Evaluation of Genome British Columbia

Final Report

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Prepared for:

Genome British Columbia

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EXECUTIVE SUMMARY

The Study. This document reports on the 2009 – 2010 evaluation of Genome British Columbia (GBC). The intent of the study is to provide an independent review of the achievements of GBC against its goals, as required under GBC's by-laws. It is also intended to be useful in a strategic sense as GBC goes forward, especially given the rapidly changing nature of genomics and proteomics research.

Genome British Columbia. Genome BC is a research organization that invests in and manages large-scale genomics and proteomics research projects and enabling technologies focused on areas of strategic importance, such as human health, forestry, fisheries, agriculture, bioenergy, mining, and the environment. GBC was established in 2000, and is one of six Genome Centres across the country. All the Centres are closely associated with Genome Canada, which is the key funding resource for genomics and proteomics research in Canada.

In its first nine years, GBC managed a total research program of over $425 million, supporting 75 research projects and science and technology (S&T) platforms. This funding leverages the region's economy: stakeholders are planning to invest a further $340 million from 2010-2015. GBC's major investors are Genome Canada (GC), the Province of British Columbia and Western Economic Diversification Canada, complemented by many other private and public investments.

Methodologies. The study incorporated: (1) document review; (2) survey of a census of GBC principal investigators (PIs) and a sample of key external Canadian and international stakeholders (with response rates of 41% and 48%, respectively); (3) follow-up interviews with a sample of external stakeholders; (4) comparisons of GBC's activities to known best practices for commercialization and exploitation of university research, and for integration of social sciences and humanities into research projects in the natural sciences, engineering, and health fields; and (5) data mining from the 2009 evaluation of Genome Canada.

Findings on Strategy. Genome BC has created a strong, value-added strategy for genomics and proteomics research in BC. The flexibility of GBC in addressing current topics in genomics and proteomics – and especially those where GBC can realistically make a contribution, and/or where practical applications are possible – were given high marks by respondents. GBC continues to build research infrastructure and provide equipment for researchers, make funds available for both biomedical and biological genomics research, and encourage economic activity.

This strategy, plus GBC's support to its PIs, has had a high impact in helping British Columbia become a leader in selected genomics research areas. However, BC is still relatively lacking in critical scientific mass, mainly because the size of genomics/proteomics investment lags behind that in some international jurisdictions.

Findings on national and international participation. Participation by GBC in national and international genomics initiatives has been high, and this participation has strengthened both BC and Canadian capabilities. The organization has become relatively well-known on the international scene, helping bring attention to BC's research community. Researchers commented that GBC has helped them in international projects by facilitating interactions with international S&T organizations, helping BC scientists be seen as peers at the international scale, "getting a jump" on new opportunities (including applied ones), fostering interactions with the international biotechnology industry, and bringing to the table critical components of large research initiatives (e.g., reagents, platforms).

Findings on generation of socio-economic impacts. GBC is seen to have a high potential for generating important socio-economic (S-E) impacts. Transformative impacts can be expected from a number of GBC projects, especially for human health (e.g., personalized medicine), but also potentially in natural resource sectors such as fisheries and forestry. GBC provides highly active management related to monitoring and supporting S-E impacts, including providing effective access to S&T Platforms having

high technical and operational capabilities. GBC's goals and management mechanisms also rate quite high when compared to best practices used world-wide in this area. (The simple fact that GBC provides active S-E management at all is, in fact, a strong point in its favour, as many other S&T organizations simply do not.)

About 70% of GBC PIs have actively explored practical applications of their research. These include many sectors of application and many mechanisms to achieve S-E benefits, both direct and indirect. The latter is important, as many recent studies have shown that important S-E impacts arise from a variety of indirect mechanisms, not just through traditional technology transfer (patenting, licensing, creation of spin-offs).

But many respondents emphasized that, because of the long-term nature of these applications, there was a strong need to have realistic expectations as to the timeframes involved (especially in human health applications which require clinical trials), and to continue support for pure science as a base from which these applications might be drawn.

Findings on training. The training of HQP is one of the key outputs of many S&T programs related to generating S-E impacts, as many HQP go on to productive careers in industry, government, and non-government organizations. Notwithstanding that GBC does not directly provide training grants, fellowships, or scholarships, it is seen as having improved this training through access of HQP to top genomics, proteomics, and social scientists, as well as access to the S&T platforms

Findings on relationships with stakeholders. The most important GBC stakeholder relationship is with Genome Canada, and these relations are collegial, constructive, and friendly. Further, GBC is seen as effective and highly collegial in working with other BC stakeholders organizations.

Findings on dealing with GE^{3}LS. Genomics-related ethical, environmental, economic, legal, and social (GE^{3}LS) issues are addressed in GBC programs in two ways: as a required element that addresses social science and humanities (SSH) issues in all genomics and proteomics research projects, and as "stand-alone" projects focused on GE^{3}LS topics. Overall, GBC is seen as addressing these topics to a moderate to high extent. When it worked, this integration often worked well, and these PIs reported that they found it useful to have perspective from other disciplines. In addition, this SSH integration is seen by external stakeholders as an important and unusual feature of GC and GBC programming.

Having said this, the requirement to have a GE^{3}LS element within every genomics/proteomics project is a controversial one among the scientists, and few PIs were very positive on this score – there were far more negative comments than positive ones, and some comments were very critical indeed. (This was also true during the 2009 overall Genome Canada evaluation.)

Best practices for integrating SSH into natural sciences, engineering, and health sciences are far from well-understood. GBC does not score especially high in many of the best practice areas identified by the study team, but it is important to note that many S&T organizations do not explicitly address these best practices at all, instead effectively leaving SSH integration and impacts to chance. Thus by comparison to many other S&T organizations GBC is well ahead of the field

Findings on public awareness. The awareness of the need for genomics research – and its risks and rewards – is seen as being higher because of GBC, although respondents also noted the difficulty of measuring and attributing changes with accuracy.

Findings on possible improvements to the GBC model. GBC has a sound model, and is a well-run organization having competent and helpful staff and management. However, there are areas in which the GBC model or program delivery could be refined. Some of these reflect difficulties with the existing system, and some reflect apparent opportunities to move into new territory. Refinements include: (1) Re-thinking the nature of GE^{3}LS and SSH projects and integration; (2) Maintaining an appropriate mix of pure and applied research; (3) Reviewing the

nature of support for S-E impacts, in particular strengthening "indirect" mechanisms which are known to be of high importance; (4) Investigating ways to reduce reporting burden; (5) Coordinating better access to "–omics" research infrastructure; and (6) Reviewing appropriate means of supporting the natural resources sectors.

Looking to the future. If sufficient, reliable funding is available, there appears to be opportunities for GBC to take on a stronger leadership role for the BC "–omics" community, and potentially more broadly across multiple stakeholder organizations, and/or with other related sciences, and/or within a broader geographic cluster (e.g., Northwestern US states). The best practices review also suggest areas in which GBC might strengthen its S-E support, such as more "people support" (students, Chairs, entrepreneurs); or more proactive "matchmaking" activities bringing together researchers, users, and venture capital in collaborative initiatives.. Finally, more support for "blue sky" research would be a welcome addition to GBC's portfolio, probably tied to the existing Science Opportunity Fund.

Conclusions. The study shows very positive findings on almost all fronts. GBC has had strong impacts on genomics and proteomics strategy development; coordination and collaboration among relevant S&T organizations; research quality and quantity; training of HQP (indirectly); and technology and knowledge transfer, translation, and mobilization. GBC seen as key anchor of the Genome Canada program, and gives the BC "-omics" community a voice. On the program delivery side, GBC is being seen as flexible and re-inventing itself as required, with strong leadership and staff. Of considerable interest is that – unlike in 2004 – the current GBC role appears to now be well defined and understood. (And other "teething problems" found in 2004 appear to have been attended to.)

There are, however, several issues that should be attended to. The three most critical to address are: (1) continued and serious concerns in some quarters about GE^{3}LS and SSH components; (2) continued concerns regarding the balance between pure and applied research; and (3) need for improvement in understanding the nature of, and mechanisms for, creating socio-economic benefits through indirect mechanisms, and in measurement of such benefits.

Should funding be available, there appears to be some room for GBC to move forward into a more proactive role in acting as hub for coordinating BC's broader "–omics" community, and for incorporating additional mechanisms directed towards practical application of "–omics" in a wider variety of applications

1 INTRODUCTION

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1.1 THE STUDY

This document reports on the 2009 – 2010 evaluation of Genome British Columbia (GBC). The intent of the study is to provide an independent review of the achievements of GBC against its goals, as required under GBC's by-laws. It is also intended to be useful in a strategic sense as GBC goes forward, especially given the rapidly changing nature of genomics and proteomics research. The study may also be compared to the evaluation of GBC carried out in 2004[1], in that changes over time are apparent. The study also benefits from selected data available from the 2009 evaluation of Genome Canada overall (see section 2)[2].

1.2 GENOME BRITISH COLUMBIA

Genome BC is a research organization that invests in and manages large-scale genomics and proteomics research projects and enabling technologies focused on areas of strategic importance, such as human health, forestry, fisheries, agriculture, bioenergy, mining, and the environment. Genome BC was established in 2000, and today is one of six Genome Centres across the country. All the Centres are closely associated with Genome Canada, which is the key funding resource for genomics and proteomics research in Canada.

By working collaboratively with governments, universities and industry, GBC intends to be the catalyst for a vibrant, genomics-driven life sciences cluster with far-reaching social and economic benefits for the province of British Columbia, Canada, and countries around the world. By bringing together research organizations, industry and government, Genome BC delivers programs in applied and translational research grounded in the genome sciences. It develops research programs to facilitate the translation of genome sciences-based research into practical applications in areas of strategic importance. In its first nine years, GBC has managed a total research program of over $425 million, supporting 75 research projects and science and technology (S&T) platforms.

This funding leverages the region's economy, and stakeholders are planning to invest a further $340 million from 2010-2015. GBC's major investors are Genome Canada, the Province of British Columbia and Western Economic Diversification Canada, complemented by many other private and public investments. The GBC projects have attracted over 100 major international co-funders and partner organizations, including many multinational corporations, pharmaceutical and biotechnology companies, worldwide charitable foundations, and top-tier research institutions.

For a full description of Genome BC, see: http://www.genomebc.ca.

[1] *Evaluation of Genome British Columbia Final Report.* BearingPoint, December 20, 2004.

[2] *Evaluation of Genome Canada – Final Report*. KPMG, May 13, 2009.

2 STUDY QUESTIONS AND METHODOLOGIES

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2.1 EVALUATION APPROACH AND QUESTIONS

The general approach to this study was developed through conversations with GBC senior management. In short, the main "big picture" considerations ddressed were:

1. What are GBC's achievements as compared to its formal goals and objectives?

2. What are key recommendations regarding GBC's model, and its delivery process, in going forward and meeting its 2010 – 2015 strategic research plan? This point is intended to address GBC's "stretch" goals.

With respect to point #1, the current study's framework was aligned with the 2004 evaluation, to allow easier comparison of findings. This was done by (1) organizing and wording the 2009 evaluation questions to mirror the earlier ones as closely as possible; and (2) using the same or very similar methodologies (i.e., same questions posed to same types of respondents). This allows GBC to more or less directly compare one set of findings to the other.

The evaluation questions used during the 2004 study are found below.[3] All questions addressed in that study are included in 2009. However, to ensure the 2009 study is as relevant as possible to GBC, we made some modifications based on the work done during the 2008 GBC performance measurement (PM) study to identify the key goals currently being addressed by GBC[4]. These are marked as "*New*" if they were not really considered during 2004, or "*More explicit*" if they were addressed earlier, but were less clearly defined than they now are.

1. Has Genome BC developed a coordinated and integrated strategy for BC's genomics research?

1.1. Does GBC have a strategy that is relevant, complete, appropriate, and adds value (especially in the BC context)?

1.2. Is GBC "on track" to enable BC to become a world leader in selected genomics research areas?

1.2.1. *New*. Is there a critical mass of genomics and proteomics researchers in BC, in selected areas? What has been GBC's impact on attraction and retention of faculty members?

1.2.2. *New*. Is there sufficient support for top scientists?

1.2.3. *More explicit*. What is the quality and quantity of research conducted by GBC scientists?

1.2.4. *More explicit*. Is there support for interdisciplinary, multidisciplinary, and/or crossdisciplinary projects and programs?

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[3] Key questions examined by the 2004 evaluation study were tied to GBC's mandate and objectives, and were defined during the design stage of the study. See: *Design Report Evaluation of Genome British Columbia*. BearingPoint. October 25, 2004.

[4] *Performance Measurement System for Genome British Columbia Final Report*. Dennis Rank and Associates, July 25, 2008.

1.2.5. *New*. Is there a portfolio of mutually supporting projects and programs?

1.2.6. *New*. What are GBC's impacts on attraction and retention?

1.3. What factors facilitate or inhibit GBC's progress in becoming a world leader?

2. Has Genome BC participated in national genomics strategies?

2.1. To what extent has GBC participated in national and international approaches and strategies?

2.2. How effective has this participation been in strengthening national genomics research capabilities?

3. Does the Genome BC Centre have the potential to generate significant socio-economic (S-E) benefits for BC and for Canada?

3.1. Has a Genome Centre been established in BC?

3.2. Do the GBC research programs and projects have the potential to generate significant S-E benefits for BC and Canada?

3.2.1. *New*. Have potential users been actively involved in design, conduct, and exploitation of the research? (Note that this also has GE^3LS implications, in that either: (1) exploitation of the research outcomes may benefit from SSH insights or be contingent on SSH interventions or (2) some uses may be non-commercial, instead being related to development of strategies, policies, regulations, economic development or health care initiatives, education, etc.;

3.2.2. *More explicit*. What direct and indirect technology and knowledge transfer activities and outputs have there been, and how have these been facilitated?

3.2.3. *More explicit*. What explicit examples of S-E benefits have resulted? (Note that non-commercial applications are also to be considered.)

3.3. Has the Centre offered researchers access to the necessary research infrastructure (I.e., the S&T platforms) to allow this socially and industrially relevant research to proceed effectively?

3.4. What barriers exist for generating S-E benefits for BC or Canada?

3.5. Has the Centre supported or facilitated the training of scientists, students, and technicians in genomics?

3.5.1. *More explicit*. Increased numbers of HQP in genomics, proteomics, and GE^3LS – including graduate students, PDFs, technicians, project and program managers.

4. Has Genome BC established appropriate contractual and/or collaborative relationships with relevant stakeholders?

4.1. Does an appropriate contract exist with Genome Canada?

4.2. Do appropriate contractual and/or collaborative relationships exist with other significant stakeholders?

4.2.1. *New*. Number, nature, & funding re. formal Canadian and international collaborative agreements

4.2.2. *New*. Partnerships and collaboration at the PI level

4.3. Have these arrangements succeeded in providing adequate financial support for the Centre and GBC researchers?

4.3.1. *More explicit*. Total co-funding by source

4.3.2. *More explicit*. What resources (in addition to co-funding) have been leveraged?

5. Has Genome BC addressed public concerns re: GE^{3}LS questions?

5.1. What activities has GBC taken with respect to addressing public concerns about GE^{3}LS questions?

5.2. What have been the impacts of these activities on the level of public concern?

5.3. *New*. Have the social sciences and humanities aspects (i.e., GE^{3}LS factors) been well addressed in GBC research? (See also question 3.2.1.)

6. Has Genome BC increased public awareness of the need for, and benefits and risks of, genomics research?

6.1. What activities has GBC taken with respect to addressing public understanding of genomics and its risks and rewards, through education and outreach?

6.2. What have been the impacts of these activities on the level of public understanding and support?

7. Improvements

7.1. *More explicit*. What possible improvements can be made to the GBC model, or operations? (This would include considerations of GBC's model vis-à-vis Genome Canada, its collaborative relationship with key BC research institutions, its project and portfolio management, its integration of GE^{3}LS into genomics research projects, etc. In addition, although GBC is not " big science" in the traditional sense, there are aspects of its operations that are not dissimilar in terms of need for strategy and appropriate management[5].)

