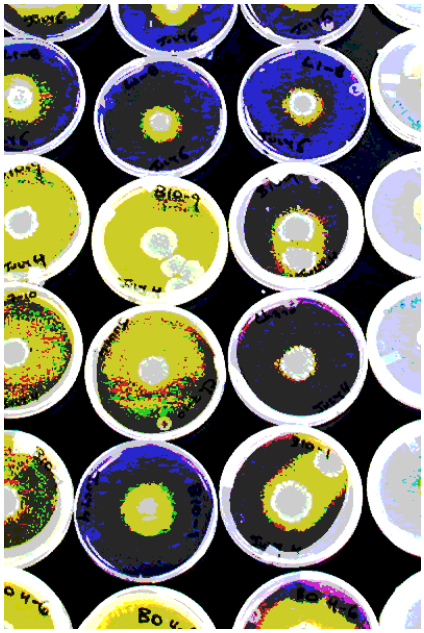
Solicitation No. 01B68-060084/B

Sporometrics Proposal No. P9224.007
March 31, 2007

National Centres
for Secure Biological Resources

Centres Nationaux
de Ressources Biologiques Protégées

Final Report



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List of Acronyms and abbreviated terms

AAFC – Agriculture and Agri-Food Canada

ABIP – Agricultural Bioproducts Innovation Program

AFTOL – American Fungal Tree of Life

ATCC – American Type Culture Collection

BCCM – Belgian Coordinated Collections of Microorganisms

biosafety – assurance that dangerous biological materials are safely handled in facilities that comply with current containment standards

biosecurity – assurance that dangerous biological materials remain only in appropriate hands and in particular are not released to potentially hostile, destructive or negligent users

CABRI – Common Access to Biological Resources and Information (a major European consortium of top SBRCs)

CBD – Convention on Biological Diversity

CBRN – Chemical, Biological, Radiological and Nuclear (warfare and terror threats)

CBS – Centraalbureau voor Schimmelcultures, also called CBS Fungal Biodiversity Centre. Contains the formerly independent National Culture Collection of Bacteria (NCCB) in addition to its fungal holdings.

CCFC – Canadian Collection of Fungal Cultures (AAFC)

CCOHS – Canadian Centre for Occupational Health and Safety

CFIA – Canadian Food Inspection Agency

CRTI –CBRN Research and Technology Initiative

DRDC – Defence Research and Development Canada

DSMZ – Deutsche Sammlung von Mikroorganismen und Zellkulturen, German Resource Centre for Biological Material.

EBRCN – European Biological Resource Centres Network

FQRNT – Fonds québécois de la recherche sur la nature et les technologies, Québec Nature and Technology Research Fund

FTE – Full-time equivalent. Human resources term for personnel allotment equivalent of one full-time staff member.

GBIF – Global Biodiversity Information Facility

GBRCN – Global Biological Resource Centre Network (a project of the OECD)

GLP – Good Laboratory Practices

GMO – genetically modified organism, generally an organism containing one or more genes artificially transferred from another organism.

IATA – International Airline Transport Association

IT – information technology

NCSBR – National Centre for Secure Biological Resources

NITE – National Institute of Technology and Evaluation (Japan)

NML – National Microbiology Laboratory

NOAMI – National Orphaned/Abandoned Mines Initiative

NRCan – Natural Resources Canada

NSERC – Natural Sciences and Engineering Research Council of Canada

NSF – U.S. National Science Foundation

NWO – Nederlandse Organisatie voor Wetenschappelijke Onderzoek, Netherlands Organization for Scientific Research

OECD – Organization for Economic Cooperation and Development

QA/QC – quality assurance/quality control

PHAC – Public Health Agency of Canada

professional SBRC – an SBRC that has full-time staff dedicated to receiving, preserving and shipping cultures or analogous specimen materials, and that has at least a partial online catalogue of its available materials

SBRC – Secure Biological Resource Centre

Secure Biological Resource Centres – This nomenclature follows the international definition of BRCs: *"BRCs contain collections of culturable organisms (e.g. micro-organisms…), replicable parts of these (e.g. genomes, plasmids, viruses, cDNAs), viable but not yet culturable organisms …, as well as*

databases containing molecular, physiological and structural information relevant to these collections and related bioinformatics." (OECD, 2007) The added *S* for "Secure" in SBRC indicates not only the long term organism preservation required of a microbiological collection, but also the use of practices and facilities consistent with modern international biosecurity (e.g., assurance that dangerous materials remain only in appropriate hands) and biosafety (e.g., assurance that dangerous materials are safely handled in facilities that comply with current biosafety standards)

