Investigating the Potential for Direct-Use Geothermal Resources in British Columbia: A New Geoscience BC Project

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INTRODUCTION

Direct-use geothermal resources are an underutilized potential asset in British Columbia. The development hurdles for direct-use applications are significantly lower than for electrical applications, thus there are untapped resources that could be developed. This project will provide the Province of British Columbia (BC) with evaluations of these underutilized resources and will suggest their potential for development. The project will comprise reviews of existing geoscience information for BC and will also work with communities to assess their levels of understanding of direct-use applications. The project will help them identify potential direct-use projects in their regions, as well as ascertain barriers to development. As one of the aids to overcome barriers, the project will create a 'Road Map' for community-development use. Tuya Terra Geo Corp., a BC-based company, and Geothermal Management Company Inc. have combined forces to complete this evaluation and document the results. The project will be carried out over the next six months, with products expected in mid-2016.

Geothermal energy in BC has long been discussed as a potential renewable- (i.e., green) energy source for the province. The recent study by Kerr Wood Leidal and GeothermEx (2015) evaluated 18 geothermal sites and provided more detailed information regarding 11 of those sites deemed 'favourable' for electrical generation. They reported that the combined potential for the 11 sites was up to 400 MWe of power. However, the hurdle for economically viable, geothermal, electrical-power–generation development is not just the confirmation of suitable resources, but also the need to identify acceptable financial and economic factors. Electrical generation can have significant long-term payback but it entails very high upfront costs. In addition, the length of time to develop a resource can also be protracted (Figure 1). The exploration required for development of high-enthalpy systems is also complex and costly (Figure 2). In contrast, direct-use applications can typically utilize lower temperature, more easily attainable resources with simpler and lower cost exploration strategies. This study will seek to quantify and evaluate these aspects to determine the potential for direct-use in BC communities from a resource and development-potential perspective.

Using existing compilations of the geothermal resources in BC (e.g., Fairbanks and Faulkner, 1992; Majorowicz and Grasby, 2010a, b; Kerr Wood Leidal and GeothermEx, 2015) and work carried out by university researchers (e.g., Kimball, 2010; Kunkel, 2014), the project will synthesize and organize the known information, along with community input.

Keywords: *geothermal, direct use, British Columbia*

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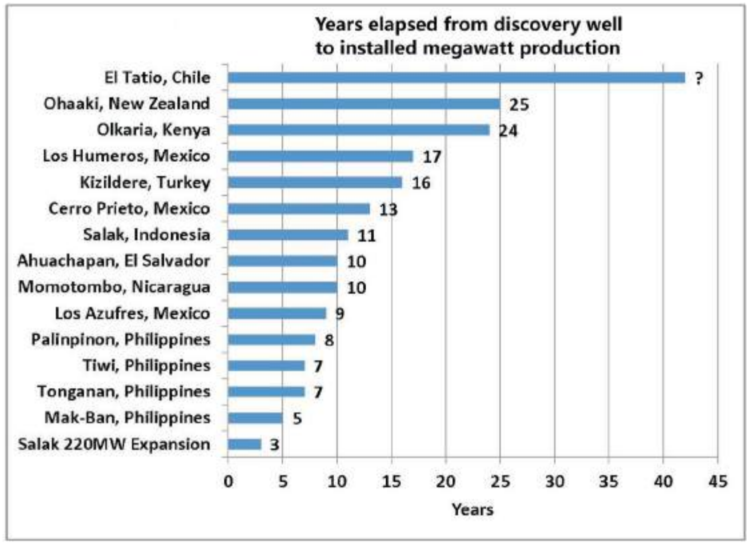

Figure 1. Some of the difficulties faced by developers when dealing with geothermal electrical-generation projects (Sussman and Tucker, 2009). The barriers for direct use are much lower and projects are often completed in less than five years.

Using a community-based participatory approach with a strong First Nations emphasis, the project will seek to engage as many communities as possible. The compelling emphasis put on First Nations participation is important, as many of the communities with direct-use potential are First Nations or have significant First Nations representation. The community-based approach has in the past been successfully carried out with First Nation communities in BC and has the added advantage of building community-research capacity and resource-development awareness. This approach enhances relationship building, and will pave the way for future community engagement and development of identified resources.