[5] See, for example, *Overview of comments received on the Major Science Investments discussion paper.* Office of the National Science Advisor, July 25, 2005. http://www.cap.ca/about/frameworkforMajorScienceInvestments_files/commentsOnMSIs_July25.pdf.

2.2 METHODOLOGIES

2.2.1 DOCUMENT REVIEW

We conducted a document review to help identify key achievements and key strategic challenges. These included:

- *Annual Reports* from 2004-2005 through 2008-2009.
- the 2005 – 2010 GBC Business Plan
- GBC performance metrics
- GBC Scientific Advisory Board reports;
- A recent report discussing the integration of social sciences and humanities (SSH) within GBC research: *Interim Report Evaluative Review of the Integrated Research Model Under Competition III and AGIP*, prepared by Leslie Rodgers of Praxis Pacific in collaboration with Dr. Sarah Hartley and Daisy Laforce of Genome BC.

2.2.2 SURVEY PROGRAM

Survey and interview instruments are found in Appendix D.

Survey of Principal Investigators. A web survey was provided to a census of GBC principal investigators (PIs) drawn from from joint GBC/GC projects: Comps I, II, and III; International; Applied Human Health; and the Technology Development Competition. The project also conducted a web survey of a census of PIs involved with the independent GBC programs: Translational Program for Applied Health (TPAH); Applied Genomics Innovation Program (AGIP); Applied Genomics Consortium Program (AGCP); Strategic Opportunities Fund (SOF); and Special projects.

Survey and interviews with key stakeholders. A web survey was made available to broad selection of GBC's key stakeholders. These included members of GBC's Scientific Advisory Boards, chairs of review committees (including AGIP), V-Ps and CEOs of partner organizations, key provincial representatives, and other individuals knowledgeable about GBC drawn from industry, venture capital, and other genomics research funding organizations world-wide. Follow-up interviews to obtain additional detail were conducted with as many individuals as were willing to participate – about 20 individuals were interviewed.

Survey response rates. The survey response rates are shown below.

Category	No. contacted	No. responded	Response rate
Principal Investigators	81	33	41%
Key stakeholders	82	39	48%

2.2.3 INTERVIEWS WITH GBC BOARD MEMBERS

We conducted interviews with the current Chair, plus the Chairs of the Board sub-committees (audit, business development, compensation, society & ethics, executive, investment, governance and nominations, and science). A total of seven interviews of a planned eight were completed.

2.2.4 COMPARISONS TO BEST PRACTICES

Commercialization and translation of university research. Because the outcomes and ultimate impacts of many GBC projects will be long-term and probably have not been fully achieved to date, we reviewed GBC management activities to see if the correct elements are in place to make it *likely* that they will succeed. This was done by comparing GBC activities to a "check list" of known best practices. This check list was based on reviews (some highly detailed, some as an overview) of 20 organizations world-wide known to the study team. Further details are found in Appendix A.

Integration of social sciences and humanities research. Both Genome Canada and GBC require genomics and proteomics research projects to address the social sciences and humanities (SSH), especially issues related to genomics-related ethical, environmental, economic, legal, and societal (GE^3LS) concerns. The study team developed a list of best practices related to integration of SSH into natural science and engineering (NSE) and health research programs and projects, based on the team's knowledge of other programs with similar aims. Further details are found in Appendix B.

2.2.5 DATA MINING FROM THE GENOME CANADA EVALUATION

The 2009 comprehensive evaluation of Genome Canada conducted by KPMG LLP[6] obtained data from GBC Principal Investigators (PIs), including genomics project leaders, S&T platform leaders, and leaders of "stand-alone" GE^3LS projects[7]. We obtained the permission of both Genome Canada and KPMG to mine the survey results for data from GBC PIs and co-funders, although most questions asked in that study were about Genome Canada, not GBC.

Detailed data from this exercise are found in the Design Report appendix. Some general conclusions from the data mining were that the responses of GBC scientists were reasonably similar to those of the GC scientists overall. There are a few areas which especially helped inform the present study: (1) the ratings of integration of SSH into large-scale genomics projects were not especially good, perhaps even slightly poorer than for GC scientists overall, and this is an area in which GBC has substantial influence; (2) the ratings of integration of socio-economic considerations, and the degree of effort at realizing practical applicants (again areas in which GBC has substantial activities) were all quite good; and (3) the ratings of the access policies and capabilities of the BC S&T platforms were quite good.

[6] *Evaluation of Genome Canada – Final Report*. KPMG, May 13, 2009. (Mr. Rank was the co-project manager for this study.)

[7] Those focused on genomics-related ethical, environmental, economic, legal, and social (GE^3LS) issues.

3 FINDINGS

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NOTE: 1 Throughout this report, average ratings in the tables are exclusive of "don't know" responses. Quotes from respondents are used to illustrate key points. These have been chosen to be representative of the findings overall, unless specifically noted otherwise. Minor editorial changes to these quotes were occasionally made for clarity's sake, but the meaning is left intact.

NOTE 2: Of the 39 stakeholder respondents, there were 21 Canadians, 15 internationals, and 3 respondents from unknown locations. Analysis was conducted separately of Canadian *vs.* international respondents, and showed that international stakeholders gave GBC higher ratings than did Canadian stakeholders on every question asked, except one in which they were essentially identical (GBC' international participation). Details per question are found in Appendix C.

- The average rating[8] across all questions for international stakeholders was 4.14
- The average rating across all questions for Canadian stakeholders was 3.64.

3.1 GBC'S STRATEGY

3.1.1 QUALITY OF THE GBC STRATEGY

The GBC research strategy was believed to represent a complete and value-added approach by a majority of respondents, as seen in Exhibit 4.1.

Exhibit 4.1 – To what extent has Genome BC (GBC) developed a strategy for BC's genomics research community that is complete and adds value?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Researchers								
Complete approach	12.9%	**48.4%**	19.4%	6.5%	0.0%	12.9%	3.78	31
Adds significant value	31.3%	**50.0%**	9.4%	0.0%	0.0%	9.4%	4.24	32
Stakeholders								
Complete approach	20.0%	**51.4%**	17.1%	2.9%	0.0%	8.6%	3.97	35
Adds significant value	**37.1%**	28.6%	14.3%	5.7%	2.9%	11.4%	4.03	35

[8] The highest (best) rating possible for GBC in all questions was 5.0.

The flexibility of GBC in addressing current topics in genomics and proteomics – and especially those where GBC can realistically make a contribution, and/or where practical applications are possible – were given high marks by respondents. GBC continues to build research infrastructure and provide equipment for researchers, continues to make funds available for both biomedical and biological genomics research, and encourages economic activity.

> *GBC is sensibly trying to select areas of expertise rather than spreading funding thinly across a number of areas.*
>
> *- Stakeholder*

> *[GBC] has promoted the diffusion of genomic and bioinformatics technologies throughout the lifesciences, and has raised public awareness and engagement in DNA based science.*
>
> *- Researcher*

> *The primary strength is the manner in which GBC funding is coupled to matched funding from other sources (e.g., private, VC, etc.). This forces the investigators to be very focused in how they approach the practical value of their work. In academia, it is very often the norm that we pay lip service to the real-world value of the research that we propose, and as soon as the funds are forthcoming, we forget completely about the applied potential of the work that we proposed. This requirement forces the investigators to keep the practical focus in sight.*
>
> *- Researcher*

GBC's inclusiveness regarding the variety of stakeholder needs was also given praise by respondents; e.g., when dealing with pressing issues for provincial government ministries. It was noted that consistency in this strategic support to stakeholders was required to keep external organizations "on board". On this point, the need to maintain government interest in genomics and proteomics research was emphasized.

> *[Good points about GBC include a] wide variety of projects being supported; willingness to partner; flexibility in approach.*
>
> *Researcher*

> *I've been pleased to see GBC go it alone with programs or research areas that were not national.*
>
> *Stakeholder*

> *Government – both provincially and federally – seem to have lost their way in terms of a focus on research, at a time when it would make the most sense to invest. The US is investing. Why aren't we?. . . So, one of the factors is this lack of support at this time. . .. In the meantime, GBC needs to keep up the communication with government (which GBC has done successfully in the past) -- and to ask how it can help with government's issues.*
>
> *- Stakeholder*

Researchers commented that GBC required a long-term strategy for dealing with the huge masses of data being collected, and maintenance of research resources such as databases and model organisms. (The study team notes that other S&T organizations are struggling with this problem, as there often are no funds dedicated to relatively routine data maintenance, storage, and retrieval[9].)

> *What are scientists going to do with all this genomic data? GBC needs to begin thinking strategically about research that is applying genomics data and translating this into health, disease not just of humans but other important natural resources (including but not limited to fisheries, forestry etc.)*
>
> *- Researcher*

Among external stakeholders (and a few researchers), there appears to be lack of clarity as to the GBC research topics, with some individuals believing that GBC focuses very narrowly and strictly on "genomics", neglecting related topics such as proteomics, functional genomics, transcriptomics, etc. , as well as non-traditional areas such as metabolomics for environmental issues or nutragenomics, and would like to GBC addressing these newer topics in future (ideally with less requirement for obvious economic impacts in the short term). Other respondents worried that a broader approach could dilute GBC's existing strengths.

> *GBC has had some trouble deciding if it is really a *genomics* funding agency, or a more general biology/biomedical funding agency. Compared to the other provincial GCs and Genome Canada generally, GBC is not as genomics-focused. I think this tends to dilute the mission.*
>
> *- Stakeholder*

GBC's lack of substantial "independent" funding (i.e., not reliant on Genome Canada) was also seen as a barrier to being able to take on a complete strategic approach. However, no serious complaints were raised on this score, and the study team points out that this relationship with GC is a "given".

> *The inability to Genome BC to proactively fund projects – i.e., they only overall can match 25% of a project, means* de facto *that projects have to be fiscally established and approved before Genome BC would contribute, [and] means that Genome BC cannot help foster leadership in a worldwide context.*
>
> *Researcher*

> *There is a tension between what Genome BC can do independently of Genome Canada and what it must do through Genome Canada. Not between the two, but just that Genome BC is more nimble but works through Genome Canada in some cases where it is not a clear advantage*
>
> *Researcher*

This study did not investigate individual GBC programs. However, the Strategic Opportunities Fund (SOF) was often mentioned as an important mechanism to support new scientific topics, and (though the study team did not investigate this in detail) there appeared to be room for a broader, and more "blue sky" approach to SOF.

[9] Sometimes there are significant infrastructure costs associated with these resources; e.g., for forestry or agricultural research plots.

Making strategic choices that relate to BC's unique resources has been well-handled. This should be continued. However, selecting targets that extend beyond that obvious base has been more tentative. The SOF program does offer an opportunity to explore new opportunities, but it could have a component that encouraged development of nascent collaborations without having to drive toward an immediate economic impact.

- Researcher

3.1.2 IS BC "ON TRACK" TO BECOME A WORLD LEADER IN SELECTED GENOMICS AREAS?

Exhibit 4.2 shows that respondents believe GBC has had, on average, a high impact in helping British Columbia become a leader in selected genomics research areas. In the PIs' opinions, this is especially because of support to top scientists. The overall opinion and pattern of results for external stakeholders are very similar, although this group is slightly more impressed with GBC's support for top science. (Possibly the difference can be explained because of some PI concern about GE^{3}LS projects, as discussed below in section 3.5, and which may also be reflected in the slightly lower – but still high – ratings for GBC's support for multidisciplinary and cross-disciplinary projects.

Outstanding scientists. Collection of clinically well annotated biospecimens for research.

- Stakeholder

Proteomics (my area) is undergoing a major technical transition that facilitates practical clinical work. This represents the kind of ground-floor opportunity that GBC presumably favours. Funding to participate in upcoming international efforts on a leadership basis would provide high leverage.

- Stakeholder

It seems to me that the portfolio that GBC has developed is extremely broad, and contains some areas that are very unique. In particular, the emphasis on genomics of forestry and economically-valuable plant and animal species are areas that BC has become a leading player.

- Stakeholder

I am at a US institution, without a direct collaborative relationship. But GBC has set a high standard and has helped me argue for elevating the standards here.

- Stakeholder

Of interest is that critical mass is given relatively high ratings (especially by external stakeholders), although some international stakeholders commented that BC still does not have a large number of top-rank scientists in genomics and proteomics – the study team interprets this to mean that GBC is doing well given resource constraints.

Exhibit 4.2 – To what extent has GBC helped BC get "on track" in becoming a world leader in selected genomics areas?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. Rating	N
Researchers								
Overall extent of support	25.0%	**56.3%**	12.5%	0.0%	0.0%	6.3%	4.13	32
Support for top scientists	34.4%	**50.0%**	12.5%	3.1%	0.0%	0.0%	4.16	32
Support for top quality science	25.0%	**40.6%**	31.3%	3.1%	0.0%	0.0%	3.88	32
Support for an integrated portfolio of mutually-supporting projects	15.6%	**34.4%**	21.9%	0.0%	3.1%	25.0%	3.79	32
Support for multidisciplinary & cross-disciplinary science	16.1%	**45.2%**	29.0%	3.2%	0.0%	6.5%	3.79	31
Developing a critical mass of researchers in selected areas through attraction & retention	18.8%	**50.0%**	15.6%	3.1%	6.3%	6.3%	3.77	32
Other	0.0%	18.2%	0.0%	9.1%	0.0%	**72.7%**	3.33	11
Stakeholders								
Overall extent of support	19.4%	**58.3%**	11.1%	2.8%	2.8%	5.6%	3.94	36
Support for top scientists	30.6%	**50.0%**	8.3%	0.0%	0.0%	11.1%	4.25	36
Support for top quality science	36.1%	**47.2%**	11.1%	2.8%	2.8%	0.0%	4.11	36
Support for an integrated portfolio of mutually-supporting projects	13.9%	**41.7%**	22.2%	2.8%	0.0%	19.4%	3.83	36
Support for multidisciplinary & cross-disciplinary science	19.4%	**47.2%**	19.4%	2.8%	2.8%	8.3%	3.85	36
Developing a critical mass of researchers in selected areas through attraction & retention	16.7%	**52.8%**	16.7%	2.8%	0.0%	11.1%	3.94	36
Other	9.1%	27.3%	9.1%	0.0%	0.0%	**54.5%**	4.00	11

There were no significant complaints about the overall strategy, although various possible improvements were mentioned (e.g., more direct student support, more visibility in the US), and some industry participants wished for more focus on immediate industry concerns.

> *I have been continually impressed by GBC's efforts. I wish that I could have something substantive to add, but I'm afraid that GBC has, in my opinion, covered all the bases, as has Genome Canada in general.*
>
> *- Stakeholder*

> *I think there need to be increased focus on supporting more short term applications of genomics that can be commercialized in a couple of years.*
>
> *- Stakeholder*

However, respondents commented that GBC's relatively small funding and small critical mass in BC relative to other countries were significant constraints to strategic development.

> *If one is being brutal, . . . British Columbia does not have all that many top scientists. . . Genome BC has probably contributed to making BC a better place to do science, and genome science. And to making Vancouver a nucleus within Canada, along with Toronto. The future challenge is to use genomics to more intelligently address living organisms and industries important to the BC economy. Very good start in addressing this.*
>
> *- Stakeholder*

> *Continued significant funding is a critical issue given very low awards given by NSERC and CIHR in comparison to other countries (e.g. Wellcome Trust and NIH)*
>
> *- Researcher*

> *The biggest factor that hinders BC is its relative size; difficult to compete with California, New Hampshire, etc*
>
> *- Stakeholder*

There were also occasional comments that GBC has not taken a sufficiently strong leadership role with respect to funding the most exciting science, or in promoting the science that is done. (And note that exhibit 4.2 shows that about 30% of PIs rated GBC's support for top science as "moderate".)