SOPs – standard operating procedures

UAMH – University of Alberta Microfungus Collection and Herbarium

UKNCC – United Kingdom National Culture Collection

USAMRIID – US Army Medical Research Institute for Infectious Diseases

UTCC – University of Toronto Culture Collection of Algae and Cyanobacteria

WFCC/MIRCEN – World Federation of Culture Collections /UNESCO Microbiological Resource Network

WSIB – Workplace Safety and Insurance Board (Ontario)

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1 Executive Summary

Security and safety precautions enacted worldwide since the attack on the World Trade Center have highlighted the value of having strong Canadian-based Secure Biological Resource Centres (SBRCs) so that anti-bioterror researchers and other scientists working in the national interest retain access to materials needed for their studies. SBRCs house valuable bacterial, viral, and other microbial strains and specimens. They also perform complex identifications, work with DNA, antigens and other microbial components, and do consultation, education and research on microbial matters. Safe backup deposit is provided as a service for economically important strains utilized by industry. Though in the past Canadian science and medicine have relied on US-based SBRC's for many types of materials and tests, this has become increasingly, often prohibitively difficult due to factors such as the U.S. Select Agent program, stringent import regulations, and very high costs for the requested biomaterials, special packaging and special shipping. Moreover, absence of expert supervision in some major U.S.-based SBRCs means the effort and cost yields a significant proportion of incorrectly identified materials. Existing Canadian SBRCs are vigorous and generally supervised by top-level experts, but are mostly small, dispersed, and poorly funded – or at best itinerantly and unreliably funded by trend-driven academic granting councils. Many if not most face extinction over the next 10 years due to staff retirements and changing trends in university and governmental administration. Those not fitting this pattern are mostly inadequately staffed and are not reliably able to send materials to researchers requesting them. Governments throughout Europe (including the UK) and in Japan have funded or co-funded state-of-the-art SBRC networks and/or centralized SBRCs, many of which have attained the high quality standards needed for membership in the Organization for Economic Cooperation and Development's planned Global Biological Resource Centre Network. However, repeated attempts in the last two decades to effect similar modernization or at least a degree of stabilization in Canada's SBRCs have been unsuccessful, and the number of SBRCs has strongly declined. The current prospectus probably represents Canada's last chance to forge a viable, international-standard SBRC network before its constituent elements are permanently lost or rendered ineffectual.

This feasibility study outlines cost-effective ways to build a strong Canadian SBRC network taking advantage of the Canada-wide distribution of still-vital existing facilities. The network is proposed as a joint venture involving a new federal government initiative, the National Centres for Secure Biological Resources (NCSBR) and existing university and governmental host facilities. A governance structure is proposed based mainly on European models but modified to fit the Canadian situation. It features establishment of a small NCSBR network coordinating office and the engagement of NCSBR-funded quality control/quality assurance staff at seven geographically dispersed "core SBRCs." The chief scientist of each core SBRC will be funded by the host institution, as per current practice, and the host institution will also provide basic facilities and amenities. Each core SBRC will safeguard a particular socioeconomically vital group of organisms, e.g.,

one will specialize in medically important viruses, one in medical bacteria, one in agriculturally important viruses, and so on. Most core SBRCs will also link to smaller and more specialized "affiliate SBRCs," which will not draw human resources directly from the NCSBR budget but, as with the core SBRCs, will be eligible to effect quality improvements and other upgrading tasks based on successful application to an NCSBR-managed Strategic Fund. Though this network can be constituted within the federal system as one of various types of secretariat structures or as a Schedule II crown agency, the recommended primary option for consideration is an independent secretariat, analogous to the CBRN Research and Technology Initiative (CRTI), reporting to Parliament through a designated Minister. The ability of SBRCs to carry on the highly cost-effective practice of cost-recovery, charging requestors for materials shipped out, is a significant consideration in determining the optimal governance structure. As with much science and technology, several ministry areas are equally relevant to this project: Health, Agriculture, Industry, Environment, Natural Resources and Defence. The reporting Minister should ideally represent the Ministry most strongly disposed to champion the safeguarding and improvement of Canada's ability to conduct effective, innovative research involving disease-causing, industrially valuable, and ecologically vital microorganisms.