In addition to identifying locations with good potential for direct-use applications, the project team will compile an inventory of current and planned direct-use projects as well as provide communities with a 'Road Map' for evaluating their resource as their first step toward development. This toolkit will provide guidance to communities as to how to move forward on direct-use projects, addressing all technical and nontechnical aspects.

The project will not include geothermal heat-pump (sometimes referred to as 'ground-sourced' geothermal) potential, though most communities in BC could take advantage of this shallow subsurface technique used to store and release heat. However, in the community-based methodological approach, geo-exchange–related topics will be included in a questionnaire sent to communities.

Methodology and Project Structure

This project will be divided into three phases as summarized below.

Phase 1

Phase 1 work will identify regions and communities in BC with potential for direct-use geothermal-energy development. As a first step, a compilation of existing BC geoscience datasets useful for the evaluation of direct-use geothermal energy will be completed. This will provide the basis for the identification of a first list of communities and regions with direct-use potential, used in conjunction with the direct-use diagram (Figure 3). This diagram lists numerous possible uses for low- to medium- (70–356^{o}F; 20–180^{o}C) temperature thermal fluids. In parallel with the compilation, a Geothermal Development Decision Matrix (GDDM; Table 1) will be used as outlined below.

This GDDM framework was originally created by Hickson and her exploration team at Magma Energy Corp. (now Alterra Power Corp.) for use in their global exploration program. It was intended as a way of differentiating between multiple projects in various jurisdictions. Geoscience BC's Geothermal Technical Advisory Committee modified the decision matrix for use in defining the scope of work for its 2014 Request for Proposal on electrical generation.

For the purpose of this study, the matrix will be customized to include more community elements (such as those covered in the 'Traditional use area' in section H) and additional factors related to direct use (section N). Less emphasis will be placed on factors more directly linked to electrical-generation development such as transmission. The project team will then build on the existing geothermal data collected for the 18 locations studied by Kerr Wood Leidal and GeothermEx (2015) for Geoscience BC. These sites are: Canoe Creek–Valemount, Clarke Lake, Clearwater volcanic field, Iskut, Jedney area, King Island, Kootenay, Lakelse Lake, Lower Arrow Lake, Meager Creek/Pebble Creek, Mt. Cayley, Mt. Garibaldi, Silverthrone–Knight Inlet, Nazko Cone, Okanagan, Sloquet Hot Springs, Sphaler Creek and Upper Arrow Lake (Figure 4). The data will be analyzed and compared with the results of earlier studies, such as those by Fairbanks and Faulkner (1992), Pletka and Finn (2009), Kimball (2010), Kunkel (2014), and Woodsworth and Woodsworth (2014).

As the next step, the 11 sites for which detailed economic calculations were completed and additional development information was compiled (Kerr Wood Leidal and GeothermEx, 2015) will be considered as feasible locations for direct-use geothermal-energy development. These sites are Canoe Creek–Valemount, Clarke Lake, Kootenay,