> *My perception is that the impact on BC and Canadian capabilities has been quite high, but that much of the funding has been spent on areas that are unlikely to lead to big breakthroughs. Much of the science is pretty descriptive.*
>
> *- Researcher*

> *Genome BC appears to rarely takes the lead, and when it does often seems more concerned about avoiding dollar commitments than fostering the best and most creative science.*
>
> *- Researcher*

[GBC needs] to use the genome brand to like-minded others in the Asia Pacific region...[its] .geographic location is BC's natural advantage

- Researcher

3.2 GBC'S PARTICIPATION IN NATIONAL AND INTERNATIONAL STRATEGIES

On average, respondents believe GBC has had high to very high participation in national genomics research strategies, and high participation in international ones, as seen in exhibit 4.3.

Exhibit 4.3 – To what extent has GBC participated in national and international genomics approaches and strategies?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Researchers								
National	40.0%	**43.3%**	6.7%	0.0%	0.0%	10.0%	4.37	30
International	20.0%	**40.0%**	16.7%	10.0%	0.0%	13.3%	3.81	30
Stakeholders								
National	**38.2%**	**38.2%**	2.9%	2.9%	0.0%	17.6%	4.36	34
International	14.7%	**50.0%**	8.8%	5.9%	0.0%	20.6%	3.93	34

GBC is continually mentioned at many of the meetings and grant review panels that I attend, as being a high-quality organization that effectively promotes genomics-based science. The organization clearly has an international reputation.

- Stakeholder

[The CEO] has shown fantastic leadership. . . on the national and international front.

Stakeholder

Genome BC is directly traveling more internationally and meeting with key scientists and organizations in different life sciences sectors, which is a very positive development in the recent 1-2 years.

Researcher

GBC has done an extraordinarily good job at proteomics; there has been tremendous development at [my institution], and I attribute a lot of it to GBC. There has been

sufficiently stable funding and enough vision by GBC to attract [a star researcher]. . . [I see] a very significantly expanding footprint of BC worldwide in proteomics.

Researcher

This participation has high to very high value for increasing BC and Canadian genomics research capabilities, as seen in exhibit 4.4.

Exhibit 4.4 – How effective has this participation in national and international approaches been at strengthening BC and Canadian genomics research capabilities?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Researchers								
BC capabilities	**37.9%**	27.6%	24.1%	0.0%	0.0%	10.3%	4.15	29
Canadian capabilities	17.2%	**37.9%**	34.5%	0.0%	0.0%	10.3%	3.81	29
Stakeholders								
BC capabilities	**44.1%**	38.2%	5.9%	0.0%	0.0%	11.8%	4.43	34
Canadian capabilities	26.5%	**44.1%**	17.6%	0.0%	0.0%	11.8%	4.10	34

Researchers commented that GBC has helped them in international projects by facilitating interactions with international S&T organizations, helping BC scientists be seen as peers at the international scale, "getting a jump" on new opportunities (including applied ones), fostering interactions with the international biotechnology industry, and bringing to the table critical components of large research initiatives (e.g., reagents, platforms).

The pre-BC profile [in genomics] was perhaps obvious within BC itself, and may have extended to the relatively insular world of human genomics, but has been expanded by virtue of the projects that have been funded, such that BC is clearly a leader in the field of genomics in general, and not just focused on human genomics.

- Researcher

Overall, GBC has been rather successful at giving voice to needs of BC and the Pacific northwest region. Also, it has been a natural articulator for some genomic and ecological issues pertinent to the northern prairies.

- Stakeholder

3.3 GENERATION OF SOCIO-ECONOMIC IMPACTS

3.3.1 POTENTIAL OF GBC TO GENERATE SOCIO-ECONOMIC IMPACTS

Respondents see high potential for GBC research to eventually result in important socio-economic (S-E) impacts, as exemplified in its long-term strategy, and demonstrated in exhibit 4.5.

> *I have been continually impressed with how successful the strategy has been for linking basic and applied research, in particular pulling together academic scientists and entrepreneurial efforts from private sources. This is a first-rate aspect of the program.*
>
> *- Stakeholder*

The study team notes that the recent Genome Canada evaluation found:

> *Genomics applications are about to transform many aspects of society. The most obvious of these applications are in health care, in particular personalized medicine, but there are many industrial and environmental applications also being investigated, several of which are critical to Canada's resource industries such as fisheries (including aquaculture), forestry, and agriculture.*
>
> *- Evaluation of Genome Canada – Final Report*. KPMG, May 13, 2009, pp 9-10.

Exhibit 4.5 – Overall, how much potential do the GBC research programs and projects have for generating significant socio-economic (S-E) benefits for BC and Canada?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Researchers								
	32.1%	28.6%	25.0%	0.0%	0.0%	14.3%	4.08	28
Stakeholders								
	18.2%	**42.4%**	27.3%	6.1%	3.0%	3.0%	3.69	33

Such transformative impacts can also be expected from a number of GBC projects (some of which were studied in more detail during a separate Genome Canada benefit-cost scoping study, and which show very high social and economic impacts.) But many respondents emphasized that, because of the long-term nature of these applications, there was a strong need to have realistic expectations as to the timeframes involved (especially in human health applications which require clinical trials), and to continue support for pure science as a base from which these applications might be drawn.

> *This will remain a challenging aspect in all genomics research, educating the public to have realistic expectation will be a crucial aspect to maintain public support for Genome BC*
>
> *- Stakeholder*

Genomics is quite a long way upstream of the clinic and maybe it will be hard to turn genomics into socioeconomic benefits.

- Researcher

3.3.2 MECHANISMS USED BY GBC TO ENSURE S-E IMPACTS ARISE

One of GBC's key roles is to review and manage its research program to ensure that appropriate "building blocks" are in place to ensure S-E impacts eventually arise for industry and society. Exhibit 4.6 lists a number of such management mechanisms, and shows that GBC is rated as moderately high, on average, with respect to these mechanisms. Included in these mechanisms is consultation with external stakeholders, which has reportedly strengthened recently:

[A constraint is that] GBC has an orientation to the science community when seeking opinion. The community of people more involved in applied applications are given less opportunity for input.

- Stakeholder

[A plus is] more direct interactions with stakeholders -- this also has been gaining moment in GBC in the recent 1-2 years, which is a big plus for everyone involved.

- Researcher

It appears to me that BC has a continual, interactive relationship with its grantees, prior to and following funding. This is unusual in my experience.

- Stakeholder

The exception in exhibit 4.6 is a moderate rating for providing entrepreneurial support. The study team notes that few S&T organizations – even applied ones – provide such support, but this may represent an opportunity for GBC (see section 3.7). Note also that very few PIs "don't know" about GBC's management for S-E impacts, implying that this management is, indeed, active (54% of PIs find this management to be high or very high in extent).

On the negative side, there are concerns about issues such as the appropriate mix between pure *vs*. applied research, long timeframes to practical application, and a possibly overly simplistic approach to commercialization and other forms of application, etc., all of which are discussed in detail in section 3.3.7.

Exhibit 4.6 – To what extent has GBC put the "building blocks" in place to ensure these S-E benefits are realized?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Researchers								
Providing active management to ensure S-E benefits are realized	10.7%	**42.9%**	28.6%	0.0%	7.1%	10.7%	3.56	28
Supporting "indirect" tech transfer (e.g., knowledge transfer, tacit knowledge, proprietary information)	10.7%	**28.6%**	21.4%	7.1%	0.0%	**32.1%**	3.63	28
Involving potential users in the design & conduct of the R&D	14.3%	25.0%	**39.3%**	3.6%	3.6%	14.3%	3.50	28
Helping link researchers, users, & investors	17.9%	21.4%	17.9%	14.3%	3.6%	**25.0%**	3.48	28
Supporting "direct" tech transfer (e.g., through IP protection, patenting & licensing)	7.1%	21.4%	25.0%	7.1%	3.6%	**35.7%**	3.33	28
Providing entrepreneurial support	3.6%	14.3%	28.6%	7.1%	3.6%	**42.9%**	3.13	28
Other	0.0%	0.0%	0.0%	0.0%	0.0%	**100.0%**	0.00	4
Stakeholders								
Providing active management to ensure S-E benefits are realized	12.1%	**30.3%**	27.3%	6.1%	3.0%	21.2%	3.54	33
Supporting "indirect" tech transfer (e.g., through knowledge transfer, tacit knowledge, proprietary information)	9.4%	25.0%	**31.3%**	6.3%	0.0%	28.1%	3.52	32
Involving potential users in the design & conduct of the R&D	15.2%	**33.3%**	24.2%	12.1%	0.0%	15.2%	3.61	33
Supporting "direct" tech transfer (e.g., through IP protection, patenting, & licensing)	9.4%	21.9%	**31.3%**	9.4%	0.0%	28.1%	3.43	32
Helping link researchers, users, & investors	18.2%	**30.3%**	24.2%	3.0%	6.1%	18.2%	3.63	33

Exhibit 4.6 – To what extent has GBC put the "building blocks" in place to ensure these S-E benefits are realized?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Providing entrepreneurial support	12.5%	18.8%	21.9%	9.4%	6.3%	**31.3%**	3.32	32
Other	15.4%	7.7%	0.0%	0.0%	0.0%	**76.9%**	4.67	13

3.3.3 THE S&T PLATFORMS

The S&T Platforms not only offer GBC researchers access to infrastructure for conducting their research, but in some cases also to help develop practical applications of it. Exhibit 4.7 shows that the S&T Platforms are seen of high importance for genomics research (with nearly 80% of PIs rating them as high or very high in importance), and of low to moderate importance for helping create S-E benefits. (A knowledgeable US respondent noted that the GBC platform model works quite well, whereas in the US "platforms" tend to not be shared extensively with non-platform PIs.)

Exhibit 4.7 – To what extent has GBC offered researchers access to the necessary research infrastructure (i.e., the S&T platforms) that will support research and development of socio-economic benefits?

	5. Very high	4. High	3. Moderate	2. Low	1. Little or none	Don't know	Avg. rating	N
Researchers								
For research	35.7%	**42.9%**	7.1%	7.1%	0.0%	7.1%	3.23	28
For S-E benefits	7.1%	25.0%	28.6%	3.6%	3.6%	**32.1%**	2.68	28
Stakeholders								
For research	31.3%	**40.6%**	6.3%	6.3%	0.0%	15.6%	4.15	32
For S-E benefits	18.8%	**25.0%**	18.8%	12.5%	0.0%	**25.0%**	3.67	32

There are also some data on the S&T platforms available from the 2009 Genome Canada study. As seen in exhibit 4.8, the three S&T platforms based in BC are all rated highly for both technical capability and operational capability, although possibly with room for improvement on the operational side[10].

[10] These definitions have been developed in consultation with the Canada Foundation for Innovation, and reflect two important but distinct features of state-of-the-art research infrastructure. A recent major evaluation of the CFI found that the operational capability of Canadian research infrastructure in general tended to lag behind its technical capability, so GBC is not unique here. Reference: *Final Report Overall Performance Evaluation and Value-for-*

- "Technical capability" refers to technical and scientific specifications such as the measurement capabilities, scientific outputs, accuracy, throughput, etc. of the specialized research equipment.
- "Operational capability" refers to the research infrastructure's building and operating space, user capacity, computing capabilities, operating and maintenance levels, etc.

Exhibit 4.8 – Ratings* from the Genome Canada study of the technical and operational capabilities of the S&T platforms – GBC respondents' average ratings (all Canadian PIs average ratings)**

	Technical capability			Operational capability	
	PIs	**Platform Leaders**		**PIs**	**Platform Leaders**
Researchers					
BC Genome Sciences Centre	4.8 (4.2)	5.0 (5.0)		**4.5** (4.0)	**5.0** (5.0)
UVic/GBC Proteomics	**3.7** (3.7)	**5.0** (4.5)		**3.3** (3.5)	**5.0** (3.5)
BC Prostate Centre and Microarray	**3.7** (3.4)	-		**3.4** (3.2)	
McGill Innovation Centre	3.7	4.3		3.6	4.0
The Centre for Applied Genomics	3.7	-		3.4	
Bioinformatics	2.7	4.0		2.5	5.0

** Rating scale from 1 = Poor, to 5 = Excellent.*

*** Only for BC platforms – very limited GBC data elsewhere*

3.3.4 GBC RESEARCHERS' PURSUIT OF PRACTICAL APPLICATIONS

About 70% of GBC PIs have actively explored practical applications of their research. Exhibit 4.9 shows that these include many sectors of application and many mechanisms to achieve S-E benefits, both direct and indirect. The latter is important, as many recent studies have shown that important S-E impacts arise

Money Audit (OPEA) – Evaluation Component. Prepared for the Canada Foundation for Innovation. KPMG LLP, October 30, 2009

from a variety of indirect mechanisms, not just through traditional technology transfer (patenting, licensing, creation of spin-offs).

Exhibit 4.9 – Have you actively explored practical applications of your GBC research?

	Already applied	In active development	Possibilities being explored	N
Researchers				
Direct tech transfer for new or improved commercial applications	17.6%	11.8%	**35.3%**	17
Indirect technology & knowledge transfer for new or improved commercial applications	11.8%	**23.5%**	17.6%	17
Public policies or programs (e.g., regulations, standards, codes, decision tools)	5.9%	**11.8%**	**11.8%**	17
Health care (e.g., diagnostics, therapeutics)	5.9%	**29.4%**	**29.4%**	17
Best practices in manufacturing, organizational structure, healthcare, etc.	0.0%	6.3%	**25.0%**	16
Environmental benefits	0.0%	11.8%	**41.2%**	17
Other societal benefits (e.g., teaching planning, justice, reforms)	5.9%	11.8%	**35.3%**	17
Other	40.0%	0.0%	0.0%	5

3.3.5 TRAINING OF HIGHLY QUALIFIED PERSONNEL (HQP)

The training of HQP is one of the key outputs of many S&T programs related to generating S-E impacts, as many HQP go on to productive careers in industry, government, and non-government organizations. Notwithstanding that GBC does not directly provide training grants, fellowships, or scholarships, it is seen as having improved this training through access of HQP to top genomics, proteomics, and GE^3LS scientists, as well as access to the S&T platforms. See exhibit 4.10.

Due to GBC linked programs the students and staff have encountered opportunities that they would not have had before.

- Researcher

I have seen first hand how this is probably one of the most significant impacts.

- Researcher

Exhibit 4.10 – How has the training environment for undergraduate and graduate students, postdoctoral fellows, and research technicians changed because of GBC?

	5. Greatly improved	4. Improved	3. About the same	2. Poorer	1. Much poorer	Don't know	Avg. rating	N
Researchers								
Undergraduate	17.9%	**39.3%**	32.1%	0.0%	0.0%	10.7%	3.84	28
Graduate	**39.3%**	32.1%	25.0%	0.0%	0.0%	3.6%	4.15	28
Postdocs	**39.3%**	21.4%	28.6%	0.0%	0.0%	10.7%	4.12	28
Research technicians	34.6%	**38.5%**	15.4%	0.0%	0.0%	11.5%	4.22	26

A number of respondents noted that direct student support would be welcomed, including support for applied activities. (The study team notes that some S&T organizations go beyond this to provide support for student and/or postdoctoral entrepreneurial activities.) However, the four-year term of Genome Canada project funding may make it difficult to support students and postdoctoral fellows effectively.

I am not aware of any programs that GBC has facilitated for training of personnel, outside of the direct benefits incurred by researchers that receive funds to conduct genomics research obviously increases to opportunities for training in that specific lab. This, of course, is valuable; however, it would be great if there was an effort to impart the knowledge to a broader spectrum of trainees.

- Researcher

As major funding agencies collapse, one group of researchers that will be hardest hit are trainees. I would like to GBC begin funding graduate students/postdocs in BC. However, the funding should not be limited to only pure genomic discovery labs.

- Researcher

[GBC should provide] more funding opportunities for 'bridge' positions for graduates in genomics needing experience in more applied programs.