2 Background

2.1 Overview

In the last two decades, science in Canada has made a steady transition from the post-Sputnik era of Cold War abundance to the lean, mean era of global high-technology trade. During that time, especially with the rise of genome sequencing, the importance of Secure Biological Resource Centres (SBRCs)[1], including culture collections, living and frozen specimen collections, and associated gene banks, has been increasingly recognized (Fetch *et al*. 2003; Sigler 2004).

SBRCs have now become living gene libraries in addition to being strain collections, natural chemistry storehouses, and bulwarks against bioterrorism and emergent epidemics. They supply cutting-edge technology with stable cultures and DNA. In addition, with the emergence of new human, agricultural and forest diseases, they have become vital repositories for cultures that can be used in production of diagnostic tests and vaccines, as well as in testing of drugs and pesticides. An equally important but less conspicuous function is that they supply biological science with an essential credibility factor, "scientific reproducibility," defined as the ability to repeat the same experiment in a different time and place and get essentially the same results. This is vital to science: it distinguishes true science from non-science by ensuring information is rooted in reality. SBRCs also have vital roles in research, teaching and organism identification. A schematic overview of the major scientific functions of SBRCs is given in Fig. 1.

[1] **Definitions:** This nomenclature follows the international definition of BRCs: "BRCs contain collections of culturable organisms (e.g. micro-organisms…), replicable parts of these (e.g. genomes, plasmids, viruses, cDNAs), viable but not yet culturable organisms …, as well as databases containing molecular, physiological and structural information relevant to these collections and related bioinformatics." (OECD, 2007) The added "S" for "Secure" in SBRC indicates not only the long term organism preservation required of a microbiological collection, but also the use of practices and facilities consistent with modern international biosecurity (e.g., assurance that dangerous materials remain only in appropriate hands) and biosafety (e.g., assurance that dangerous materials are safely handled in facilities that comply with current biosafety standards).

Fig. 1 Major scientific roles fulfilled by SBRCs (from Sigler 2004).

Critically, however, the position of these SBRCs as parts of the research infrastructure in Canada has remained in the Sputnik era, and is rapidly being eroded by retirements. For still-surviving SBRCs, existing support systems are derelict. Ongoing handling of university-associated SBRCs under unreliable 2- to 5-year support systems better designed for individual research projects tends to destroy the incentive to build long-term SBRCs. Government-based SBRCs are often very poorly funded auxiliaries to departments primarily doing other business. **While Canadian SBRC resources are being whittled away, the dramatic effect of the destruction of the World Trade Centre has meant that it has become difficult or impossible for Canadian researchers doing essential research on dangerous pathogens to obtain test cultures from U.S. or other foreign sources.** For this and numerous other reasons, the piecemeal collapse of Canadian microbial SBRCs is deeply disadvantageous. The present report investigates the feasibility of re-integrating these SBRCs, in revitalized form, into contemporary Canadian science infrastructure as a coordinated, distributed network based around a national Centre. Such a network, modelled after the bioresource networks of Europe, Australia and the U.S., would make Canadian SBRCs compatible with the Organization for Economic Cooperation and Development (OECD) in its developing plans for establishing a Global Biological Resource Centre Network (GBRCN) for governmentally accredited Biological Resource Centres. Currently, Canada is one of the few OECD signatory nations not represented in the development of the GBRCN and it

lacks any mechanism for recognizing, certifying, or otherwise systematically managing these nationally and globally significant scientific-industrial resources.

2.2 Attempts in recent years to modernize and stabilize Canada's SBRCs

There have been several attempts since the mid-1980s to address the difficult situation in which Canadian microbial SBRCs have found themselves. Though these efforts have won considerable attention and have had some governmental response, they are generally perceived as unsuccessful. Efforts by stakeholders, including researchers, national and international regulators, the defence department, and experts from industry, medicine and plant protection (Sanderson & Russell, 1988; Stevenson, 1991; Baillargeon et al. 1993, Netolitzky 2003) have repeatedly failed to win the higher-level financial support to implement a consolidated SBRC network.

