APPENDIX A

Part 3 Population Effects Model

1 INTRODUCTION

This appendix presents the population model used to forecast population changes attributable to the Project's construction phase. The model is based on the Project's total labour requirements (Section 17 Labour Market) and applies assumptions and parameter values to yield estimates of Project related annual average population changes. The approach is consistent with the Worker Accommodation plan (Section 4 Project Description, Section 4.3.6). The purpose of this appendix is to support Section 28 Population and Demographics, Section 29 Housing and Section 31 Transportation of the Site C Clean Energy Project EIS.

2 DESCRIPTION AND METHODOLOGY

The model is premised on the assumption that people will move to the Peace River Regional District (PRRD) to take employment opportunities arising from the Project's construction phase. This means that the number of Project related employment opportunities exceeds the number of appropriately skilled and available residents in the PRRD's labour force. The Labour Market assessment determined that this would likely be the case, and there would be the need for in-migrants to fill the employment gap (Section 17 Labour Market and Volume 3 Appendix A Economic Assessment, Part 3 Labour Market: Additional Baseline Information). The need to provide on-site temporary accommodation is premised on this need to attract non-resident workers (Section 4 Project Description, Section 4.3.6).

The population model quantifies the employment gap and then allocates the in-migrant workers to either residing in the on-site accommodation and those that do not. The latter group would include dependents, which add to the population count. The method and parameter values adopted for completing the allocations and specifying population attributes was informed by Census data, experience of other projects and informed judgment. The assumptions and parameter values are addressed in the following sub-section (Section 3).

The two primary sources of employment data are the Summary of Workforce by Craft prepared according to the Project's 2010 cost estimate and an estimate of local supplier employment prepared for the Project by BC Stats (Volume 3 Appendix A Economic Assessment, Part 3 Labour Market: Additional Baseline Information).

The Summary of Workforce provided person months of employment by detailed craft categories (mostly trades' positions), contract supervisors and engineering/procurement/construction management (construction management). The model aggregates the craft category such that population estimates are developed for the three major occupation categories.

The Project expenditure creates employment opportunities in industries supplying the Project, as well as in industries supplying the supply industries, and consumer industries affected by the spending of those employed in the Project or the supply industries. This is termed indirect and induced employment effects, respectively. BC Stats, using a detailed breakdown of the Project's 2010 cost estimate and the B.C. Input-Output model (BCIOM), estimated the added employment that might be expected in B.C with the Project. Using regional industry level information, BC Stats also estimated the number of

jobs that could be supported in the PRRD. The BCIOM does not provide occupation description of the jobs.

A third source of labour that has population implications are persons drawn to the PRRD to fill positions vacated by residents that take Project positions. The Labour Market baseline indicated that skilled craft persons are generally fully employed in the PRRD, even during periods of economic slowdown. Given the shortage of skilled labour, it is expected the position would be filled by an in-migrant, which has population implications.

The characteristics of the employment such as length of contract and potential for additional similar work may suggest different housing choices that have population implications. These are addressed in the next section (Section 3).

Population is quantified in terms of average annual number of persons because that corresponds to the level of precision reflected in the assumptions and other data adopted to estimate population changes.

Finally, the assumptions adopted here regarding employment shares and numbers are for the purposes of forecasting population. The assumptions do not imply any commitments, intentions or targets regarding the construction labour force or labour arrangements.

3 MODEL ASSUMPTIONS AND INPUT DATA

The model uses the main data inputs identified above, and particular parameter values and assumptions, to produce estimates of the Project's effect on populations and demographic characteristics during construction. The key assumptions and parameter values are summarized here. In some instances, Census data is available to inform the magnitude of the value or assumption adopted, but in other cases anecdotal evidence and professional judgment is required because direct data is not available. In adopting the parameter values and assumptions, the tendency was to select a value that would contribute to augmenting rather than reducing the change in population. This is intended to be a conservative assumption if one views relatively higher population values as more likely to cause potential adverse effects.

3.1 Share of existing residents taking project related employment

Existing residents that take project related employment would not add to the LAA population, except to the extent they leave an existing job, which is addressed later.