- Stakeholder

3.3.6 COMPARISON OF GENOME BC TO BEST PRACTICES FOR COMMERCIALIZATION

Appendix A provides a detailed review of how GBC mechanisms for commercialization compare to best practices used by similar organizations world-wide. Overall, GBC rates quite high when compared to best practices, as it uses many mechanisms known to be effective. The simple fact that GBC provides active management on this topic at all is, in fact, a strong point in its favour, as many other S&T organizations simply do not. There are some opportunities for improvement seen in selected areas, especially with respect to "people support", entrepreneurship, training, foresight exercises, more focus on non-IP mechanisms for creating S-E benefits, and proactive "matchmaking" of PIs, users, and venture capital[11].

3.3.7 FACTORS WHICH AFFECT EXPLOITATION AND COMMERCIALIZATION OF GENOME BC'S RESEARCH

The discussions above show that GBC is doing good work with respect to commercialization and other means of applying research findings, and has strong mechanisms in place to identify, manage, and exploit these opportunities. Further, transformative practical impacts for society and industry are likely in a number of sectors.

However, respondents noted a number of constraints to actually achieving these impacts. Key constraints are discussed below. The study team notes that these constraints are common to virtually all S&T programs which attempt to marry pure and applied research, although "–omics" research may suffer more from them because of the relative uncertainty of exactly how future applications will occur.

1. Timeframe to commercialization is long, and expectations are sometimes unrealistic. The findings demonstrate that most practical applications from GBC research – even from projects that have been supported from the beginning – are still years from full application. This is not through lack of human or financial resources, or lack of effective management, but from two main factors:

1. Much of the science is still not well-understood, as genomics and proteomics are in a period of tremendous flux (with many new and unexpected findings recently having arisen); and

2. The exact means through which practical applications will arise is still unknown. In many GBC projects, there are several potential important applications spread across many disciplines and sectors. It is difficult to know which of these applications will eventually be the most significant, and ideas about potential practical applications are still evolving (and expanding) rapidly.

Many study respondents commented on this point. Two representative quotes:

> *The one key issue is the long time line to commercialization.*
>
> *- Stakeholder*

> *[A constraint is the] perceived time from funding award to product in the hands of stakeholders. Too many potential investors and end users, as well as the general public, expect breakthroughs in unrealistically short amounts of time. We need to continue to educate the public on the complexities of -omics research and related product development.*
>
> *- Researcher*

[11] GBC's new Strategic Research Initiatives – Workshop Program is quite similar in intent.

2. A possible need for a more complex approach to commercialization and exploitation, especially regarding protection of intellectual property (IP), to the exclusion of more indirect means of exploiting research findings and expertise. This point is related to point #1, and the study team notes that the academic literature on the nature of S-E impacts from S&T, and concrete studies done to measure S&T impacts, both show that indirect mechanisms (e.g., development of tacit knowledge, changes to codes and standards of practice, changes to organizational behaviour and strategies) often have significantly higher economic impacts than those associated with traditional technology transfer through patenting, licensing, and spin-offs[12]. This is especially true when end-user benefits (as opposed to only benefits to, say, manufacturers) are measured, as open-source, open-access, unprotected IP may provide higher impacts for end-users[13].

> *The larger assumption is that IP protection etc. is a good way to capture the value of the work for the province. The UK is better off economically and scientifically for not having patented monoclonals. Etc.*
>
> *- Stakeholder*
>
> *As far as I can tell (through experience with the AGIP program) they are focused on the economic side of things, and less on the 'socio' side of things.*
>
> *- Researcher*
>
> *I think the IP protection has been counter-productive and that GBC should adopt stronger open-source and open-access policy rather than trying to safeguard much of the genomic and bioinformatics IP.*
>
> *- Stakeholder*

Detailed investigation of this topic was beyond the terms of reference of this study, but the study team notes that many S&T organizations world-wide struggle with this issue. A significant concern for GBC will be that the pharmaceutical industry typically requires strong IP protection before they will provide co-funding for R&D, which will limit GBC's ability to pursue non-IP mechanisms in this field.

3. A need to maintain an appropriate balance between long-term pure research and short-term applied work. The researchers in particular note that the linkages back to pure research need to be strong, and

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[12] See for example, B. Martin and A. Salter, "*The relationship between publicly funded basic research and economic performance*". Science Policy Research Unit, University of Sussex (UK), July 1996. Another excellent reference is L.G. Georghiou and G. Walshe et al, The Office of Science and Technology (OST) and the Programme for Policy Research in Engineering Science and Technology (PREST) at the University of Manchester (UK), "*Returns to research and development spending*", Her Majesty's Stationery Office (HMSO), May 1993.

[13] Recent studies suggest a 20% - 100% increase in citations of open-access (OA) papers over non-OA papers and highlight five key advantages: early advantage, quality advantage, usage advantage, competitive advantage and quality bias. Open access repositories: *Maximizing and measuring research impact through university and research-funder open-access self-archiving mandates*, Harnad, S., Carr, L., Swan, A, Sale, A., & Bosc, H. (2009). Wissenschaftsmanagement, 4(4), 36-41; for a more complete bibliography see http://opcit.eprints.org/oacitation-biblio.html .

that some excellent science that may eventually prove tremendously important may be neglected if too much emphasis is put on short term economic results, especially industrial sales revenues.

> *There is too much emphasis on short-term outcomes to allow investigators to tackle the really big questions with big potential payoffs. . .. It would be great if there was a program that emphasized discovery-based research with a lower threshold for matching funding. It could represent a relatively small amount of the total budget, but it would make truly "blue-sky" research possible.*
>
> *- Researcher*

> *Socio-economic benefits of research rarely result from targeting them in advance. Usually, they flow from research in unexpected ways, often years after the basic science is studied.*
>
> *- Researcher*

> *Narrow definition of socio-economic benefits reflects a financial bias.*
>
> *- Researcher*

> *Let the best ideas and the best scientists work on the most important problems, but put in place a process where discoveries that have a potential for translational application are nurtured. I am a strong supporter of facilitating and emphasizing knowledge translation, but emphasizing short-term S-E benefits as a metric of a program's success is counter productive.*
>
> *- Researcher*

It should be said that a number of stakeholders from industry believed exactly the opposite, believing that GBC does not focus nearly enough on clearly defined problems of relatively immediate interest for commercialization.

> *Lack of translational capabilities (i.e. commercialization), this is being addressed by collaboration with CDRD, more could be done.*
>
> *- Stakeholder*

> *General lack of market driven need. For [my field], private sector labs will not invest in generating genomic data or gear up their labs unless there is a demand or requirement (law or Act) that other industry sectors need to comply with.*
>
> *- Stakeholder*

The study team notes that, in our experience, such tensions exist in all S&T programs that support a mix of pure and applied R&D – we did not find the complaints on either side to be stronger than usual, which likely means that GBC is treading the middle ground.

4. A perceived mis-match between some GBC research topics and the needs of the user sector, or possibly the receptor capability of the users to be able to benefit from the findings. Respondents from one sector in particular voiced this concern very strongly. (The study team prefers not to name the sector for fear of losing anonymity of respondents.) Even here, though, the respondents were strongly split in their opinions about the need for genomics, and the ability of the industry to use them – interestingly, government regulators appeared to strongly support the research.

[This sector's] applications for genomics are very limited. Consultation with users has been limited and claims for future value have been excessively optimistic.

Stakeholder

The science has been very well conducted. It is the limited scope for application that is lacking.

Stakeholder

5. BC and Canadian receptor capacity is often limited. While this is a common refrain for Canadian science, it may be more pointed for "–omics" as applied to BC resource sectors such as fisheries, forestry, and agriculture/agri-food. Tied to this is difficulty accessing venture capital.

Lack of research sophistication in the resource-based industry sector, and therefore low uptake capacity for genomics discoveries.

- Researcher

[We lack] a robust VC community, larger life-science companies and pharma.

Stakeholder

[Difficulty] delivering practical applications of products / projects. . . due to the need to translate high-end research into the user environment.

- Researcher

Some external stakeholders had strongly divergent opinions on this score, instead believing that GBC has not effectively identified "dollar" applications in natural resource sectors, and had not consulted with the sectors sufficiently ahead of time. It was also commented that "dollar" metrics of success were not necessarily appropriate; instead, measures such as ecological diversity, reduced pollutant levels, might be more so.

Genomics [in our sector] is a solution looking for a problem.

- Stakeholder

6. Evolving nature of S&T platforms. This topic also arose in the 2009 Genome Canada evaluation – the technology is evolving very quickly, and new types of expertise, and possibly new models for using the platforms, may be required. A point specifically mentioned for GBC was bioinformatics: some respondents noted that as genome sequencing becomes a commodity, the challenge of dealing with genomic data will grow. There are substantial challenges in the analysis of the data that will require the development of new bioinformatics tools, but even these will require additional resources to be made available, including high-performance computing and high-performance storage. Further, this is a growth area for biomedical research, meaning that GBC will be competing with many other organizations (and jurisdictions) for qualified people.

7. Problems with "-omics" communications, perceptions, and measures of success. There is reportedly still poor government, public (and some industry) perception and understanding of the nature and potential impacts of "-omics" research. Respondents noted that GBC needs to maintain strong continuity with government (especially regarding ongoing support and evidence-based decision-making), and with industry and industry associations. Others suggested more use of modern and/or social media such as twitter, blogs, etc., especially to reach younger audiences. And related to the point #2 above, GBC was

said to need more and better measures of benefits (especially non-dollar ones; e.g., in resource sectors), and more fully address and measure indirect and non-linear effects.

3.4 RELATIONSHIPS WITH KEY STAKEHOLDERS

3.4.1 RELATIONSHIP WITH GENOME CANADA

A key GBC stakeholder relationship is with Genome Canada. Exhibit 4.11 shows that respondents believe that GBC's relationship here is good - these relations are said to be collegial, constructive, and friendly.

> *All staff [at GBC and GC] give a strong impression of trying to fulfill the mission of both organisations. . . Both [organizations] work hard to support researchers and projects in achieving their goals.*
>
> *- Stakeholder*

> *GBC has been one of the key anchors for the Genome Canada program.*
>
> *- Stakeholder*

Exhibit 4.11 – To what extent is GBC's relationship with Genome Canada effective? What about its collaborations with key BC stakeholders (including other research institutions

	5. Very effective	4. Effective	3. Moderate	2. Low	1. Very Low	Don't know	Avg.	N
Researchers								
With Genome Canada	14.3%	**32.1%**	25.0%	0.0%	3.6%	25.0%	3.71	28
With other BC stakeholders	14.3%	28.6%	21.4%	0.0%	0.0%	**35.7%**	3.89	28
Stakeholders								
With Genome Canada	24.2%	27.3%	9.1%	6.1%	0.0%	**33.3%**	4.05	33
With other BC stakeholders	**28.1%**	18.8%	25.0%	6.3%	3.1%	18.8%	3.77	32

Although some tensions were noted by respondents for all Centres working with Genome Canada (mainly related to administrative overburden perceived from Genome Canada, and the fact that GBC has

relatively little funding that is independent from GC), representatives from Genome Canada reported that their working relationship with GBC was generally excellent.

Of interest is that about a quarter of GBC's PIs don't know enough about the GBC relationship with Genome Canada to comment – there was a similar finding in the 2009 Genome Canada evaluation, almost certainly because Canadian researchers are not involved in proposal reviews for GC (this is all done by international researchers), and thus there is a "disconnect" between the Canadian genomics and proteomics research community and GC.

3.4.2 RELATIONSHIP WITH OTHER BC STAKEHOLDER ORGANIZATIONS

Further, GBC is seen as effective and collegial working with other BC stakeholders organizations:

> *GBC has done a truly outstanding job in stakeholder relations.*
>
> *- Stakeholder*

> *Genome BC is seen as a very collaborative entity.*
>
> *- Stakeholder*

Having said this, there are apparently opportunities for further networking and collaboration with external agencies, especially in government, including ways to better coordinate GBC and Genome Canada programs (e.g., GBC's AGIP and GC's ABC program).

> *Genome BC needs to be more inclusive and take advantage of synergies in other sectors. The perception of a "Club" mentality is a hindrance.*
>
> *- Stakeholder*

These collaborative arrangements have had impacts for individual researchers and stakeholders, as seen in exhibit 4.12. Most PIs benefitted from GBC's relations with other organizations, especially for increasing their research quality and quantity (with 67% and 63% of PIs, respectively, rating this as higher or much higher), and slightly less so for training and practical applications. It is notable, however, that many PIs do not report any synergies or improvements because of these collaborations.

Stakeholder organizations also benefited from these relationships, and in similar ways to PIs, although substantially fewer noted really significant impacts. The study team believes this probably reflects a size effect, as a number of these external organizations are very large, and it is unrealistic to expect a connection with GBC to dramatically affect them. Stakeholder organizations without impacts from contact with GBC noted that: (1) They were outside Canada; (2) They only provided assistance with GBC reviews; or (3) Their organization did not attempt practical applications of genomics or proteomics.

Exhibit 4.12 – What effects (if any) have GBC's collaborative relationships with other stakeholders had on your own research?

	5. Much higher	4. Higher	3. About the same	2. Lower	1. Much lower	Don't know	Avg. rating	N
Researchers								
Research quality	29.6%	**37.0%**	29.6%	0.0%	0.0%	3.7%	4.00	27
Research quantity	**33.3%**	29.6%	29.6%	3.7%	0.0%	3.7%	3.96	27
Focus on practical applications	22.2%	33.3%	**40.7%**	0.0%	0.0%	3.7%	3.81	27
Investment levels	22.2%	25.9%	**44.4%**	0.0%	0.0%	7.4%	3.76	27
Genomics training	22.2%	25.9%	**44.4%**	3.7%	0.0%	3.7%	3.69	27
Other	0.0%	14.3%	28.6%	0.0%	0.0%	**57.1%**	3.33	7
Stakeholders								
Research quality	12.5%	25.0%	**31.3%**	0.0%	0.0%	**31.3%**	3.73	32
Research quantity	12.5%	25.0%	**31.3%**	0.0%	0.0%	**31.3%**	3.73	32
Focus on practical applications	12.5%	15.6%	**37.5%**	3.1%	0.0%	31.3%	3.55	32
Investment levels	6.3%	18.8%	**40.6%**	3.1%	0.0%	31.3%	3.41	32
Genomics training	15.6%	18.8%	**34.4%**	0.0%	0.0%	31.3%	3.73	32
Other	5.9%	5.9%	23.5%	0.0%	0.0%	**64.7%**	3.50	17

3.5 DEALING WITH GE^{3}LS ISSUES

3.5.1 DATA FROM RESEARCHERS AND EXTERNAL STAKEHOLDERS

Genomics-related ethical, environmental, economic, legal, and social (GE^{3}LS) issues are addressed in GBC programs in two ways: as a required element that addresses social science and humanities (SSH) issues in all genomics and proteomics research projects, and as "stand-alone" projects focused on GE^{3}LS topics. Exhibit 4.13 shows that, overall, GBC is seen as addressing these topics to a moderate to high

extent. When it worked, this integration often worked well, and these PIs reported that they found it useful to have perspective from other disciplines.

> *I can't speak for the other projects but will say that the GE^{3}LS component for our project is embedded and has worked well and has been a very fruitful collaboration for all.*
>
> *- Researcher*

> *Integrating SSH research is a necessary component for the socio-economic benefit of GBC projects*
>
> *- Researcher*

Exhibit 4.13 – To what extent has GBC addressed GE3LS overall? To what extent are the "stand-alone" GE3LS projects integrated into the overall GBC effort? To what extent has GBC integrated social sciences and humanities (SSH) research and researchers in its genomics projects?

	5. Very high	4. High	3. Moderate	2. Low	Little, none	Don't know	Avg. rating	N
Researchers								
Addressed GE^{3}LS overall	14.3%	25.0%	28.6%	0.0%	0.0%	**32.1%**	3.79	28
Integrated "stand-alone" GE^{3}LS into overall effort	0.0%	22.2%	25.9%	3.7%	3.7%	**44.4%**	3.20	27
Integrated SSH in genomics projects	3.7%	11.1%	**40.7%**	7.4%	3.7%	33.3%	3.06	27
Stakeholders								
Addressed GE^{3}LS overall	12.1%	**48.5%**	18.2%	6.1%	0.0%	15.2%	3.79	33
Integrated "stand-alone" GE^{3}LS into overall effort	12.5%	**28.1%**	18.8%	9.4%	3.1%	**28.1%**	3.52	32
Integrated SSH in genomics projects	15.2%	**27.3%**	24.2%	3.0%	3.0%	**27.3%**	3.67	33

This integration is seen by external stakeholders in particular as an important and unusual feature of GC and GBC programming. One respondent noted that SSH concerns that do not appear to be of immediate importance may become so later on.