With the passage of time the situation has become increasingly critical, with more and more SBRCs closing up or moving out of the country. The number of active SBRCs fell from 140 in 1986 to 86 in 1994 (Sigler, 2004). Only 29 registered for a survey conducted by the Public Health Agency of Canada (PHAC) and Agriculture and Agri-Food Canada (AAFC) in 2006 (Bernard et al. 2007), while a national meeting held in connection with the current prospectus disclosed another 8 active or potentially active SBRCs, for an estimated national total of 37-40. A total of 18 Canadian SBRCs are currently registered with the main international body coordinating microbial SBRCs, the World Federation of Culture Collections /UNESCO Microbiological Resource Network (WFCC-MIRCEN) World Data Centre for Microorganisms (http://wdcm.nig.ac.jp/hpcc.html).

Though this is a greater number of SBRCs than, for example, is listed for Germany, the matter of SBRC size and centralization must also be taken into account. No Canadian SBRC in the current database has more than 3 FTE staffing, as compared to approximately 35 FTE for the biggest Dutch SBRC, the Centraalbureau voor Schimmelcultures (CBS), and circa 50 FTE in PhD scientist staff alone at the principal German collection, DSMZ (German Resource Centre for Biological Material). Canadian

endeavours are naturally spread across a wide geographic area, and unlike in Europe and the U.S., no national governmental effort has yet been made to provide a focus. Since Canadian SBRCs have arisen from local efforts and have never been coordinated in any way, the coverage of organisms in Canadian SBRCs is very strong in some groups, e.g., some medically important bacterial and fungal groups, and very weak or nonexistent in others, e.g., environmental bacteria.

This situation that gives special poignancy to Canada's brave but threadbare national SBRC infrastructure is that the importation of biological materials from other countries has become steadily more difficult over recent decades. In the 1990's, regulations about the import and shipping of all types of disease agents became radically more stringent, and this process of security escalation continues to this day. American and many other foreign SBRCs raised prices by up to 400%, moving the acquisition of more than a very small number of microbial research cultures out of the economic range of most Canadian researchers. Increasingly elevated shipping costs for specialized courier services, regulated special safety packaging and permits must be added on top of that, and extensive time delays must also be accommodated. Finally, the U.S. Patriot Act and the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 gave rise to the Select Agent Program that made potential bioterror agents essentially unavailable from U.S. sources. Any nation wishing to do research so that it can defend itself against bioterror organisms now requires reliable suppliers *within* the same jurisdiction.

2.3 Nature of the current structure and condition of SBRCs in Canada

The major Canadian SBRCs are listed in Table 1. Only institutions that regularly supply materials on request to other institutions are listed. Note that "fully professional shipping" (Table 1) refers to a level of response typical of professional collections: shipping is on-demand where not inappropriate, not favour-based, not contingent on diverting staff from their normal duties, and is combined with possibility of cost recovery. It goes well beyond supplying materials selectively or only when time permits.

Table 1. SBRCs in Canada

Host	Full Name	Principal Holdings	Staffing	On-line Database	Fully professional shipping (On-demand where appropriate, not favour-based; combined with possibility of cost recovery)	Other major service functions (except informational question-answering)
National Microbiology Laboratory, Winnipeg, Public Health Agency of Canada (PHAC)	Culture Collection of Special Bacteriology Section	Medically important bacteria and closely related bacteria, 4,500	0.1 FTE	No	No	International Depository Agency for patent purposes (where not technically inconvenient), identification service
National Microbiology Laboratory (PHAC)	Enteric Disease Program	Medically important bacteria of the human digestive system, over 30,000	<1 FTE for SBRC itself	No	No	strain identification (phage typing)
National Microbiology Laboratory (PHAC)	Viral Exanthemata Biorepository	Viral lines, 34	2.5 FTE	No	No	Identification service
Agriculture and Agri-Food Canada (AAFC)	LRC Microbial Collection	Bacteria, 5,000 Fungi 600	1.0 FTE	No	Yes	Identification for research purposes
Agriculture and Agri-Food Canada (AAFC)	Canadian Collection of Fungal Cultures	Fungi, agricultural, environmental, 14,000	2.0 FTE	Yes	Yes	Identification service
Agriculture and Agri-Food Canada (AAFC)	LRC Entomo-pathogenic Collection	Fungi, 280	FTE Unknown	No	No	Identification and consultation