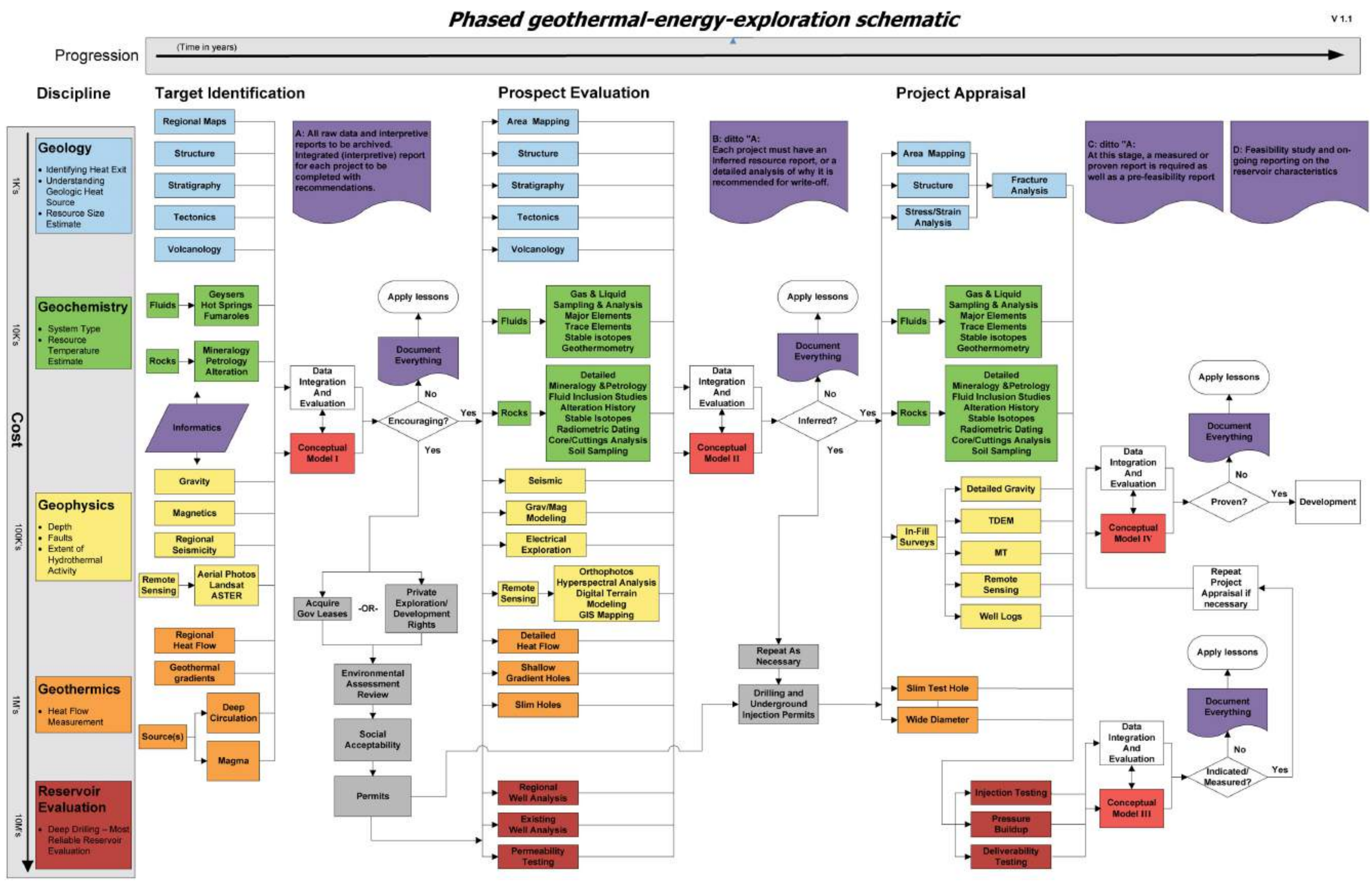

Figure 2. This concept of phased exploration for geothermal resources (Hickson and Yehia, 2014) is applicable to a range of resource temperatures, but the detailed exploration shown here is usually only required for electrical-generation development. Direct use will often be far less complicated and involve far fewer steps. Though technical understanding and parameter quantification are important, a key to economically viable direct-use development is the minimization of ‘upfront’ costs. The ‘Road Map’ to accompany the final report will outline the development steps.