The resident's share of project employment would depend on the relative employment conditions offered by the Project, the state of the local economy during the Construction phase and the number of existing residents with the requisite skills and experience. Given different views about these conditions leads to a range of plausible values.

Current research indicates that the number of existing residents with craft skills taking construction phase employment would probably be between 5% and 20%. The primary factors that would support the higher end of this range (i.e., 20% total craft positions) was if the work was relatively long term and it would allow one to retain their primary place of residence (Spiruda 2011, pers. comm.). The lower estimate of the local participation rate (i.e., 5%) is from recent experience in the LAA which has been

experiencing skill shortage. Few resident tradespeople took positions in the retooling of the pulp mill modernization in Taylor, the Spectra gas plant refit, or construction of the hospital in Fort St John, as trade occupations were in very high demand in the oil and gas industry which was offering higher wages (Koshman 2011, pers. comm.).

Given this range of data and opinions, a mid-point value of 15% is adopted for the share of existing residents taking craft positions (Table 1, line 3). With respect to the Project's supervisory and management positions, there are relatively few persons in these occupational categories in the LAA (Volume 3 Appendix A Economic Assessment, Part 3 Labour Market: Additional Baseline Information, Table 4). Given this, it was assumed that all of the management/supervisory positions would be filled by in-migrants (Table 1, lines 6 and 8 respectively). The number of project positions taken by existing residents is subtracted from the total number of positions because existing residents would not cause a population change. A caveat is discussed in the following paragraph.

From purposes of estimating the Project's population implications it is not enough to identify the employment share of existing residents, particularly if the labour force is at full employment as has been the case for trades in recent years. The view of regional employment centers was that "tradesmen that want to work can always find work" (Jones 2011, pers. comm.) An otherwise employed resident that takes a project job will create a vacancy that is either filled by an in-migrant or remains vacant (which exacerbates labour short conditions). The exception is where resident is employed outside the LAA or in a remote camp. Presently, an estimated half of the members of Local 115 (Operating Engineers) are working in remote camps or outside the LAA. Based on this consideration, it was assumed that 50% of the positions taken by local residents (craft positions) in the Project would draw an in-migrant to fill the position and would reside in the LAA. The increment is shown on line 13 of Table 1.

Table 1 Project labour demand (employment positions)

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Comment
Direct Employment										
Total Crafts	149	536	726	702	803	1,349	1,194	720	212	N/A
Local Hire of Crafts	22	80	109	105	120	202	179	108	32	Assume 15% local hire
Non-Local Crafts persons	126	456	617	596	682	1,147	1,015	612	180	N/A
Total Contractor Supervision[a]	29	104	145	140	197	413	375	234	63	N/A
Local hire Contractor Supervision	0	0	0	0	0	0	0	0	0	Assume no local hire
Total Construction Management[a]	83	178	229	236	297	304	306	331	169	N/A
Local hire Construction Management	0	0	0	0	0	0	0	0	0	Assume no local hire
Displacement Employment (number of in-migrant workers to fill vacated LAA position)[b]										
Crafts	11	40	54	53	60	101	90	54	16	50% of local hire vacate trade jobs that will draw in migrants
Supervisors	0	0	0	0	0	0	0	0	0	Assume no local hire
BC Hydro Managers	0	0	0	0	0	0	0	0	0	Assume no local hire
Total Displacement	11	40	54	53	60	101	90	54	16	Sum of lines 10 to 12
LAA Supplier and Induced employment[c]										
Supplier and induced	80	210	260	280	368	398	368	268	118	BCIOM Base Case

NOTES:
a from BC Hydro and Power Authority (2012)
b derived values, details in text
c Volume 3 Appendix A Economic Assessment, Part 2 Project Economic impacts: BC Stats
SOURCE: BC HYDRO AND POWER AUTHORITY (2012)

3.2 Direct project workers residing in on-site accommodations and demographic characteristics

Planning of on-site accommodation is presented in Section 4 Project Description. It broadly sets out the locations, capacity of the workforce camps. It is noted that camp sizing is sensitive to short term peak requirements where the population forecast is average annual value.