Table 1. SBRCs in Canada

Host	Full Name	Principal Holdings	Staffing	On-line Database	Fully professional shipping (On-demand where appropriate, not favour-based; combined with possibility of cost recovery)	Other major service functions (except informational question-answering)
Agriculture and Agri-Food Canada (AAFC)	Cereal Research Center: Smuts and Ergots	Fungi, 800	0.1 FTE Research 0.1 FTE Technical support	No	Yes, "within reason"	Identification
Agriculture and Agri-Food Canada (AAFC)	Canadian Plant Virus Collection	Plant viruses, 450	2.0 FTE	No	Yes, to researchers and other collections	None
Agriculture and Agri-Food Canada (AAFC)	WRS Fungal Collection	Fungi, 1,000 Bacteria 50	0.1 FTE Technical	No	Yes, to researchers upon request	None
Agriculture and Agri-Food Canada (AAFC)	Cereal Stem Rust	Fungi (*Puccinia graminis*), 268	0.1 FTE Technical	No	Yes, negotiable	None
Agriculture and Agri-Food Canada (AAFC)	Wheat Leaf Rust	Fungi, 400	0.1 FTE Curator, 0.1 FTE Technical	No	Yes, negotiable	None
Agriculture and Agri-Food Canada (AAFC)	Biocontrol of Weeds Collection	Fungi, 700	0.1 FTE Curator, 0.1 FTE Technical	No	No	None

Table 1. SBRCs in Canada

Host	Full Name	Principal Holdings	Staffing	On-line Database	Fully professional shipping (On-demand where appropriate, not favour-based; combined with possibility of cost recovery)	Other major service functions (except informational question-answering)
Université Laval	Felix d'Hérelle Reference Center for Bacterial Viruses	Phage-virus infected (or infectable) bacterial lines, 381	1.0 FTE	Yes	Yes	Phage identification
Université Laval	CEF mycorrhizal fungi	Symbiotic fungi and bacteria important in forestry, c. 400	No data	Yes	Yes	None
Université Laval	CEF plant pathogenic fungi	Fungal tree pathogens and wood destroyers, c. 525	No data	Yes	Yes	None
Université Laval	ARBOREA cDNA and EST Libraries	Cloned gene libraries in bacterial vectors, 12 (several thousand strains, exact number not stated)	No data	Yes	Yes for “small requests of up to 50 stabs”	None
National Research Council of Canada	Biotechnology Research Institute	No data	No data	No	Yes	Industrial research collaboration
University of Toronto	University of Toronto Culture Collection of Algae and Cyanobacteria	Algae and Cyanobacteria, 485	0.8 FTE	Yes	Yes	Limited identification service

Table 1. SBRCs in Canada

Host	Full Name	Principal Holdings	Staffing	On-line Database	Fully professional shipping (On-demand where appropriate, not favour-based; combined with possibility of cost recovery)	Other major service functions (except informational question-answering)
University of Alberta, Devonian Botanical Garden	University of Alberta Microfungus Collection and Herbarium	Medically important and environmental fungi 10,300	2.6 FTE	Yes	Yes	Identification service, environmental consulting, paid on-site training, safe deposit
Natural Resources Canada	Northern Forestry Centre Culture Collection	Bacteria, 200; Fungi, 2,400;	0.1 FTE Curator, 0.1 FTE Technical	No	Yes	Identification
Natural Resources Canada	Fredericton Stock Culture Collection	Fungi, 225	0.1 FTE Curator	No	Yes	None
Canadian Food Inspection Agency	Charlottetown Lab Collection of Bacterial Strains	Bacteria, 800	0.1 FTE Curator, 0.1 FTE Technical	No	No	None
Forintek Canada Corp.	Culture Collection of Wood-Inhabiting Fungi	Fungi, 2,525	0.2 FTE Curator, 0.4 FTE Technical	No	Yes	None
University of Western Ontario	Yeast Collection UWO	Fungi, 5,300	1.0 FTE Curator	No	Yes, to industry	Consultation and training
University of Alberta	*Azotobacter* Collection	Bacteria, 100	No data	No	Yes	None