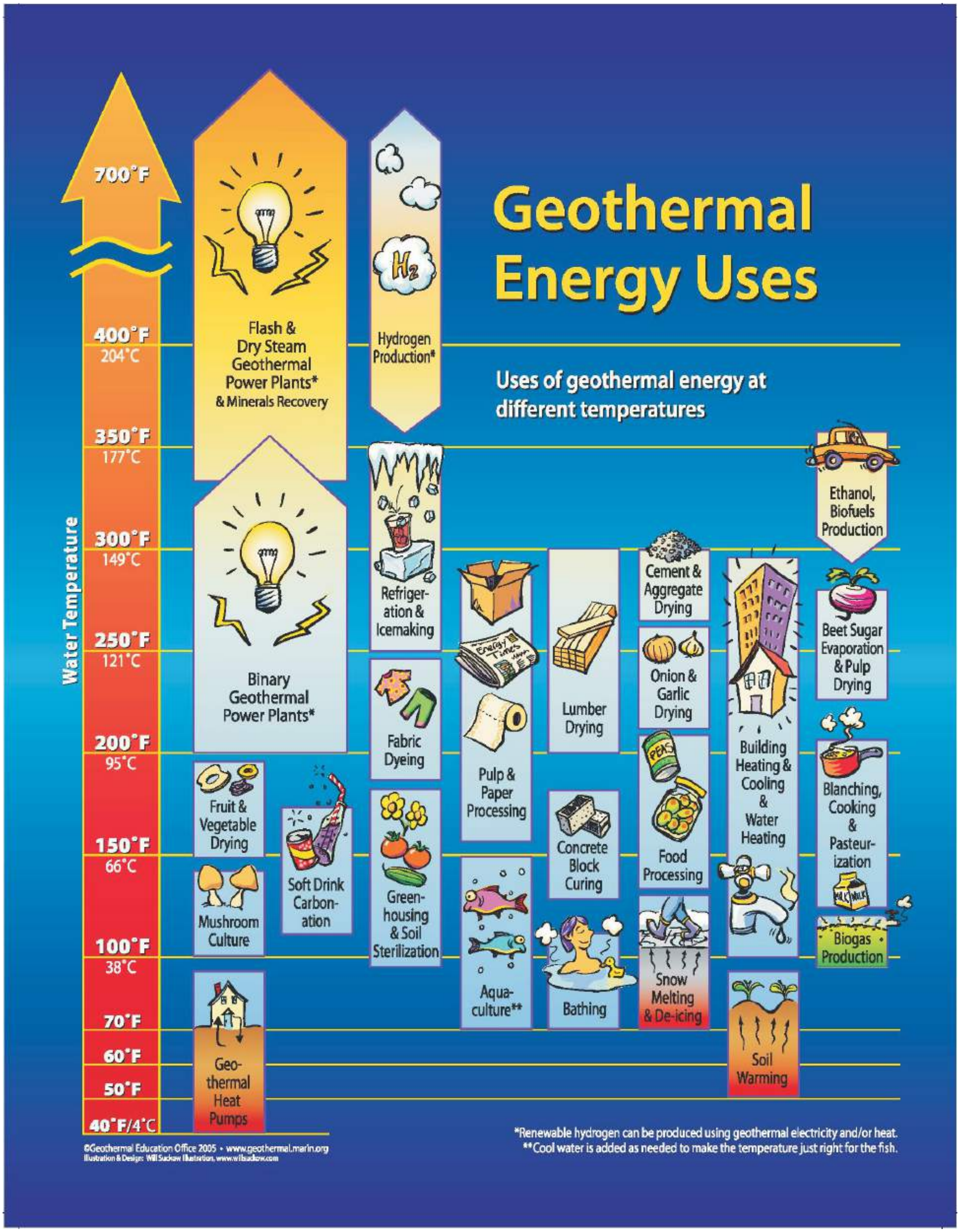

Figure 3. Direct-use diagram of temperature ranges and applications for direct-use geothermal projects (from Geothermal Education Office [2005] and Lund [2010]).

Table 1: Example of a Geothermal Development Decision Matrix (GDDM) to assess development potential. This table and the development-potential index generated were created for prospects having electrical power–generation potential and will be modified for the British Columbia direct-use situation. New information will be gathered where applicable. The weighting factors for direct use have not yet been determined.