> *The linkage to GE^{3}LS concerns have always been highlighted. However, in many cases these concerns do not become significant until a product or process is being commercialized and public/industry exposure is now apparent.*
>
> *- Stakeholder*

These issues are the most difficult of all to deal with. Most genomics scientists are quite familiar with the hard science that is proposed, but these 'softer' (nonetheless important) issues are sometimes given less emphasis. It has been my experience that this situation is improving, however, as GBC (and the scientific community) become more adept at handling these types of projects.

- Stakeholder

Having said this, the requirement to have a GE^{3}LS element within every genomics/proteomics project is a controversial one among the scientists, and few PIs were very positive on this score – there were far more negative comments than positive ones, and some comments were very critical indeed. (This was also the case during the 2009 Genome Canada evaluation, and does not reflect on GBC alone, although GBC has more stringent GE^{3}LS requirements than some other Genome Centres.) Especially troubling is the integration of SSH and GE^{3}LS into individual genomics and proteomics science projects, and of GE^{3}LS into the overall research effort – only 15% and 22% of PIs, respectively, rated GBC's efforts here as high or very high. In addition, the study team believes that the high proportion of "don't know" PI responses may reflect either an unwillingness to be publicly critical of this sensitive topic or a degree of discomfort in assessing what effective "integration" means or should look like in the context of their projects.The main concerns raised were:

- The SSH integration detracted from the quality of many of the genomics and proteomics research projects, and occasionally also from the quality of the SSH research;
- The SSH component was often a "forced fit" in the project, and represented a resource "tax" on the other science;
- It was difficult to find top quality SSH scientists, and top quality SSH research proposals, to integrate into genomics and proteomics projects;
- The nature of the projects and management (including reporting) were not well aligned with how the SSH fields operate.

Some representative comments include:

From the SSH perspective, the reporting requirements are onerous. They are not designed for SSH research and are too frequent

- Researcher

. . . the metrics and review systems you use to evaluate the bench science, falls flat when trying to evaluate the SSH activities. What gets looked at is how germane the GE^{3}LS research is to the bench research, how will it complement and enhance that work. Perhaps rather than how good the actual GE^{3}LS research is... It's a noble cause, but his concern is that we don't have the right systems in place to ensure that the best GE^{3}LS research takes place.

- Stakeholder

This business of integration serves neither GE^{3}LS or biological researchers. If Genome BC wishes to advocate and support GE^{3}LS research, it should fund GE^{3}LS projects independently instead of the current approach of shotgun weddings.

- Researcher

GE^{3}LS research fulfills an important need. However, the integration of SSH with genomics projects compromises the quality of both types of research. That is, both types of research should be judged independently on their own merits. Integration can be encouraged using other mechanisms.

- Researcher

The requirement that all science project have a GELS component is really bad. It is wrong to assume that all genomic research involves GELS issues. More importantly, the current system funds GELS research above its capacity and includes no selection for quality of GELS proposals.

- Researcher

Genome BC does a reasonable job of creating a supportive environment for GE^{3}LS work, but at the project level real integration does not always happen. On the one hand, I like that all AGIP projects require an integrated GE^{3}LS component, but on the other, it can feel as though GE^{3}LS components are a tacked on necessity.

- Researcher

This is a complete waste of time. The trial has failed and should be abandoned.

- Researcher

The external stakeholders were far more positive on this topic – the average ratings were similar to the PIs', but far fewer stakeholders said "don't know". Even here, though, the open-ended commentary showed a clear split between those who considered this to be a tack well taken, *vs.* those having concerns.

GE^{3}LS has been one of the unique achievements of the Genome Canada and GBC programs and are to be complimented and continued.

- Stakeholder

I think this is hard to do -- we still have a siloed approach in most of our organizations. . .. [and it will] take some time to do the integration required. But GBC has been leading in this – just need to keep at it.

- Stakeholder

This was the most dysfunctional aspect of the project about which I know most

- Stakeholder

In the [projects in my sector], there is almost no tangible or serious GE^{3}LS issues; [but] quite a bit of effort has had to go into this component, in order to 'qualify' for GC funds

- Stakeholder

3.5.2 COMPARISON OF GENOME BC TO BEST PRACTICES FOR INTEGRATION OF THE SOCIAL SCIENCES AND HUMANITIES

It is fair to say that best practices for integrating SSH into natural sciences and engineering (NSE) and health sciences are far from well-understood. Even what "integration" means is not widely accepted. The study team proposes a definition:

- **Integration**: Implies a scope and range of knowledge brought to bear to tackle a common challenge, bringing heterogeneous skills and expertise to the problem-solving process. Effective integration requires a cohesive team and a coherence of goals among contributing disciplines and fields of research, often involving new partnerships. The linkages and relationships among disciplines and sub-components of a research project should develop and strengthen during a project, even if tenuous at first.

Appendix B shows that GBC does not score especially high in many best practice areas identified by the study team for integration. However, it is important to note that no individual S&T organization uses all of these methods, and many S&T organizations, in fact, do not explicitly address these best practices at all, instead effectively leaving SSH integration and impacts to chance. Thus by comparison to many other S&T organizations GBC is well ahead of the field. While there are many examples of interdisciplinary centres and funding programs, no existing list of best practices for integrating the SSH into NSE and health research was known to the study team – the list shown in Appendix B is a first cut at identifying these practices.

3.6 PUBLIC AWARENESS

The awareness of the need for genomics research – and its risks and rewards – is seen as being higher because of GBC, as seen in exhibit 4.14, although respondents also noted the difficulty of measuring and attributing changes with accuracy.

> *As with the scientific community as a whole, these efforts are never enough to counteract the suspicion and ignorance that far too often plagues public discussions of genomics and other scientific issues. GBC has probably done as well as anyone.*
>
> *- Stakeholder*

> *Continue this important education through forums and science fair presence.*
>
> *- Researcher*

> *There is no question that public awareness is higher.[But] I would think it almost impossible to know how much of this is due to GBC's efforts.*
>
> *- Researcher*

Exhibit 4.14 – To what extent has GBC changed public awareness of the need for genomics research? To what extent has it addressed public awareness of the risks and rewards of genomics research?

	5. Much higher	4. Higher	3. About the same	2. Lower	1. Much lower	Don't know	Avg. rating	N
Researchers								
Awareness of the need	14.3%	**60.7%**	0.0%	0.0%	0.0%	25.0%	4.19	28
Awareness of risks and rewards	7.1%	**60.7%**	7.1%	0.0%	0.0%	25.0%	4.00	28
Stakeholders								
Awareness of the need	6.1%	**51.5%**	9.1%	3.0%	0.0%	30.3%	3.87	33
Awareness of risks and rewards	6.3%	**46.9%**	12.5%	3.1%	0.0%	31.3%	3.82	32

A number of respondents commented that this question was not worded appropriately, as it assumed *a priori* that genomics and proteomics research was needed, and that risks and rewards of this research were of major concern. (The question was based, however, on the wording of GBC's by-laws.)

> *. . . the question pre-supposes the existence of a "need". I am sure GBC has helped raise public awareness of genomics in BC. As for public awareness of risks and rewards, with respect, I must ask what risks the question askers have in mind? And what rewards?*
>
> *- Stakeholder*

> *I think that raising awareness in the general public is challenging when there are no immediate benefits. But I think GBC has been doing as well as it can - and better than most other programs.*
>
> *- Stakeholder*

3.7 POSSIBLE IMPROVEMENTS TO THE GENOME BC MODEL

3.7.1 OVERVIEW

The discussion above points to GBC having a sound model, and is a well-run organization having competent and helpful staff and management. The study team notes that the 2004 GBC evaluation finding that GBC's role was poorly understood by both PIs and stakeholders was not mentioned in 2009 - 2010. In addition, although there were still complaints about GBC's "micromanagement", these were far less common than in 2004 – whether this means management has become less onerous or because the PIs are more used to it (or resigned to it) is unknown. Other concerns about the model voiced in 2004 were not noted at all in the present study, including: difficulties managing large-scale genomics projects,

helping PIs find co-funding, and improving GBC's business management (especially of the S&T platforms). The study team interprets this to mean that GBC has effectively attended to the key "teething problems" identified in 2004.

> *GBC is a great organization – extremely well run. It has historically kept "re-inventing" itself each year, responding to changes in society and to government's needs.*
>
> *- Stakeholder*

> *I knew of a particular proposal that had good science but was poorly aimed at the call for proposal. The staff did incredible work to try to get the PI ready for the Genome Canada call. They do that with all the applicants to help them be competitive. This is very unusual [in my country]. Also GBC does an excellent job getting the right panel together.*
>
> *- Stakeholder*

However, there were a number of areas in which the GBC model or program delivery could be refined, of which the most important are discussed in section 3.7.2. Some of these reflect difficulties with the existing system, and some reflect apparent opportunities to move into new territory.

3.7.2 REFINEMENTS TO EXISTING MODEL OR SERVICE DELIVERY

Re-think the nature of GE^{3}LS and SSH projects and integration. There remain serious concerns about the way in which SSH and GE^{3}LS research is conducted and/or integrated within GBC, especially as integrated within pure –omics research and research at the bench scale. Notwithstanding that GBC is to be commended for its efforts in this area, these concerns are serious enough to apparently compromise the quality of science in both SSH and genomics/proteomics.

The SSH fields of course cannot be neglected, as their inclusion is a requirement of Genome Canada funding. However, the way in which they are included needs to be refined for the benefit of both "sides", both in terms of support for meaningful science and in terms of reduced friction among the participants. (The study team points out that such interpersonal frictions are not to be ignored – we are aware of a significant S&T initiative which foundered because of such tensions.)

Issues to be addressed include the quality of GE^{3}LS research and researchers, the nature of integration within individual projects and overall, SSH leadership and goals, peer review of GE^{3}LS applications, and education about the cultures and methodologies across disciplines. In general, the study team suggests taking a more pragmatic portfolio approach to SSH – integrating these disciplines where it makes sense from either a programmatic or project perspective, but eliminating the absolute requirement to have SSH within every project. Care would be required to ensure that this is not seen as a retreat from a laudable goal. Further management specifically directed to attracting top SSH scientists and research projects, providing further communication and education, and addressing tensions as they arise, would be welcomed. (Essentially, this entails a review of all elements rated "Low" in Appendix B.)

Maintain appropriate mix of pure research vs. *commercial and other applications, and the processes for getting there*. The data do not suggest that GBC's current programming is much too far to one end or the other of the "R" vs. "D" spectrum. However, GBC must ensure that it continues to support "blue sky" research, and educates major government and industry stakeholders regarding the nature and timescales of impacts that will arise from this research. See also section 3.7.3 regarding the SOF.

Review support for indirect mechanisms for creating S-E impacts. Although GBC rates highly in terms of its overall focus on creating S-E impacts and having explicit mechanisms for doing so, it must ensure that its activities and metrics do not overly emphasize traditional technology transfer (TTT) such as patenting,

licensing, and spin-offs. A significant problem is that the easiest commercialization and exploitation metrics are related to TTT – this has the "quantum measurement" effect of tending to drive research programs towards activities which look good with respect to these metrics, and neglecting research and/or translation activities which do not.

This will require additional thought regarding important indirect means through which benefits can arise (e.g., non-TTT methods of knowledge transfer, translation, and mobilization; tacit knowledge, codes and standards, access to expertise), benefits for end-users, social *vs*. economic benefits, degree of IP protection, etc.

The study team notes that three of the largest dollar impacts known to one of the authors[14] arose from indirect effects[15]. None of these impacts would have been adequately measured (or in two of the cases, measured at all) through TTT metrics.

Provide support for routine genomics and proteomics databases, animal models, and other resources. There is a need to support such resources after they are no longer state-of-the-art, but are still relied upon as basic infrastructure to conduct research. (The study team notes that other S&T organizations are struggling with this problem, as there often are no funds dedicated to data maintenance, storage, and retrieval.)

Continue to investigate ways to reduce reporting burden. Although this topic was not a major focus of this study, the reporting burden required by GBC (which then reports to GC) remains an issue for researchers. Any ways of reducing this would be welcomed. (GBC's recent initiative at on-line reporting should help here.) It was also suggested that GBC staff and project managers are suffering "burn-out", and reductions to paperwork might help on this score as well.

Coordinate better access to S&T platforms across stakeholder organizations. Again, this topic was not investigated in detail. However, several comments were made that suggest that there is still limited access to the S&T platforms for the broader community (this includes access to non-GBC platforms)

Natural resources sectors. In these sectors, profit margins are often low, inhibiting take-up of innovations, and the ability to apply cutting-edge science is often lacking. The exact nature through which -omics can be applied in these sectors requires additional thought, especially with respect to industrial benefits, participation, and metrics for success.

3.7.3 LOOKING TO THE FUTURE

Some of the suggestions below require more – or substantially more – funding, and/or more consistent and guaranteed funding. Nonetheless, they are worthy of consideration.

Leadership. GBC appears to be well-regarded enough to be more confident in attempting a greater leadership role in selected areas. Some of the study consultations suggested that broader, coordinated strategic development with relevant BC organizations (e.g., the Michael Smith Foundation for Health

[14] Dennis Rank has conducted two dozen formal economic impact and/or benefit-cost studies of S&T programs, plus many more economic impact studies that were slightly less rigorous.

[15] In one case, proprietary (but non-patented) innovations from space programs research was applied to great success in the real estate market. In the other two examples, no IP from the original program was used, but literally billions of dollars in benefits arose from indirect mechanisms such as changes to corporate innovation strategies. Two reports are confidential. The public reference is: *Evaluation of the High Performance Polymer Membrane Research Program: Final Report.* KPMG Consulting (now KPMG LLP). May 15, 2002.

Research, and the BC Cancer Agency's Michael Smith Genome Sciences Centre) is required. This would include, among other things, more long-term thinking about "beyond genomics", now that genomics has become relatively routine, more strategic outreach to resource sectors and industry, and more explicit consideration of the appropriate roles of various BC S&T organizations[16]. In addition, a broader approach inclusive of northwest coast US states may not be impossible, as is inclusion of broader goals such as environmental sustainability in the resource sectors.

This might also include more support to the broader -omics and lifesciences communities, so that the larger community – not just researchers within individual organizations – benefits from platforms, databases, workshops, innovation support activities, and other common research strategies and resources. (This is currently a GBC "stretch" goal, although as noted earlier GBC must ensure it does not dilute its support for its core mandate.) The study team notes the power of the recently identified "facility" and "organization" effects[17] seen in significant strategic investments by the Canada Foundation for Innovation and its partners (requiring strategic planning and action by institutions as well as research agencies), and suggests that there are lessons herein that could be linked to:

- the current GBC Portfolio Review; and
- the best practices analyses discussed in Appendix A, such as making more use of the proactive opportunity-focused "matchmaking" for practical applications (in which researchers, users, and venture capital organizations identify future opportunities, and actively design research, training, and human resources programs around them); coupled with more use of Foresight- and roadmap-type exercises to identify projects and technologies that will be at the forefront 5-10 years from now.

Within this evolving strategy, respondents noted that GBC needs to be mindful of points where being grounded in "genomics" may begin to restrict it. Although genomics was very new 20 years ago, it is now regarded as routine, not cutting-edge. Keeping BC at the forefront may require modifying or expanding its mandate explicitly into the broader "–omics space", and link this to new ideas of how genomics and proteomics are linked to other research areas such as functional MRI, microanatomy, and behaviour.