Table 1. SBRCs in Canada

Host	Full Name	Principal Holdings	Staffing	On-line Database	Fully professional shipping (On-demand where appropriate, not favour-based; combined with possibility of cost recovery)	Other major service functions (except informational question-answering)
University of Guelph	Ciliate Culture Collection	Protozoa, 20	0.2 FTE Technical, 0.3 FTE Technical	No	Yes	None
Dalhousie University	*Clostridium perfringens* and *Clostridium difficile*	Bacteria, 600	No data	No	Yes	None
University of British Columbia	North East Pacific Culture Collection	Algae, 242; Cyanobacteria, 7	1.0 FTE Curator	Yes	Yes	None
Institute of Parasitology	ATCC/HRY *Plasmodium falciparum*	Protozoa, 12	No data	No	No	None

The Canadian SBRCs of today are an array of moderate to small facilities that nonetheless collectively constitute a substantial national resource. However, all but a few are now within the final 10 years of their projected existence, based on planned retirements and known successorship and long-term funding plans. A brief review of some key national SBRCs follows.

Medically important bacteria and viruses are handled mainly by the National Microbiology Laboratory (NML), Winnipeg, with some high-risk pathogens also in the repository of the Chemical Biological Defence Section, Defense Research and Development Canada (DRDC), Suffield. The NML, which is part of PHAC is accredited as Canada's International Depository Agency for patent-related depositions, but in fact is not generally able to fulfill this role except for a few groups of organisms technically compatible with existing collections. All fungal patent depositions, for example, must be placed in foreign countries. The viral, bacterial and prion SBRCs working in loose association at NML are not constituted as a professional SBRC, generally defined as an SBRC that has full-time staff dedicated to receiving, preserving and shipping cultures or analogous specimen materials, and that has at least a partial online catalogue of its available materials. Though cultures and specimens can be sent out to Canadian researchers at appropriate facilities, legitimate requests may well be declined simply due to lack of staff time. For example, a recent request by Prof. James Scott of the Dept. of Public Health Sciences, University of Toronto for four cultures of low-hazard bacteria in the *Mycobacterium abscessus* complex in connection with an Ontario Workplace Safety and Insurance Board (WSIB)-funded research grant were declined for this reason. Having also exhausted other avenues, Prof. Scott has found that he must obtain these cultures from outside Canada at extremely high cost.

Some other long-important bacterial SBRCs in Canada are red-listed. The *Salmonella* Genetic Stock Centre at University of Calgary has come to end of its proprietor's academic career cycle and is likely to move to the U.S.A. The Janet A. Robertson Collection of *Ureaplasma urealyticum* Cultures (Univ. Alberta) can be declared an 'orphan collection'; the managing investigator has been retired for some time and there is

no indication that the SBRC will be re-activated. Both of these collections contain strains highly important to medical science.

Medically important fungi are mainly handled by the internationally well known University of Alberta Microfungus Collection and Herbarium (UAMH), Edmonton, which also handles important environmental and industrial fungi. The Principal Investigator (chief scientist or, in older terminology not used in this case, curator) is likely to retire within three years. Despite considerable effort, she has not succeeded in having a successorship plan implemented. The SBRC, despite being institutionally connected to the University of Alberta, is somewhat anomalously situated in a small botanical garden well outside of Edmonton. Essentially unconnected to the core business of the facility, it is an obvious "sitting duck" for any administrative rationalizer who may gain authority in the future.

The situation of the University of Toronto Culture Collection of Algae and Cyanobacteria (UTCC, containing organisms important for the study of water quality, with cyanobacteria in particular causing water to become poisonous) is similar to that of the UAMH fungal collection described above. The associated chief scientist is near retirement, and no definite plan for perpetuation of the facility exists. Both the UAMH and the UTCC have been supported in recent years by Natural Sciences and Engineering Research Council of Canada (NSERC)'s Major Facilities Access Program, recently renamed the Major Resources Support Program, which supports a small number of key pieces of science infrastructure based on an application cycle of 3 to 5 years. This unreliable and very limited funding pot is the closest current Canadian approximation of stable funding for core SBRCs.

(Understanding the situation of SBRCs at universities requires the following background information: the streamlining of academia due to funding cuts and increasingly competitive, business-like management in the last two decades has caused all academic science departments to focus sharply on a small number of high-reward areas. Science has become as intensively trend-driven as, for example, the fashion industry or the music business (Smaglik, 2004). Though academic departments universally recognize SBRCs

as critically important, they also increasingly take the view that these relatively stable and partially service-oriented facilities should be someone else's responsibility. There are, of course, few university-based takers so modestly competitive as to wish to be that "someone else" – except, critically, where substantial outside funding is available to sweeten the deal. Funding from academic research councils is hardly suitable, since it is by nature intermittent and subject to trend-driven whim. A repository of living organisms can no more be cyclically funded than can a family be fed one week and not the next.)

