route hydraulics.

Pipeline Diameter	Segment 1 (7 miles at 565 psi)	Segment 2 (7.5 miles at 90 psi)
24-inch	0.300-inch	0.200-inch
48-inch	0.560-inch	0.200-inch
60-inch	0.700-inch	0.250-inch

Table 7 – Steel pipe thicknesses.

Date	Inlet to upper Twin Lake (cfs)	Inlet to Coffee Pot Lake (cfs)	Highway 21 crossing above Pacific Lake (cfs)	Upstream of confluence with Crab Creek (cfs)
Aug-98	0.5		0	0
Oct-98	0.86		0	0
Nov-98	0.87	0.037	0	0
Dec-98	2.5			
Jan-99	14.4			
Feb-99		44.6	33.4	0
Mar-99	34			
Apr-99	13.7	16.6	17.2	18.1
May-99		6.61	8.58	5.36
Jun-99	2.24	0	0	0
Jul-99	0.639	0	0	0

Table 8. Spot measurements on Lake Creek, 1998-1999.

Date	Inlet to upper Twin Lake (cfs)	Inlet to Coffee Pot Lake (cfs)	Highway 21 crossing above Pacific Lake (cfs)	Upstream of confluence with Crab Creek (cfs)
Aug-98	**0.5**	*0*	**0**	**0**
Sep-98	*0.5*	*0*	*0*	*0*
Oct-98	**0.86**	*0*	**0**	**0**
Nov-98	**0.87**	**0.037**	**0**	**0**
Dec-98	**2.5**	*5*	*3*	*0*
Jan-99	**14.4**	*20*	*15*	*0*
Feb-99	40	**44.6**	**33.4**	0
Mar-99	**34.0**	*38*	*25*	*0*
Apr-99	**13.7**	**16.6**	**17.2**	**18.1**
May-99	*5*	**6.61**	**8.58**	**5.36**
Jun-99	**2.24**	**0**	**0**	**0**
Jul-99	**0.639**	**0**	**0**	**0**

Table 9. Measured (bold) and estimated (italics) flows in Lake Creek, 1998-1999, used to develop water budget.

Location	Estimated Baseflow	Estimated Seepage Loss
Above upper Twin Lake	0.5 cfs	
Above Coffee Pot Lake	0.4 cfs	
Above Pacific Lake		5.4 cfs
Above Crab Creek confluence		9.6 cfs

Table 10. Estimate of seepage rates for Lake Creek sub-basin using spot data from August 1998 to July 1999.

Location	Estimated Baseflow	Estimated Seepage Loss
Above upper Twin Lake	0.5 cfs	
Above Coffee Pot Lake	0.4 cfs	
Above Pacific Lake		7.0 cfs
Above Crab Creek confluence		12.4 cfs

Table 11. Estimate of seepage rates for Lake Creek sub-basin based on long-term water balance model, January 1985 to August 2010.

Added Inflow (cfs)	Predicted # of years out of 26 Pacific Lake would fill	Predicted average annual flow from lake Creek into Crab Creek (cfs)
0	6	2.3
10	25	8.3
15	26	10.7

Table 12. Summary of predictive results for when water is and is not added to Lake Creek.