	Area of interest	Numerical favourability index
	Nearest community name	n/a
	Country/state/community	n/a
	Topographic map sheets (name and code)	n/a
	Geological map sheets (name and code)	n/a
A.	**Resource potential**	**Weighting factor**
A.1	General geological setting	TBD
A.2	Size/potential/type	TBD
A.3	Temperature gradient/ Heat flow data	TBD
A.4	Water and gas chemistry	TBD
A.5	Mineral indicators and/or surface alteration	TBD
A.6	Surface thermal features (type, temperature)	TBD
A.7	Surface flow rates and resource recharge	TBD
A.8	3D permeability (heat exchange potential)	TBD
A.9	Recent magmatism	TBD
A.10	Structural setting / seismic / tectonics	TBD
A.11	Geophysics (type and interpretation)	TBD
A.12	Potential resource hostrocks	TBD
A.13	Potential drilling issues	TBD
A.14	Geological setting of thermal features	TBD
B.	**Exploration uncertainty (risk)**	**Weighting factor**
B.1	Degree of identification of resources/reserves	TBD
B.2	Likelihood of covering resource with concession	TBD
B.3	Expected authorization date	TBD
B.4	Specific timing of exploration	TBD
B.5	Previous exploration (can be good or bad)	TBD
B.6	Surface operational capacity	TBD
B.7	Exploration to exploitation (difficult to easy)	TBD
C.	**Environmental issues**	**Weighting factor**
C.1	Protected areas (type and classification)	TBD
C.2	Endangered species	TBD
C.3	Geothermal surface features	TBD
C.4	Other	TBD
D.	**Geothermal area - bidding and/or type of land holding**	**Weighting factor**
D.1	Bidding area	TBD
D.2	Electrical generation potential?	TBD
D.3	Other claim rights(mining and/or oil)	TBD
E.	**Market**	**Weighting factor**
E.1	Potential commodities for direct-use applications	TBD
E.2	Political stability and community relationship to development	TBD
E.3	Time constraints on development	TBD
E.4	Renewal energy 'green value' for potential development	TBD
F.	**Transmission-line infrastructure**	**Weighting factor**
F.1	State of the Infrastructure	TBD
F.2	Transmission route (distance, terrain and costs)	TBD
F.3	Wheeling power	TBD
F.4	Transmission providers	TBD
G.	**Laws governing direct-use renewable energy sources**	**Weighting factor**
G.1	General criteria of the geothermal law	
G.2	General criteria of the water resources law	
G.3	Direct sales possible	
G.4	Carbon credits	
G.5	Lease time and ability to renew or extend exploration licence	
G.6	Conversion from exploration to exploitation	
G.7	Time frame for exploitation licence	

Table 1 (continued)

H.	Community issues	Weighting factor
H.1	Indigenous law and Indigenous development areas	TBD
H.2	Land claims	TBD
H.3	Community action	TBD
H.4	Surface rights	TBD
H.5	Visual considerations	TBD
H.6	Tourism	TBD
H.7	Traditional use area: harvesting	TBD
H.8	Traditional use area: cultural	TBD
H.9	Traditional use area: archeology and other	TBD
I.	**Water rights**	**Weighting factor**
I.1	Availability for proposed development	TBD
I.2	Availability for drilling	TBD
J.	**Engineering**	**Weighting factor**
J.1	Development proposal and design	TBD
J.2	Construction issues	TBD
J.0	Transportation issues	TBD
J.4	Architectural Issues (design styles)	TBD
J.5	Construction issues (heat exchanger and full injection)	TBD
K.	**Non-electrical infrastructure (roads and habitation)**	**Weighting factor**
K.1	Nearest large community > 50 000	TBD
K.2	Nearest community and size	TBD
K.0	Nearest road and condition	TBD
K.4	Current access conditions (restrictions)	TBD
K.5	Terrain and distance factor for road building	TBD
L.	**Development finance**	**Weighting factor**
L.1	Development value (greenhouses; tourism; heating)	TBD
L.2	Market price for similar commodities not using direct-use heat	TBD
L.3	Green power premium for commodity?	TBD
L.4	Commodity price	TBD
L.5	Marketing implications	TBD
L.6	Estimated size of resource	TBD
L.7	Are there any green use incentives?	TBD
L.8	Grants	TBD
L.9	Tax holidays	TBD
L.10	Tax relief	TBD
L.11	Loan guarantees	TBD
L.12	Royalties/fees	TBD
L.13	General idea of royalties	TBD
L.14	Private land owner or government land	TBD
L.15	Tax rate in the country	TBD
L.16	Transmission Tariffs	TBD
M.	**Maps**	**Weighting factor**
M.1	Regional topographic map of infrastructure (1:500 000?)	n/a
M.2	Regional map land tenure in area (1:500 000?)	n/a
M.3	Regional geological map (1:250 000 or 1:500 000?)	n/a
M.4	Detailed geological maps (1:50 000 or 1:100 000)	n/a
N.	**Other issues and considerations**	**Weighting factor**
N.1	Spatial concentration of potential customers	TBD
N.2	Distance to market for prospective commodities	TBD
N.3	Costs to potential customers to receive direct-use benefits	TBD