The one Canadian university centre where SBRCs have relatively high priority is Université Laval. The Félix d'Hérelle Reference Center for Bacterial Viruses, though listing NSERC as major supporter, had a new chief scientist/ curator appointed in 2003, indicative of university support. Three forestry-related SBRCs at U. Laval have also benefited from a conducive academic climate, and in particular the fallout from the Coulombe Commission Report on the future of forestry in Québec (http://www.commission-foret.qc.ca/rapportfinal.htm), where a shift was recommended from older forest management methods to ecosystem-based approaches. These SBRCs, linked together as the collections of the large multi-university network called Centre for Forest Research (Centre d'Étude de la Forêt), are managed by mid-career researchers and provided with network funding from the FQRNT (Fonds québécois de la recherche sur la nature et les technologies). The actual SBRCs situated at Laval are relatively small, highly specialized niche repositories. Their relatively strong support level may reflect priorities given to these niches, but in addition, it may reflect a general trend in Québec to provincial establishment of bioscience infrastructure. Provincial funding for SBRCs is all but unknown outside Québec and none was disclosed in the recent PHAC/AAFC survey of collections. In fact, consistent with Prime Minister Harper's recent announcement about Québec within Canada, the impetus for the SBRC investment made by the Québec government can be correctly classified as national in nature.

A major grouping of SBRCs containing fungi important in agriculture, the environment, forestry and industry resides in the federal ministries AAFC and Natural Resources Canada (NRCan). The largest AAFC collection, the Canadian Collection of Fungal Cultures (CCFC) is relatively well supported for day-to-day operation, but is heavily

stressed by the need to integrate valuable orphan collections from elsewhere in the Canadian SBRC network (including other Government of Canada collections) and by a byzantine procedure needed to recover the costs of shipping cultures to researchers outside the federal system. The 9 existing AAFC collections all provide only limited shipping to outside researchers; none functions as a professional SBRC as defined above. All AAFC respondents in a recent survey of SBRCs reported concern over inadequate staffing or facilities, and some reported concern about ongoing support in general. Of the two NRCan SBRCs, one, the Fredericton Stock Culture Collection (wood-decaying fungi), has no budget and no continuity plans for a retirement less than 5 years away, while the other, the Northern Forestry Centre Culture Collection, enjoys a modest support level.

The situation with miscellaneous smaller SBRCs across Canada is consistent with the scenarios outlined above. In short, all major Canadian SBRCs, and most smaller SBRCs except a few specialty facilities in Québec, are imperilled, or compromised in their ability to supply Canadian researchers with needed cultures, or both.

An additional problem is that biosafety standards set by regulators such as PHAC's Office of Laboratory Security have become increasingly stringent in recent years, and many Canadian SBRCs handling biosafety risk group 2 and 3 organisms range require significant modification of facilities to allow them to continue doing their work. This need will become particularly acute if, as is now being discussed at PHAC, standards applied to laboratories importing cultures are applied for purely domestic work.

2.4 Current Canadian SBRC condition in the global context: a missing piece of the industrial world

2.4.1 National needs

Canada's good international relations, relatively open borders, extended geography and high standard of economics expertise have all contributed to the rational, non-nationalistic sentiment that not every type of institution and technical specialty needs to be replicated here. It is acutely symbolic that the well known Canadian efforts in space

science consist mainly of an arm attached to an American spacecraft. There is no question that the status of Canada's SBRCs has been strongly influenced by the conjecture that Canada's bioscience infrastructure can also consist of an "arm," and that SBRCs perhaps need not be part of that arm. The American Type Culture Collection (ATCC; Manassas, VA) with its 70,000+ microbial strains, 8000 animal cell lines and 8 million cloned genes has been one of the traditional suppliers of Canadian science and medicine. Moreover, with modern transportation and financial systems it is no more difficult to obtain strains from the German DSMZ or the Japanese NITE repositories than it is to obtain them from south of the border. International patent agreements mean that isolates critical to Canadian industry could be safeguarded in other countries; in various other ways, it would seem that many Canadian biological endeavours requiring SBRC participation could be safely and efficiently integrated into international cooperation schemes.