People support. Comments from respondents, as well as the best practices analysis, suggest that more "people support" might be a useful addition to GBC's suite of activities. GBC does support one program directly relevant to this point, the Research Leadership Awards, although to date only one such award

[16] The study team's thinking was: (1) Does BC need a more coordinated "-omics strategy"? (2) It seems yes, for broader inclusiveness re. disciplines and access to platforms, more coordination with other players like MSFHR and GSC, more outreach to resource sectors and industry, more thinking about "beyond genomics, now that genomics is routine", stronger province-wide strategy, etc. (3) If so, who has the mandate, the broad discipline and sector approach, the resources, the management skills, and the staff to potentially take this on? GBC is the most obvious candidate. (4) Does GBC have not just the interest and ability to do it, but the respect of the community so that GBC's leadership would be accepted? (5) This appears to be at least feasible. (6) So the topic is worthy of investigation.

[17] Facility effect – the collective power of integrated suites of state-of-the-art equipment, usually housed in purpose built facilities, and deliberately sited to maximize their accessibility and multi-disciplinary, multi-sectoral effects. "Organization effect" – the impact of deliberate and strategic integration of infrastructure acquisitions with the organizational policies and structures for research (e.g. institutes, networks and other means of creating synergies), educational curricula and research training (e.g. undergraduate and graduate programs that reflect research strengths and synergies), and innovation and technology transfer activities. Reference: [17] *Canada Foundation for Innovation OMS 2008 Summary Report.* Dennis Rank (KPMG LLP) and Janet Halliwell. October 30, 2008. http://innovation.ca/en/accountability/evaluation-and-outcome-assessment/outcome-measurement-study-oms

has been made. (Some other GBC programs such as TDIF and SOF provide minor support in this area.). Additional effort might include:

- Direct support for students and postdoctoral fellows (which might be targeted to specific goals, such as exposure to different research or laboratory techniques through short-term secondments to other PIs' labs, or exposure to completely different disciplines). This may be challenging within the four-year Genome Canada project lifecycle.

- Support for Chairs for research and/or technology transfer and knowledge translation. It was suggested that GBC might target areas that are broader than genomics (e.g. mathematics applied to genomics, genomics applied to medicine etc), and recruit internationally leading investigators. If possible, fund them generously with a rolling horizon of ~5 years and let them run their programs relatively free from constraints. (GBC has been doing some of this, and has some well-known genomics scientists, but the field is moving fast and continuous heavy investment – and where necessary recruitment – are seen as justified. Of course, this cuts across the mandates of GBC partners, especially the universities, which will pose challenges.)

- Support for entrepreneurial activities (e.g., workshops with entrepreneurs, specific entrepreneurial training for PIs and/or students).

Blue sky research. Some of the concerns related to pure vs. applied focus may be alleviated through more attention to blue sky research. In this, the SOF program is frequently mentioned. An expansion to this program may be useful, possibly tied to a lesser (or no) requirement for co-funding, as this may be difficult to find for such research.

4 CONCLUSIONS

4 CONCLUSIONS

It has been a huge success story for BC

- Researcher

The study shows very positive findings on almost all fronts. The data from researchers and stakeholders are unusually consistent in this matter; evaluations normally find that external stakeholders are noticeably less positive than funded researchers, but that is not the case here (in fact, here the international stakeholders are the most positive about GBC's achievements). GBC has had strong impacts on genomics and proteomics strategy development; coordination and collaboration among relevant S&T organizations; research quality and quantity; training of HQP (indirectly); and technology and knowledge transfer, translation, and mobilization. GBC seen as key anchor of the Genome Canada program, and gives the BC "-omics" community a voice. On the program delivery side, GBC is being seen as flexible and re-inventing itself as required, with strong leadership and staff. Of considerable interest is that – unlike in 2004 – the current GBC role appears to now be well defined and understood.

There are, however, several issues that should be attended to. The three most critical to address are: (1) Continued and serious concerns in some quarters about GE^{3}LS and SSH components, and their integration with genomics and proteomics projects and in the program overall (notwithstanding the overall positive findings regarding this integration. (2) Continued concerns regarding the balance between pure and applied research, although these seem partially alleviated by new programs (e.g., AGIP, SOF) that separate these functions from pure research. (3) There is room for improvement in understanding of the nature of, and mechanisms for, creating socio-economic benefits, and in measurement of such benefits. The study team notes that although all three of these concerns are found in other programs that foster multidisciplinary and cross-disciplinary research, or that support a mix of pure and applied research, they are important challenges for GBC to solve if it is to remain relevant.

There also appears to be some room for GBC to move forward into a more proactive role in acting as hub for coordinating BC's broader "–omics" community, and for incorporating additional mechanisms directed towards practical application of "–omics" in a wider variety of applications. Such changes, however, would depend on sufficient and reliable funding being available.

APPENDIX A

BEST PRACTICES FOR COMMERCIALIZATION OF UNIVERSITY RESEARCH

Best Practices for Commercialization of University Research

Methodology

Operational benchmarking was done to compare the activities of client organizations against best practices for the commercialization of IP supported by the public sector. Reviews were conducted of a number of models used to assist R&D commercialization by other well-known organizations world-wide. These were mainly university-based organizations, but some government lab models were also included in order to have a wide range of models investigated. One well-regarded non-S&T organization was also reviewed.

Specific activities within these organizations were not investigated with respect to their individual effectiveness and efficiency. However, it can reasonably be assumed that these organizations use methods which they themselves consider to be best practices. Of note is that no individual organization uses all of these methods.

Models Reviewed

- Singapore's Biopolis (limited information);
- The Canadian Light Source Inc.
- The Canadian Optics Consortium (www.photonics.ca);
- The Centre for Advanced Science and Technology Incubation (CASTI), which is the University of Tokyo's technology licensing organization, and part of its Research Centre for Advanced Science and Technology (RCAST);
- Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO; limited information);
- CONNECT at University of California, San Diego;
- Gateway to Asia, which puts Asian immigrant entrepreneurs and Western Canadian companies together with Asian customers and investors[18];
- The Industrial Technology Research Institute (ITRI) in Taiwan, a non-profit organization with about 6,000 employees that serves as the technological centre for industry and the unofficial arm of the government's industrial policies.
- NRCan's Industry Energy R&D Program;

[18] Not all of GTA's activities are related to high technology, but some are, and there is a GTA connection with one of the older IRIS/Precarn projects. In addition, the model has several useful elements with respect to international trade issues.

- NRC's National Institute for Nanotechnology, Institute for National Measurement Standards, Institute for Research in Construction, and more limited information on several other NRC institutes;

- The New York State Foundation for Science, Technology, and Innovation (NYSTAR; www.nystar.state.ny.us/) ;

- The EU's Sixth Framework Programme (FP6) Network of Excellence on Micro-Optics (NEMO), which has an Industrial Users Club; http://www.micro-optics.org/www/about_us/nemo);

- The Netherlands Organization for Applied Scientific Research (TNO)[19], a for-profit R&D organization dedicated to supporting market-driven innovation of use to society as a whole, with roughly 4,500 employees working in many strategic sectors;

- The Office of Technology Licensing (OTL), Stanford University;

- The Ontario Centres of Excellence; http://www.oce-ontario.org/Pages/Home.aspx.

- Les Pôles de compétitivité, a French clusters program,– an industry-academia-government program aimed at developing technology and innovation clusters; see http://www.competitivite.gouv.fr/index.php?lang=env (71 have been funded to date)

- The Swedish Governmental Agency for Innovation Systems (VINNOVA, vaguely similar to Canada's Networks of Centres of Excellence; www.vinnova.se/In-English/)

- The Technical Research Centre of Finland (VTT), a non-profit R&D organization with about 2,800 employees, that seeks to provide strategic high-technology solutions[20] to improve industrial competitiveness and quality of life.

- UBC's TRIUMF facility (limited information)

[19] And its subsidiary, TNO Companies BV, which is the commercialization arm.

[20] Currently in seven strategic areas.

Appendix A – Best Practices in Commercialization

Vision:

- Goal-driven
- Specific commercialization goals
- Consideration of public good benefits
- Explicit strategic sector focus

Strategy:

- Strong industry input at the "front end"
- Large integrated portfolio of projects to support large research themes,
- Portfolio of projects along the R&D continuum from basic to development, prototyping, etc.
- "Foresight" and "roadmap" exercises

Partnerships:

- Strategic partnerships both to boost scientific power and to deliberately stretch resources (what one organization doesn't have, the other does)
- Dedicated international programs and/or offices and institutes

Multidisciplinarity:

- Multi- and/or cross- and/or inter-disciplinary projects and/or themes
- Integration of __E^3LS issues[21]

R&D Funding Support:

- Specific funding for applied R&D;
- Projects selection based on their applied focus
- Support for commercial projects even w/o protectable IP, depending on sector

Collaboration and Networking:

- Collaboration at the project leader (scientist) level
- Networking among scientists, engineers, users, investors, and students
- Industrial consortia involved

[21] Fill in the blank (e.g., ***G***E^3LS for genomics, ***N***E^3LS for nanotechnology, etc.)

HQP:

- Sector's HQP needs identified
- Trainees involved in applied R&D, often working jointly with user organizations
- Assists in job placement, matching jobs & graduates;
- Entrepreneurship credit, programs, and/or degrees

Commercialization:

- Explicit program and project management tools re. commercialization of projects
- Program acts as "hub" to link researchers, users, capital
- User community actively assisted with finding technologies and experts
- Technical problem-solving function for users (usually for one user at a time)
- Proactive opportunity-focused "matchmaking" between scientists and users, with specific goals identified (usually for multiple users with common problems and opportunities)
- General knowledge exchange between scientists, universities, industry, and VC.
- Investment-focused presentations
- Explicit international programs (or offices) as for above
- Funding for start-up needs
- In-house technology transfer and licensing office
- Mechanisms to support "out of the box" thinking

Cost Recovery:

- No accepted "best practice"

Clustering:

- Deliberate physical clustering of R&D efforts, especially where multidisciplinarity is required

Support for Entrepreneurship, Start-ups and Spin-Offs:

- Explicit support for start-ups and spin-offs:
    - the "technology side" – technologies, processes, IP, etc.
    - the "operational side" – strategy, management, marketing, etc.
    - the "capability side" – finding & training the people
- "People support" for CEOs – often volunteer support from the community
- "Corporate talent development" at universities or colleges
- Venture capital and/or angel support groups or networking events
- In-house VC investment units

Communication and Outreach:

- Explicit external communication plan – what message, when, how, to whom, why, what outcomes hoped for, measure impacts if possible
- Explicit internal communications plan
- Recognition programs and awards – including for applied efforts, networking, etc.
- Linkages (usually through websites) to other resources

Management and Governance:

- Strong leadership, especially Centre/program head
- Strong Board
- Strong management by full-time staff
- Clear policies for dealing with conflict of interest

Commercialization Rating Table for Genome British Columbia

Overall, GBC rates quite high in both its focus on achieving socio-economic impacts, and in having explicit mechanisms to support this focus, when compared to best practices. In reviewing GBC's efforts, it is important to note that no individual S&T organization uses all of these methods. Many, in fact, do not explicitly address most of these practices at all, instead effectively leaving practical impacts to chance. Thus even though GBC does not score high in all areas, by comparison to many other S&T organizations it is well ahead of the field. However, there may be opportunities for GBC improvement in some selected areas currently rated "Low".

Note: An asterisk (*) indicates that the study team did not have enough information to form a strong conclusion.

Summary Best Practice	GBC Focus	Comments
Vision:		
Goal-driven	H	Strong focus on "practical application" goals
Specific commercialization goals	H	Strong focus on specific commercialization goals, several management mechanisms devoted to this
Consideration of public good benefits	M	Although a strong part of strategy, shorter-term commercialization goals may supersede public good efforts
Explicit strategic sector focus	M-H	Extensive consultation with user sectors, recently increasing
Strategy:		
Strong industry input	M	See above; appears this could be stronger
Large integrated portfolio of projects to support large research themes,	M-H	A major part of GBC's strategy; likely opportunity to strengthen this through "organization effect".
Portfolio of projects along the R&D continuum	M	Less clear that projects are mapped out to be mutually-supportive across this continuum.
"Foresight" and "roadmap" exercises	L	Not a formal part of GBC's strategy
Partnerships:		
Strategic partnerships	M	A strong part of GBC's strategy (esp. internationally), but likely limited by willingness of regional S&T players

Dedicated international programs and/or offices/institutes	L	Not used by GBC.
Multidisciplinarity:		
Multi- and/or interdisciplinary projects and/or themes	H	A strong part of GBC's strategy
Integration of E^3LS issues	M	A strong part of GBC's strategy, though with mixed success to date.
R&D Funding Support:		
Funding for applied R&D;	M	GBC has independent programs specifically devoted to this, but funding limited
Projects selection based on their applied focus	H	A strong part of GBC's strategy, though with generally appropriate focus on pure research as well.
Supports commercial projects w/o protectable IP	*	GBC mainly focuses on IP protection, but probably less so on opportunities where other mechanisms might be more appropriate.
Collaboration and Networking:		
Collaboration at the project leader (scientist) level	H	A major part of the large-scale genomics projects
Networking among scientists, engineers, users, investors, and students;	M	Networking is strong, though with lesser participation from the "practical" side
Industrial consortia involved;	L	Not used by GBC.
HQP:		
Sector's HQP needs identified	L	Not used by GBC.
Trainees involved in applied R&D	L	Not explicitly used by GBC.
Assists in job placement, matching jobs & graduates;	L	Not used by GBC.
Entrepreneurship programs and/or degrees	L	Not used by GBC.
Commercialization:		
Explicit program and project management tools re. commercialisation of projects	H	A strong part of GBC's management practices.
User community assisted with finding technologies and experts	L	Not used by GBC.
Opportunity-focused "matchmaking"	L	Not used by GBC.

General knowledge exchange between scientists, universities, industry, and VC.	M	Occurs, but does not appear to be explicitly targeted.
Investment-focused presentations	L	Not used by GBC.
Explicit international programs as for above,;	L	Not used by GBC.
Funding for start-up needs	L	Not used by GBC.
In-house technology transfer and licensing office	L	Not used by GBC (and would be inappropriate given relationship and agreements with other institutions, especially universities).
Mechanisms to support "out of the box" thinking, both for research and for exploitation	M	Science Opportunity Fund of considerable interest; likely opportunity to increase effort here along the "practical" front
Cost Recovery:		
No accepted "best practice"	N/A	Not applicable
Clustering:		
Deliberate clustering of R&D efforts	M-H	The Centre itself represents a cluster, as do the S&T platforms. Likely opportunity to strengthen this through "facility effect"
Support for Entrepreneurship, Start-ups and Spin-Offs:		
Explicit support for start-ups and spin-offs:		
- the "technology side"	L	Not used by GBC, usually the purview of its partners
- the operational side	L	Not used by GBC, usually the purview of its partners
- the "capability side"	L	Not used by GBC, usually the purview of its partners
"People support" for CEOs	L	Not used by GBC.
"Corporate talent development" at universities or colleges;	L	Not used by GBC.
VC and/or angel support groups or networking events	L	Not used by GBC.
In-house VC investment units	L	Not used by GBC.
Communication and Outreach:		
Explicit external communication plan	H	A strong part of GBC's policies & management practices.

Explicit internal communications plan	*	Unknown
Recognition programs and awards	*	Unknown
Linkages (usually through websites) to other resources	*	Unknown
Management and Governance:		
Strong leadership, especially Centre/program head	H	Widely regarded as having strong leadership
Strong Board	H	Strong Board
Strong management by full-time staff	H	Large, active, and competent staff
Clear policies for dealing with conflict of interest	N/A	Most funding decisions made by Genome Canada, not GBC

APPENDIX B

BEST PRACTICES FOR INTEGRATING RESEARCH FROM THE SOCIAL SCIENCES AND HUMANITIES, NATURAL SCIENCES AND ENGINEERING, AND HEALTH

Appendix B – Best Practices for Integrating SSH, NSE, and Health Research

Introductory note: These comments apply to how GE^{3}LS and other types of SSH concerns are integrated into NSE and health research projects, and into GBC's research program overall. They do not apply to the "internal" conduct of GE^{3}LS projects. These practices span the appropriate actions of the granting councils, universities, program managers, project managers, and individual researchers. Of course, no single organization or individual has control over all factors. Often, however, actions can be taken by several types of participant.