On-site accommodation is encouraged where it contributes to public and worker safety, workforce attraction, project construction productivity, cost and schedule. Temporary on-site accommodation is planned for the Site C dam site. From the individual's perspective it is thought that the length of employment is an important factor in determining accommodation preferences with short term work favouring on-site accommodation. The terms of the employment contract are also a factor. For crafts and contractor supervisor's positions, the typical engagement is expected to be shorter term and would tend to favour on-site accommodation (BC Hydro 2012, pers. comm.). The Construction management and supervisory positions are expected to have the most stable and long term positions and could be encouraged to take residence in the community (BC Hydro 2012, pers. comm.). A survey of mobile workers in Alberta found that 75% to 90% of the workforce lived in camp facilities (Nichols Applied Management 2007). The assumptions adopted for each of the project labour categories are summarized inTable 2. That is, it is assumed that 85% of the craft and supervisors will reside in the on-site accommodations and 15% of the construction managers. In the peak year 5, the assumed values results in 74% of the non-resident direct work force residing in camps.[1]

The craft labour force is male dominated, as is the case for construction camp population (Nichols Applied Management 2007). The assumptions for the camp population adopted by the model are summarized in the following table:

Table 2 Housing and demographic assumptions for in-camp project labour

Direct labour category	% in camp	Sex[a] (% male)	Median age (years)[b]
Crafts	85	92	35 [b]
Contractor Supervisors	85	92	40[c]
Construction Management	15	92	40[c]

NOTES:
[a] Male percentage in the LAA's Trades, Transport and Equipment Operators labour force at the 2006 Census.
[b] The LAA's median age is 34.7 in 2011, and the median age of the northern Alberta workforce surveyed was 35 years.
[c] Median age of B.C. population (BC Stats 2010)
SOURCES:
Nichols Applied Management (2007); BC Stats (2010)

The population total estimated by the model is inversely related to the percentage of the work force assumed to reside in on-site accommodation. That is because a portion of the workers residing outside the on-site accommodation will be accompanied by spouse/partners and children, whereas those taking on-site accommodation would have a permanent residence outside the LAA where their dependents would be domiciled. If a

[1] In year 5, the total direct Project labour force (less participation of residents) is 1,864 and the on-site accommodation population is estimated at 1,372 persons (annual average).

higher proportion of supervisors and managers were assumed to reside on-site, the total population estimate would be reduced.

Based on the employment demand presented in Table 1 and the assumptions summarized in Table 2, the annual average camp population was estimated and shown on line 5 of Table 5.

3.3 Direct project workers residing in off-site accommodations and demographic characteristics

The number of in-community project workers was determined by subtracting the on-site population from the Project's total labour demand (after netting out local hires). This is shown in Table 5, line 10.

The median age and sex distribution is assumed to be the same as those residing in the on-site accommodation. The marital status and family size of this population is relevant as dependents are expected to accompany the direct project worker. The assumptions regarding these characteristics were informed by the high proportion of occupations in the LAA labour force that could be required of the Project. This includes trade, primary and manufacturing occupations, which make up 40% of the LAA's labour force. It is assumed that in-coming population will also share demographic features, such as marital status, household size and spousal/partner participation in the labour force. The household and demographic characteristics of the LAA (from the 2006 Census) were used for forecasting the in-migrant population as summarized in Table 3.