Abbreviations: n/a, an element that is not evaluated; TBD, to be determined during the course of the project

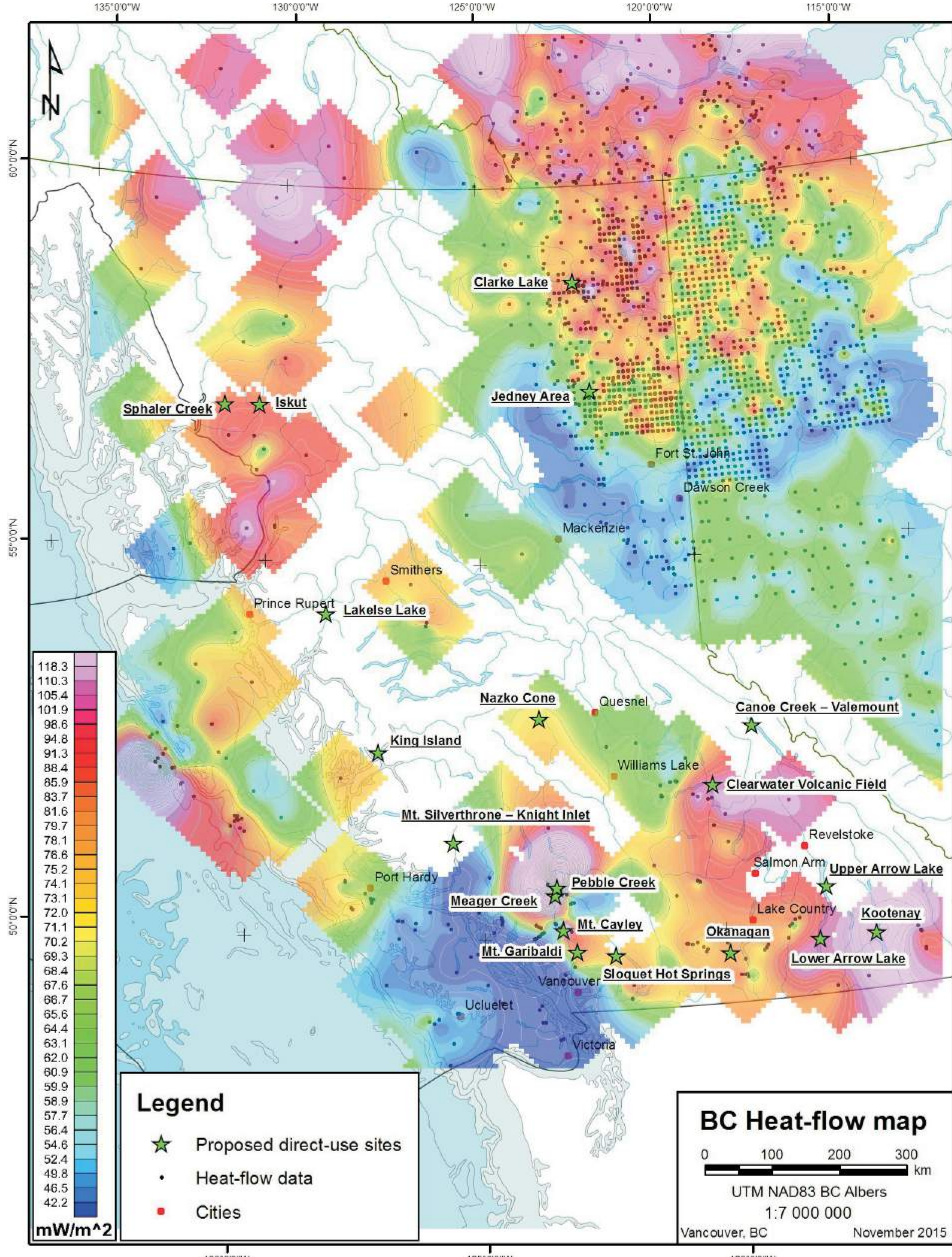

Figure 4: This updated British Columbia heat-flow map uses new data (J. Majorowicz, pers. comm., 2015), as well as results from Lewis (1991) and Majorowicz and Grasby (2010a). It provides a rough guide to regions with potential direct-use resources. Also shown are the 18 sites evaluated by Kerr Wood Leidal and GeothermEx (2015) for electrical generation, which will also be evaluated for direct use.

Lakelse Lake, Lower Arrow Lake, Meager Creek/Pebble Creek, Mt. Cayley, Okanagan, Sloquet Hot Springs, and Jedney (Figure 4). Kerr Wood Leidal and GeothermEx (2015) completed the economic evaluations using the Geothermal Electricity Technology Evaluation Model, a computer modelling system developed by the Office of Energy Efficiency and Renewable Energy (2015); this study will consider additional economic aspects that are suitable for direct-use development (e.g., Beckers et al., 2014).

The compiled GDDM information will then be used to inform and modify the process for the next steps. Following the above process, the remaining seven sites that did not meet the electrical generation–criteria threshold will also be evaluated to see if they might meet more generalized criteria for direct-use applications, using the GDDM (Table 1) and direct-use diagram (Figure 2) as guides.

Additional locations, beyond the initial 18 evaluated for electrical generation, may be identified from available information, as well as any known direct-use projects under development. It is projected that there will likely be another 10–15 sites that might meet the lower temperature threshold necessary for direct-use applications.

Phase 2

Phase 2 will start with a review of the community and technical information gathered for the original 18 sites and any additional sites identified in Phase 1. The direct-use weighting factors for the GDDM (Table 1) will be determined. In the study by Kerr Wood Leidal and GeothermEx (2015), each category (e.g., reservoir potential) was weighted equally and assigned a score by designated experts. The scores to be applied were limited to four: negative one, zero or plus one, as well as a category called 'major barriers', which category was defined as key criteria that eliminated those sites from further consideration.