It is fair to say that best practices for integrating SSH into NSE and health sciences are far from well-understood. However, the study team considered comments made by GBC researchers and key stakeholders, and also reviewed the activities of GBC against lessons[22] that have been learned in this area within other research initiatives that attempt such research integration. Among the examples considered were:

- certain SSHRC programs, e.g. Major Collaborative Research Initiatives;
- individual networks within the Networks of Centres of Excellence that have attempted integrated research programs, e.g., AquaNet;
- certain CFI facilities that foster integrated approaches, e.g., cognitive sciences at McGill, and information and computer technology at Dalhousie;
- S&T organizations that are intended to achieve substantial economic returns from non-traditional technology transfer[23], e.g., the Directed Research program of the Canadian Mortgage and Housing Corporation, NRCan's R-2000 program; and
- S&T organizations that are intended to have substantial non-commercial end-user input and/or relevance, e.g., Michael Smith Foundation for Health Research, Canadian Breast Cancer Research Initiative, environmental applications of the Canadian Light Source Inc.

Terminology

Integration: Implies a scope and range of knowledge brought to bear to tackle a given challenge, bringing heterogeneous skills and expertise to the problem-solving process, often involving new partnerships. It involves a cohesive team and a coherence of goals among contributing disciplines and fields of research. Linkages and relationships among disciplines and sub-components of a research project should develop and strengthen during a project, even if tenuous at first

[22] Both best and worst practices.

[23] Such as knowledge translation, development of tacit knowledge, impacts on codes and standards, etc.

Fostering the environment

- Ensure reward systems are designed to reflect the nature of inter- and multi-disciplinary research
    - Neither the NSE/health fields, nor the SSH fields, currently place much value on such integrated research. In general, granting councils and universities have difficulty fostering and rewarding research that integrates this broad a spectrum of fields, given their reliance on traditional discipline peers. (A conclusion is that individual funding programs and projects are best structured to foster an environment for integrated trans-disciplinary research.)

- Prior to launching targeted RFPs, explore the larger social and civil society issues associated with the sector, e.g. engage in discussions with researchers in the SSH, NSE and health and members of local communities who have an academic, social or economic interest in the target sector – e.g. the impact of drought on the wine industry in the Okanagan.
    - This will help identify areas where SSH can make "real" contributions to NSE/health research, and *vice versa*
    - It will also increase the time available to build "real" teams and foster more inter-sectoral partnerships.

- Formulate the RFP/proposal call in language that captures the interest of NSE, health, and SSH researchers, and (as appropriate) fosters integration of local knowledge
    - It is important to frame RFPs in a way that captures the interests of the best researchers in all fields
    - Find ways to disseminate the RFPs to the larger SSH research community. These research opportunities and RFPs are often unknown to the top researchers from fields other than the "core" NSE/health discipline.
- Use a broad SSH definition (as GBC has recently done) rather than focus uniquely on ethics.

Ensuring the right participants

Fostering a supportive environment will help attract top people in the first place. But in addition the project needs to deliberately and actively select the right mix of people:

- Leadership – There is a need for strong leadership regarding the importance and impacts of effective integration:
    - at the program level
    - at individual theme and project levels
- Researchers - Individuals from all disciplines with a lively curiosity about other fields and a willingness to listen/expand perspectives and respect other approaches and disciplines..
    - It is especially important that theme and project leaders be such individuals, since leadership is crucial to effective integration.
    - Conversely, inclusion of highly critical or negative individuals can compromise or damage collaborative efforts.
- External users and larger civil society – find means appropriate to the project to integrate both types of external participants – actual users of the outcomes and societal interest groups. For example, . both the forestry industry and civil society groups have an interest in the health of communities reliant on the forestry sector and the environmental and sustainability issues associated with that industry

- End-user involvement is especially important if technology transfer and knowledge translation and diffusion are included in project/program goals ("contact sports").
- Participation in the research often pays large dividends.

Learning the culture and roles

Build in sufficient time and face-to-face opportunities at front end for researchers from different fields to:

- Build trust and understanding of the other discipline parishes around the table – through group discussion of the nature of the research questions, the vocabulary, the relevant methodologies, and accepted modes of knowledge dissemination among all participating disciplines
    - All fields need to communicate the nature, complexity and potential impact of their research in a way that can be understood by the non-specialist researcher
    - This takes a surprisingly long time even in a multidisciplinary setting, much less a trans-disciplinary one;
    - Even "same discipline – different country" collaborations may suffer this problem

- Ensure there is, and continues to be, common understanding of the project's objectives, the opportunities, and the roles of the diverse participants
    - Understand how, in actual practice, each discipline intends to help the others
    - Go beyond diagnosis and description of problems to constructive engagement in developing solutions
    - Understand that an important intent of the collaboration is to improve the quality of the research, and improve the ability to conduct knowledge translation and technology transfer of the results.
    - These will be supported through frequent interactions around evolving goals, research findings, etc. discussed under "management"

- Build common management protocols for issues that are frequently handled differently among fields, e.g.:
    - Intellectual property
    - Data access and use
    - Communications

Assessing the proposals

- Require an integrated proposal, not one in which the SSH or GE^{3}LS components are segregated.
    - Provide an overall page limit, not a separate one for the SSH component
    - Allow budgetary requests that reflect the real costs of the research and are not artificially capped in one sub-area
- Ensure that applicants are asked to address how they will manage and monitor the project to lead to effective integration, on an ongoing basis, of:
    - Knowledge and insights from all of the contributing disciplines
    - Involvement of participants outside the traditional research units

Management of the project

- Ensure that the engagement and involvement of project researchers from all fields is meaningful and not token, with "real" goals and activities intended to better the project.
    - Build backwards from the common understanding of the long-term goal of the program/theme/project to understand how SSH can assist (just as you would with any other discipline). Important SSH themes and topics will have been identified and defined through the stages discussed above – genuinely useful SSH research will influence and improve the conduct or translation of NSE/health research, and *vice-versa.*
    - SSH may be the primary focus of a stand-alone SSH project (perhaps with NSE/health as sub-activities), or integrated within an NSE/health project – whatever makes the most sense given the research topic.
    - If a "real" SSH component cannot be identified, then SSH should not be included in the individual theme/project activities – force-fitting SSH into every project only causes resentment and inefficient use of resources, and diverts focus from "real" opportunities. (This is no different from not including, say, particle physics researchers in a study of salmon ecology)

- Seek opportunities to collaborate and have co-management among disciplines and sectors at every stage:
    - Collaboration in definition of the larger/overall project directions/objectives – this is especially important during the planning stages of the project or program (as opposed to "parachuting in" SSH after the projects are defined).
    - Co-supervision of students (among researchers of different discipline backgrounds)
    - Co-production of knowledge
    - Co-publication
    - Co-exploitation of the results. This may include non-commercial exploitation. .

- Build modes of communication and interaction that are both effective and pragmatic; foster creative "intellectual transaction spaces" – e.g. through:
    - co-location of research groups,
    - shared facilities and other resources,
    - common office space for graduate students and PDFs,
    - off-site group retreats,
    - regular face-to-face meetings in which different aspects of the research is discussed among all participants, including potential users

- Ensure student training provides students with the opportunity to interact with researchers from other fields and using different methodologies
    - some programs use explicit short- and long-term "cross-laboratory" fellowships to support this
    - graduate level courses, especially in methodology, are especially valuable for students in other disciplines
    - foster opportunities for graduate students to present their research to their peers in other fields involved in the project

Monitoring and Facilitating

Given both the challenges of, and potential returns on, integration of knowledge across disciplines within genomics, actions to monitor and facilitate the process can be helpful

For projects, monitor the success of integration, knowledge translation, communication:

- Establish metrics for both commercial and non-commercial knowledge non-traditional translation activities at the project level and use this activity as a way of building understanding across discipline lines.
- Tackle areas of friction as soon as they are apparent
- Ideally there should be SSH representatives on Science Advisory Boards (SAB) involving integrated research. However, experience has shown that a single SSH member on a science advisory or review committee has minimal impact. At the very least all SAB members should be provided with guidelines on SSH integration. Ideally there should be two members with SSH expertise on a relevant SAB.

For funding agencies

- There is significant benefit in having a senior level staff advisor on SSH integration to provide advice to applicants. This coordinator could also continuously monitor the “non-SSH” projects to seek potential opportunities for SSH integration
- In determining whether a project should be allowed to be SSH-free, ask the question of whether the involvement of the SSH will improve the “social robustness” of the project – e.g. going beyond the production of reliable knowledge to considerations of its acceptability to various stakeholders.
- Treat the integration of the SSH, NSE and health as a learning experience and share lessons learned.

SSH Integration Rating Table for Genome British Columbia

In reviewing GBC's efforts, it is important to note that no individual S&T organization uses all of these methods. Many, in fact, do not explicitly address these practices at all, instead effectively leaving SSH integration and impacts to chance. Thus even though GBC does not score especially high in many areas, by comparison to many other S&T organizations it is ahead of the field.

Summary Best Practice	**GBC Effort**	**Comments**
Fostering the environment:		
Reward systems encourage integration	L-M	Perhaps more on the "stick" than the "carrot" side, but GBC makes real effort to create "rewards" through knowledge dissemination across fields. But GBC has little control over reward systems in larger research environment.
Explore real SSH opps during targeted RFPS	M-H	GBC has engaged in extensive stakeholder consultation, including wider stakeholder community
Make targeted RFPs available & attractive to best researchers in SSH (& other) fields	L-M	GBC making a significant effort, but it is a non-trivial challenge to attract the best SSH researchers to projects where they feel less than comfortable
Use broad definition of SSH (i.e., not just "ethics")	M-H	GBC has recently been much stronger here
Ensure right participants:		
Leadership: • At program level • At theme and project level	 H L-M	 Strong leadership at GC and GBC level, including hiring of GE^{e}LS Advisor. But mixed buy-in at theme and project level.
PIs (esp. theme and project leaders) have lively curiousity about other fields	L-M	PIs appear to be a mix of modestly supportive, and quite negative in regard to intellectual value added of other fields. This may reflect difficulties in defining and funding integrated projects, plus lack of experience with useful integration, rather than the individuals themselves, and in study team's experience such a mix is not unusual. Negativism would likely be diminished by ensuring that "forced fit" alliances are not required.
Two kinds of external users involved: • users of the research results;	 M	Where appropriate in strategic and applied projects, external users are involved. (Though industry would prefer even more involvement, unclear how feasible this is.)

Summary Best Practice	GBC Effort	Comments
• broader society with interest in the topic	L-M	Broader society deliberately addressed through strong Outreach program. But need to assess effectiveness of such actions in a structured way
Learning cultures and roles		
Sufficient time for face-to-face interactions, discussions of vocabulary, develop understanding of differing goals, methods, etc. across fields	L-M	Hampered by short time frame (4 years) of Genome Canada projects and the time constraints on proposal submission. Mix of "forced fit" projects where this likely doesn't happen, and others with a strong interaction process. Those with good ties to key SSH researchers and/or GBC's GE^{e}LS Advisor may also be more successful.
Continuous efforts to ensure understanding of project goals, opps, and roles – with intent to maximize project success	M	As immediately above, plus mixed success across projects depending on project leadership, degree of "real" integration, and good intent of participants.
Effective management protocols to handle differences across disciplines in dealing with IP, data access, communications, etc.	*	Unknown.
Proposal review		
Integrated proposal, rather than "science" vs. "SSH"	L-M	Many proposals not really integrated, but genuine efforts to improve this situation
Require applicants to discuss management & integration issues re. SSH	*	Unknown
Project management		
Meaningful SSH activities, goals, engagement & management	M	Mixed across projects, from "real" to "forced". Genuine effort in many projects, but artificial in others and constrained by requirement to have SSH component in every project
Co-management, including for project definition, student supervision, knowledge production, publication, and exploitation of results	*	Unknown to what extent management explicitly addresses this. Study team believes this is done in different ways according to the institutional procedures and the discipline cultures.
Effective communications across disciplines (e.g., "transaction spaces", co-location, retreats, face-to-face meetings, etc.)	L	Appears to be fostered by GE^{e}LS Advisor, workshops devoted to this topic (but apparently poorly attended by non-SSH researchers.)
Training across disciplines	L	Does not appear to be deliberately fostered.
Project monitoring		

Summary Best Practice	GBC Effort	Comments
Deliberately monitor ongoing effectiveness of integration, non-traditional knowledge translation; address friction areas	*	Unknown. GBC's GE^{e}LS Advisor may take an active role in this.
Similar activities at funding agency (i.e., Genome Canada) level	*	Unknown. Genome Canada has a GE^{e}LS Officer, but effectiveness of activities unknown.

APPENDIX C

AVERAGE RATINGS OF INTERNATIONAL *VS.* CANADIAN STAKEHOLDERS

Appendix C – Average Ratings of International vs. Canadian Stakeholders

Ratings from 1 = lowest impact of GBC to 5 = highest impact of GBC

	Average Rating	
Question	**International**	**Canadian**
1. GBC strategy		
- Complete?	4.23	3.79
- Adds value?	4.58	3.68
2. BC "on track" to become world leader in selected area?		
- Overall	4.15	3.81
- Critical mass	4.15	3.79
- Top scientists	4.40	4.12
- Top science	4.33	3.95
- Integrated portfolio	4.18	3.61
- Multidisciplinary & cross-disciplinary support	4.21	3.58
5. GBC's national & international participation		
- National	4.64	4.18
- International	3.91	3.94
6. Impact of GBC's nat'l & int'l participation		
- Strengthened BC	4.58	4.33
- Strengthened Canada	4.25	4.00

	Average Rating	
Question	**International**	**Canadian**
8. GBC potential for S-E benefits	4.00	3.47
9. GBC has “building blocks” for S-E benefits?		
- Active management	4.11	3.24
- Involving users	4.00	3.39
- Direct technology transfer	3.50	3.38
- Indirect technology & knowledge transfer	4.00	3.27
- Links among researchers, users, VC	4.40	3.18
- Entrepreneur support	4.13	2.86
10. Usefulness of S&T platforms		
- For research	4.60	3.88
- For S-E benefits	4.33	3.27
13. GBC’s relations with key stakeholder organizations		
- Rel. with GC	4.50	3.79
- Rel. w/ other BC stakeholders	4.43	3.53

	Average Rating	
Question	**International**	**Canadian**
14. Impact of GBC collaboration on stakeholder's own organization.		
- Research quality	4.00	3.67
- Research quantity	4.00	3.67
- Investment	3.50	3.39
- Training	4.00	3.67
- Focus on S-E benefits	4.00	3.44
16. Addressing GE3LS		
- Overall	3.83	3.75
- Stand-alone GE3LS integrated into overall program	3.60	3.46
- SSH integrated into genomics research	3.78	3.60
18. GBC's impact on public awareness		
- Of need for genomics research	4.14	3.75
- Of risks and rewards	4.29	3.60

APPENDIX D

INSTRUMENTS

Survey – Genome BC Researchers

Instructions to respondent: To the extent possible, please consider the value added (if any) by Genome British Columbia, as opposed to the basic impacts of the funding provided through Genome Canada grants, or the impacts of other organizations that may help support BC genomics research (e.g., CIHR, CFI, etc.)

All information will be reported in an aggregate fashion that does not allow identification of any individual.

Background on Respondent (this is only in case we need to contact you)

Name	
Organization	
Your position	
Phone	
Fax	
E-mail	

1. Coordination and Integration of BC's Genomics R&D

1. To what extent has Genome BC (GBC) developed a strategy for BC's genomics research community that is complete and adds value?

	Very high	High	Moderate	Low	Little or none	Don't know
Complete approach	❑	❑	❑	❑	❑	❑
Adds significant value	❑	❑	❑	❑	❑	❑

2. To what extent has GBC helped BC get "on track" in becoming a world leader in selected genomics areas? Please consider the overall extent of this support, as well as individual aspects listed below.