Table 3 Demographic assumptions for non-camp direct labour and other labour

Labour Category	Sex (% male)	Median Age (years)	Marital Status[a] (% married or common-law)	Number of Children per couple[b]
Crafts	92	35	61	1.1
Contractor Supervisors	92	40	61	1.1
Construction Management	92	40	61	1.1
Supplier and induced industry employment	50	34	61	1.1

NOTES:
a corresponds to the PRRD at 49% married and 12% common law relationship at the 2006 Census
b average number of children per Census family PRRD at the 2006 Census
SOURCES:
Nichols Applied Management (2007); BC Stats (2010)

3.4 Supplier Industry and Induced Population

The number of jobs in industries supplying goods and services to the Project and in consumer industries was estimated by BC Stats and shown on line 15, Table 1. The method for quantifying the population implications of this employment took into account the view expressed by employment counselors that visitors seeking employment in the region were not seeking entry level jobs, or service industry jobs, and that many entry level positions are held by spouses where the primary wage earner was in a primary

industry (Jones 2011, pers. comm.). This view is corroborated by the high spousal employment rate[2] of 65% as compared to B.C. rate of 56.9% (BC Stats 2010).

The method for estimating the number of in-migrants required to fill non-project jobs involved estimating the number of spouses accompanying direct project worker that would be available for employment. This was found by multiplying the number of "couple households" by the spousal participation rate of 65% (Table 5, line 16). The remainder would be filled by in-migrants (Table 5, line 18). In-migrants were couples (line 19) and singles (line 20), in proportion to the 2006 Census. The demographic features of this population are summarized in Table 4. The sex ratio was set at the B.C. split because the type of employment is not traditionally as male dominated as the Project employment.

Table 4 Demographic assumptions for indirect and induced population

Labour Category	Sex (% male)	Median Age (years)[b]	Marital Status[a] (% married or common-law)	Number of Children per couple[b]
Supplier and induced industry employment	50	34	61	1.1

NOTES:
a corresponds to the PRRD at 49% married and 12% common law relationship at the 2006 Census
b average number of children per Census family PRRD at the 2006 Census
SOURCE:
BC Stats (2010)

4 RESULTS AND LIMITATIONS

The model results are summarized in Table 5. The table reports average annual population values for the construction phase of the proposed Project. Assuming the same age profile of Census families, the child forecast is further broken down into forecast numbers of pre-school, school-age and older children at home (Table 6).

Table 5 reports the average annual persons by occupation type and whether living in on-site accommodation or in the community. The population values correspond to average annual values. As discussed above, the population effect is driven by the Project workforce numbers and Project expenditure and assumptions about the availability of resident skilled tradesmen. The camp and In-community populations are estimated in Year 0 at 145 direct employees living on-site, and a total of 300 persons living in the community. Ninety-three of these are direct Project employees, with the remainder in-migrants taking employment attributed to the Project (i.e. direct supplier and induced jobs) and dependents. Peak year 5, the model indicates that an average of 1,372 persons would live on-site, and the total in-community population increment is estimated at 1,613 people.

The model results are a consequence of assumptions described above, that are constant over the forecast period which imposes a linear relationship between the main input values (i.e. Project and non-project employment) and total population estimates. The model is reliable in the sense that for given input values, it will estimate the same population estimates.

[2] The employment rate is the number employed as a percent of the population.

The model is sensitive to changes in the timing and magnitude of the Project's labour requirements, in that the population change correlates to the shape of the labour requirement through construction, including the peak as modelled in year 5. The Project's labour requirements were drawn from the Project's 2010 cost estimate and an estimate of local supplier employment prepared for the Project by BC Stats. This is the best available information, but could be subject to change if the Project moves to final design and to tendering stages.

The population forecast is also sensitive to assumptions about where the in-migrant labour force resides, either on-site accommodations or off-site housing. The choice is influenced by relative incentives that may be offered by BC Hydro, employers and communities, the terms of employment as well as the general state of the LAA and BC economy. The rationale for the assumed values adopted in the model is addressed in Section 3.2. The number of direct workers residing in off-site housing is positively correlated with higher total population as the model assumes dependents would accompany the direct worker.

The total population estimate is also related to the proportion of existing residents taking project employment. Informed opinion was that the number of existing residents taking Project jobs could range from a low of 5% to a high of 20%, depending on the state of the LAA's and BC economies. The base modelling assumption was that existing residents would take 15% of the craft jobs. That yields a total population estimate of 2,985 persons with 1,372 residing on-site in (peak) year 5 of construction, as reported in the table. If existing residents take only 5% of the craft jobs, the total population would increase as a relatively greater number of in-migrants would be required. The model estimates a total population of 3,020 persons, with 1,486 living on-site in peak Year 5. If existing residents occupied 20% of the craft jobs, fewer in-migrants would be required and the total population increase is estimated to be 2,967 total persons, with 1,314 living on-site. The variance in total population given these alternative assumptions is only about 2%.