In this study, the weighting factors will be customized for direct-use development by the designated experts. A priority list will be created comprising the top 10 sites based on the results of the weighting. The factors to be considered include community desire, geothermal potential and economic potential. This aspect of the study is limited to a desktop review of available information, including community input. The Phase 2 processes will be designed to build community-research capacity, and to increase communities' awareness and knowledge of geothermal resources in their region. Questionnaires and information packages will be sent to the communities; this step will then be followed up by telephone interviews with community members. By using inclusionary methods, it is intended that community knowledge of geothermal resources will be increased through the data-gathering and information-dissemination processes.

Phase 3

Phase 3 will entail summarizing and analyzing the community-engagement as well as GDDM results, and completing the geothermal direct-use 'Road Map'. The final report will include conclusions and recommendations regarding the next steps for assisting communities that may wish to move forward with development planning. The 'Road Map' will include, but will not be limited to, information to support such key considerations in the assessment and development of potential direct-use geothermal resources as

- the conduct of ground surface–based activities designed to characterize the resource (geology and geochemistry, possibly some geophysics depending on the cost, location and other circumstances);
- the acquisition of land control;
- the acquisition of all federally, provincially and locally required permits;
- the cost of drilling shallow thermal-gradient holes;
- the cost of drilling either slim hole(s) or production/injection well(s), depending on the amount of money available;
- the testing of wells;
- the design and construction of facilities for beneficial, commercial use and disposal of the produced thermal fluids; and
- the cost of transporting the direct-use product(s) to the potential end user(s).

Conclusions

Through this study, it is anticipated that a great deal more information on geothermal direct-use applications in BC will become available. This information will all be publicly accessible. The updated geoscience and development data, when combined with the geothermal direct-use 'Road Map' and community capacity building, should assist both developers and communities to carry out more cost-effective and timely direct-use geothermal projects.

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