	Very high	High	Moderate	Low	Little or none	Don't know
Overall extent of support	❑	❑	❑	❑	❑	❑
Developing a critical mass of researchers in selected areas through attraction & retention	❑	❑	❑	❑	❑	❑
Support for top scientists	❑	❑	❑	❑	❑	❑
Support for top quality science	❑	❑	❑	❑	❑	❑
Support for multidisciplinary science	❑	❑	❑	❑	❑	❑
Support for an integrated portfolio of mutually-supporting projects	❑	❑	❑	❑	❑	❑
Support for multidisciplinary & cross-disciplinary science	❑	❑	❑	❑	❑	❑

3. What are the key factors that are helping or hindering BC's ability to become a world leader in selected genomics area? Are there any critical gaps that GBC could assist with?

4. Do you have any other comments about GBC's efforts in coordinating and integrating BC's genomics R&D, or in helping BC become a genomics leader?

2. Participation in National and International Genomics Strategies

5. To what extent has GBC participated in national and international genomics approaches and strategies?

	Very high	High	Moderate	Low	Little or none	Don't know
National participation	❑	❑	❑	❑	❑	❑
International participation	❑	❑	❑	❑	❑	❑

6. How effective has this participation been at strengthening BC and Canadian genomics research capabilities?

	Very high	High	Moderate	Low	Little or none	Don't know
Strengthening BC capabilities	❑	❑	❑	❑	❑	❑
Strengthening Canadian capabilities	❑	❑	❑	❑	❑	❑

7. Do you have any other comments about GBC's efforts in this area ?

3. Potential to Generate Socio-Economic (S-E) Benefits

8. Overall, how much potential do the GBC research programs and projects have for generating significant S-E benefits for BC and Canada?

	Very high	High	Moderate	Low	Little or none	Don't know
Potential for S-E benefits	❑	❑	❑	❑	❑	❑

9. To what extent has GBC put the "building blocks" in place to ensure these S-E benefits are realized?

	Very high	High	Moderate	Low	Little or none	Don't know
Providing active management to ensure S-E benefits are realized	❑	❑	❑	❑	❑	❑
Involving potential users in the design & conduct of the R&D	❑	❑	❑	❑	❑	❑
Supporting "direct" tech transfer (e.g., through IP protection, patenting & licensing)	❑	❑	❑	❑	❑	❑
Supporting "indirect" tech transfer (e.g., through knowledge transfer, tacit knowledge, proprietary information)	❑	❑	❑	❑	❑	❑
Helping link researchers, users, & investors	❑	❑	❑	❑	❑	❑
Providing entrepreneurial support	❑	❑	❑	❑	❑	❑

10. To what extent has GBC offered researchers access to the necessary research infrastructure (i.e., the S&T platforms) that will support your research and development of socio-economic benefits?

	Very high	High	Moderate	Low	Little or none	Don't know
Infrastructure to support genomics research	❑	❑	❑	❑	❑	❑
Infrastructure to support creation of S-E benefits	❑	❑	❑	❑	❑	❑

11. Have you actively explored practical applications of your GBC research, or research conducted on GBC's S&T infrastructure?

Yes	No
❑	❑

If no, go to Question 12.

If yes, has any of this research led to any of the following types of potential practical applications?

	Yes, already applied	Yes, in active development	Yes, possibilities being explored	No
New or improved health care protocols, diagnostics, prognostics, therapeutics, protocols, etc.	❑	❑	❑	❑
New or improved public policies or programs (including improved regulations, standards, codes of practice, decision tools, etc.)	❑	❑	❑	❑
Direct technology transfer for new or improved commercial products, processes, or services (e.g., patenting, copyrights, licensing agreements, spin-off companies, etc.)	❑	❑	❑	❑
Indirect technology and knowledge transfer for new or improved commercial products, processes, or services (e.g., trade secrets, tacit knowledge, proprietary processes, etc.)	❑	❑	❑	❑
Best practices in manufacturing organizational structure, healthcare, , marketing, etc.	❑	❑	❑	❑
Environmental benefits (e.g., reduced harmful impacts, improved ecosystem)	❑	❑	❑	❑
Other societal benefits (e.g., better teaching methods, community planning, social structure, justice system, economic reform, etc.)				
Other (Please specify)				

12. How has the training environment for undergraduate and graduate students, postdoctoral fellows, and research technicians changed because of GBC?

	Greatly improved	Improved	About the same	Poorer	Much poorer	Don't know
For undergraduates	❑	❑	❑	❑	❑	❑
For graduate students	❑	❑	❑	❑	❑	❑
For postdocs	❑	❑	❑	❑	❑	❑
For research technicians	❑	❑	❑	❑	❑	❑

13. What are the key factors that are helping or hindering BC's ability to generate socio-economic benefits?

14. Do you have any other comments about GBC's efforts in this area ?

4. Contractual and Collaborative Relationships with Stakeholders

15. To what extent is GBC's relationship with Genome Canada effective? What about its collaborations with key BC stakeholders (including other research institutions, potential users and investors)

	Very effective	Effective	Moderate	Low	Very low	Don't know
Relationship with Genome Canada	❑	❑	❑	❑	❑	❑
Collaborations with other BC stakeholders	❑	❑	❑	❑	❑	❑

16. What effects (if any) have GBC's collaborative relationships with other stakeholders had on your own research? (For example, changes in quality and quantity of your genomics research, investment levels, training, focus on practical applications, etc.)

	Much higher	Higher	About the same	Lower	Much lower	Don't know
Research quality	❑	❑	❑	❑	❑	❑
Research quantity	❑	❑	❑	❑	❑	❑
Investment levels	❑	❑	❑	❑	❑	❑
Genomics training	❑	❑	❑	❑	❑	❑
Focus on practical applications	❑	❑	❑	❑	❑	❑

17. Do you have any other comments about GBC's efforts in this area ?

5. Addressing GE^{3}LS Concerns

18. To what extent has GBC addressed GE^{3}LS concerns (genomics-related ethical, environmental, economic, legal, and social) in its programs overall? To what extent has it integrated social sciences and humanities (SSH) research and researchers in its projects?

	Very high	High	Moderate	Low	Little or none	Don't know
Addressed GE^{3}LS overall	❑	❑	❑	❑	❑	❑
Integrated SSH in its projects	❑	❑	❑	❑	❑	❑

19. Do you have any other comments about GBC's efforts in this area ?

6. Increasing Public Awareness

20. To what extent has GBC increased public awareness of the need for genomics research? To what extent has it addressed public awareness of its risks and rewards?

	Very high	High	Moderate	Low	Little or none	Don't know
Awareness of the need	❑	❑	❑	❑	❑	❑
Awareness of risks and rewards	❑	❑	❑	❑	❑	❑

21. Do you have comments about GBC's efforts in this area ?

7. Possible Improvements

22. Do you have any suggestions for how GBC might improve its model, strategy, or services?

Other

23. Do you have any other comments about GBC?

Thank you!

Interview Guide – Genome BC Stakeholders and International Experts

Instructions to respondent: To the extent possible, please consider the value added (if any) by Genome British Columbia, as opposed to the basic impacts of the funding provided through Genome Canada grants, or the impacts of other organizations that may help support BC genomics research (e.g., CIHR, CFI, etc.)

If possible, please complete this ahead of time (especially the rating scales) and return it to us. Then the interview can focus on discussing the most important points.

All information will be reported in an aggregate fashion that does not allow identification of any individual.

Background on Respondent

Name	
Organization	
Your position	
Phone	
Fax	
E-mail	

1. Coordination and Integration of BC's Genomics R&D

1. To what extent has Genome BC (GBC) developed a strategy for BC's genomics research community that is complete and adds value?

	Very high	High	Moderate	Low	Little or none	Don't know
Complete approach	❑	❑	❑	❑	❑	❑
Adds significant value	❑	❑	❑	❑	❑	❑

2. To what extent has GBC helped BC get "on track" in becoming a world leader in selected genomics areas? Please consider the overall extent of this support, as well as individual aspects listed below.

	Very high	High	Moderate	Low	Little or none	Don't know
Overall extent of support	❑	❑	❑	❑	❑	❑
Developing a critical mass of researchers in selected areas through attraction & retention	❑	❑	❑	❑	❑	❑
Support for top scientists	❑	❑	❑	❑	❑	❑
Support for top quality science	❑	❑	❑	❑	❑	❑
Support for multidisciplinary science	❑	❑	❑	❑	❑	❑
Support for an integrated portfolio of mutually-supporting projects	❑	❑	❑	❑	❑	❑
Support for multidisciplinary & cross-disciplinary science	❑	❑	❑	❑	❑	❑

3. What are the key factors that are helping or hindering BC's ability to become a world leader in selected genomics area? Are there any critical gaps that GBC could assist with?

4. Do you have any other comments about GBC's efforts in coordinating and integrating BC's genomics R&D, or in helping BC become a genomics leader?

2. Participation in National and International Genomics Strategies

5. To what extent has GBC participated in national and international genomics approaches and strategies?

	Very high	High	Moderate	Low	Little or none	Don't know
National participation	❑	❑	❑	❑	❑	❑
International participation	❑	❑	❑	❑	❑	❑

6. How effective has this participation been at strengthening BC and Canadian genomics research capabilities?

	Very high	High	Moderate	Low	Little or none	Don't know
Strengthening BC capabilities	❑	❑	❑	❑	❑	❑
Strengthening Canadian capabilities	❑	❑	❑	❑	❑	❑

7. Do you have any other comments about GBC's efforts in this area ?

3. Potential to Generate Socio-Economic (S-E) Benefits

8. Overall, how much potential do the GBC research programs and projects have for generating significant S-E benefits for BC and Canada?

	Very high	High	Moderate	Low	Little or none	Don't know
Potential for S-E benefits	❑	❑	❑	❑	❑	❑

9. To what extent has GBC put the "building blocks" in place to ensure these S-E benefits are realized?

	Very high	High	Moderate	Low	Little or none	Don't know
Providing active management to ensure S-E benefits are realized	❑	❑	❑	❑	❑	❑
Involving potential users in the design & conduct of the R&D	❑	❑	❑	❑	❑	❑
Supporting "direct" tech transfer (e.g., through IP protection, patenting & licensing)	❑	❑	❑	❑	❑	❑
Supporting "indirect" tech transfer (e.g., through knowledge transfer, tacit knowledge, proprietary information)	❑	❑	❑	❑	❑	❑
Helping link researchers, users, & investors	❑	❑	❑	❑	❑	❑
Providing entrepreneurial support	❑	❑	❑	❑	❑	❑

10. To what extent has GBC offered researchers access to the necessary research infrastructure (i.e., the S&T platforms) that will support their research and development of socio-economic benefits?

	Very high	High	Moderate	Low	Little or none	Don't know
Infrastructure to support genomics research	❑	❑	❑	❑	❑	❑
Infrastructure to support creation of S-E benefits	❑	❑	❑	❑	❑	❑

11. What are the key factors that are helping or hindering BC's ability to generate socio-economic benefits?

12. Do you have any other comments about GBC's efforts in this area ?

4. Contractual and Collaborative Relationships with Stakeholders

13. To what extent is GBC's relationship with Genome Canada effective? What about its collaborations with key BC stakeholders (including other research institutions, potential users and investors)

	Very effective	Effective	Moderate	Low	Very low	Don't know
Relationship with Genome Canada	❑	❑	❑	❑	❑	❑
Collaborations with other BC stakeholders	❑	❑	❑	❑	❑	❑

14. What effects (if any) have these collaborative relationships with GBC had on your own organization? (For example, changes in the quality and quantity of genomics research, investment levels, genomics training, focus on practical applications, etc.)

	Much higher	Higher	About the same	Lower	Much lower	Don't know
Research quality	❑	❑	❑	❑	❑	❑
Research quantity	❑	❑	❑	❑	❑	❑

Investment levels	❑	❑	❑	❑	❑	❑
Genomics training	❑	❑	❑	❑	❑	❑
Focus on practical applications	❑	❑	❑	❑	❑	❑

15. Do you have any other comments about GBC's efforts in this area ?

5. Addressing GE^{3}LS Concerns

16. To what extent has GBC addressed GE^{3}LS concerns (genomics-related ethical, environmental, economic, legal, and social) in its programs overall? To what extent has it successfully integrated social sciences and humanities (SSH) research and researchers in its projects?

	Very high	High	Moderate	Low	Little or none	Don't know
Addressed GE^{3}LS overall	❑	❑	❑	❑	❑	❑
Integrated SSH in its projects	❑	❑	❑	❑	❑	❑

17. Do you have any other comments about GBC's efforts in this area ?

6. Increasing Public Awareness

18. To what extent has GBC increased public awareness of the need for genomics research? To what extent has it addressed public awareness of its risks and rewards?

	Very high	High	Moderate	Low	Little or none	Don't know
Awareness of the need	❑	❑	❑	❑	❑	❑
Awareness of risks and rewards	❑	❑	❑	❑	❑	❑

19. Do you have any other comments about GBC's efforts in this area ?

7. Possible Improvements

20. Do you have any suggestions for how GBC might improve its model, strategy, or services?

Other

21. Do you have any other comments about GBC?

Thank you!

Interview Guide – Genome BC Board

Instructions to respondent: To the extent possible, please consider the value added (if any) by Genome British Columbia, as opposed to the basic impacts of the funding provided through Genome Canada grants, or the impacts of other organizations that may help support BC genomics research (e.g., CIHR, CFI, etc.)

All information will be reported in an aggregate fashion that does not allow identification of any individual.

Background on Respondent

Name	
Organization	
Your position	
Phone	
Fax	
E-mail	

1. Coordination and Integration of BC's Genomics R&D

1. To what extent has Genome BC (GBC) developed a strategy for BC's genomics research community that is complete and adds value?

2. To what extent has GBC helped BC get "on track" in becoming a world leader in selected genomics areas?

3. What are the key factors that are helping or hindering BC's ability to become a world leader in selected genomics area? Are there any critical gaps that GBC could assist with?

4. Do you have any other comments about GBC's efforts in coordinating and integrating BC's genomics R&D, or in helping BC become a genomics leader?

2. Participation in National and International Genomics Strategies

5. To what extent has GBC participated in national and international genomics approaches and strategies?

6. How effective has this participation been at strengthening BC and Canadian genomics research capabilities?

7. Do you have any other comments about GBC's efforts in this area ?

3. Potential to Generate Socio-Economic (S-E) Benefits

8. Overall, how much potential do the GBC research programs and projects have for generating significant S-E benefits for BC and Canada?

9. To what extent has GBC put the "building blocks" (i.e., various management mechanisms, tech transfer and knowledge translation support) in place to ensure these S-E benefits are realized?

10. To what extent has GBC offered researchers access to the necessary research infrastructure (i.e., the S&T platforms) that will support their research and development of socio-economic benefits?

11. What are the key factors that are helping or hindering BC's ability to generate socio-economic benefits?

12. Do you have any other comments about GBC's efforts in this area ?

4. Contractual and Collaborative Relationships with Stakeholders

13. To what extent is GBC's relationship with Genome Canada effective? What about its collaborations with key BC stakeholders (including other research institutions, potential users and investors)

14. What effects (if any) have these collaborative relationships with GBC had on your own organization? (For example, changes in the quality and quantify of genomics research, investment levels, genomics training, focus on practical applications, etc.)

15. Do you have any other comments about GBC's efforts in this area ?

5. Addressing GE^{3}LS Concerns

16. To what extent has GBC addressed GE^{3}LS concerns (genomics-related ethical, environmental, economic, legal, and social) in its programs overall? To what extent has it successfully integrated social sciences and humanities (SSH) research and researchers in its projects?

17. Do you have any other comments about GBC's efforts in this area ?

6. Increasing Public Awareness

18. To what extent has GBC increased public awareness of the need for genomics research? To what extent has it addressed public awareness of its risks and rewards?

19. Do you have any other comments about GBC's efforts in this area ?

7. Possible Improvements

20. Do you have any suggestions for how GBC might improve its model, strategy, or services?

Other

21. Do you have any other comments about GBC?

Thank you!