The model is simplification of complex reality and a portrayal of future conditions that are not known with certainty. Uncertainties related to the direct labour force and on-site accommodation options. These factors would become more certain as the Project moves to tendering. Population flows related to supplier and induced employment may never be known with certainty because of difficulties in clearly separating general economic growth and the project effect. While recognizing these uncertainties, the population estimates are representative of the timing and magnitude the Project's population effect consistent with the design stage of the Project and provides the basis for assessing potential population implications to value components that are sensitive to changing population levels (e.g. Housing, Community Infrastructure and Services).

Table 5 Project population forecast (persons)

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Camp Population (no dependents)									
Crafts	108	387	525	507	580	975	863	520	153
Contractor Supervision	25	88	124	119	168	351	318	199	54
Construction Management	12	27	34	35	45	46	46	50	25
Total Camp Population	145	502	683	661	792	1,372	1,227	768	233
In Community Project Population (no dependents)									
Non-Local Crafts	19	68	93	89	102	172	152	92	27
Contractor Supervision	4	16	22	21	30	62	56	35	10
Construction Management	70	151	194	201	253	258	260	281	144
Total Non-Camp Project Employees	93	235	309	311	385	492	469	408	180
In Community Project population (no dependents)									
Displacement Employees	11	40	54	53	60	101	90	54	16
In Community Households (Project employees and displacement employees)									
Couples (1 couple=2 people)	65	171	226	226	277	369	347	287	122
Single households	40	104	137	137	168	224	211	175	74
Non-camp Project spouses available for direct supplier and induced employment	42	111	147	147	180	239	225	186	79
Supplier and induced jobs	80	210	260	280	368	398	368	268	118
Less jobs filled by In community Project spouses	38	99	113	133	188	159	143	82	39
Supplier and induced jobs taken by Non-Project couples	14	37	43	50	71	60	54	31	15
Supplier and induced taken by non-Project singles	14	37	43	50	71	60	54	31	15
In Community population summary (Project, direct supply, induced and displacement employees and dependants),									
Total Couples	79	209	269	276	348	429	401	318	137
Total Singles	54	141	180	188	239	284	265	205	89
Total children	87	229	296	304	383	472	441	350	150
Population (includes dependents)	300	788	1,013	1,045	1,317	1,613	1,508	1,191	513
Households	133	350	449	464	587	713	666	523	226

Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Change in population	300	488	225	32	273	296	-105	-317	-679
Change in households	133	217	99	15	123	126	-47	-143	-298
Summary of Population Increment by worker category									
Camp Project Workers	145	502	683	661	792	1,372	1,227	768	233
In-Community Project Workers and dependents	216	542	712	717	887	1,135	1,081	941	416
Non-Project In-Community Indirect and Induced workers and dependents	84	246	301	327	430	479	427	251	97
Total Population (includes dependents)	444	1,290	1,696	1,706	2,110	2,985	2,735	1,960	745

Table 6 - Project population forecast - total children by age category[a] (persons)

Age Category	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Total Children	87	229	296	304	383	472	441	350	150
Preschool [b](0-4 years)	21	55	71	74	93	114	107	85	36
School Age (5-17)	52	137	176	181	228	281	263	208	89
Adult (18 yrs and over)	14	37	48	50	62	77	72	57	25

NOTES:

a Age profile of 2006 Census families for Peace River North. The percentages are 29% of total children in age group 0 to 5 years, 54.7% in the 6 to 17 age group, and 16.3% for 18 years and older.

b Pre-school was estimated by assuming equal number of children in each year of age (0 to 5), to estimate the number of 5 year olds (i.e. 16.6% of age group) which was removed and added to the school age category

Source: Derived from Table 5

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