In fact, however, such cosy international dependencies have long had their drawbacks and, in recent decades, have led to acute and chronic problems. Some of these were mentioned above in section 2.2. Receiving biological materials from other countries has become steadily more difficult in Canada since the 1970s. Firstly, nations as well as the shipping industry have become much more stringent about what can be moved from place to place and how it can be done. Canada, like most nations, has justly become rigorous about importation of human, animal and plant disease agents, and this has led to a need for permits for all living materials transferred across borders. In Canada, any imported organism that might be a human pathogen needs a permit from PHAC's Office of Laboratory Security while any that might be of agricultural significance, whether to plants or animals, requires a permit from the Canadian Food Inspection Agency (CFIA). Since there is strong overlap between human and animal pathogens (and, in fungi, between human and plant pathogens), this means that many imports must be double-permitted. Also, organisms with no disease significance require documentation substantiating this status. Nothing is safe without the paperwork to prove it. Organisms of unknown disease significance or identity pose a constant conundrum; for example, Dr. Kathy Bernard of NML has had considerable difficulty importing isolates from the U.S.

Centres for Disease Control and Prevention that are as yet scientifically undescribed bacterial species (pers. comment).

Shipping of etiologic agents has also become increasingly difficult, as International Airline Transport Association (IATA) specifications for packaging and labelling become more exacting and the courier companies willing to handle the shipments becoming rarer and more expensive. This in itself is understandable, but as the world discovered during the Y2K situation, even realistic speculations about relatively minor hazards can grow to enormous proportions if unchecked by comparison with actual events. There are now a large number of organisms that are routinely isolated from normal air, tap water and room surfaces and yet are classified as risk group 2 pathogens because they can cause secondary disease in rare types of highly immunocompromised, severely ill patients. Thus, reference and standard quality-control strains may be difficult and expensive to ship and, especially, to import, even though equally "dangerous" wild strains could be isolated in any house.

This situation is far from unique to Canada, and the regulations involved can by no means simply be dismissed. The frustration of scientists is tempered by the knowledge that regulatory authorities are doing an extremely conscientious and thorough job of preventing mishaps that, while very unlikely to occur, are not impossible. The crux of the matter is that, although the very ill persons vulnerable to the various risk group 2 'tabletop moulds' and 'kitchen sink bacteria' are scarcely likely to be working in a shipping job, flying in a commercial airliner, etc., in the first place, let alone having dangerous contact with the organisms in a shipping accident or as the result of an importation, such possibilities cannot be absolutely excluded. Personal medical information is considered private, and employees cannot ethically be forced to disclose their non-contagious health status. Therefore, from the labour risk management point of view, any airline or shipping employee could be highly immunocompromised. So could any air traveler. Rare and bizarre accidents happen every day and nothing can be ruled out as unrealistic. These ethical and logical viewpoints have radical consequences. For example, though the fungus *Aspergillus fumigatus* can be isolated from any indoor or outdoor airspace worldwide in sufficient quantity to cause rapid death to a highly

immunosuppressed bone-marrow transplant patient, importing a reference culture from the ATCC into Canada requires not only the permits and special etiologic-agent shipping mentioned above, but also, the inspection and, if deemed necessary, refitting or reconstruction of the importing laboratory to ensure it meets current PHAC biosafety containment level 2 criteria (recent experience of Prof. James Scott, pers. comm.). A laboratory lacking specialized equipment such as a type II biological safety cabinet cannot import this fungus even though any laboratory or high-school science fair participant could readily isolate it from a dust swab taken from any bookshelf, at least during the warmer months. This sort of "grade inflation" of hazard levels, where anything that could remotely cause harm becomes a nemesis in international shipping, is firmly entrenched in modern life worldwide. It obstructs border passage of a large proportion of microbial biology.

IATA shipping requirements and specialty courier costs apply within Canada as well as in flights across its borders, but beyond that, most of the difficulty and expense of dealing with etiologic agents is avoided if these agents are already legitimately present within Canada. It is extremely beneficial and cost-effective when Canadian researchers are able to obtain such organisms within the country. Canadian SBRCs make this possible. Their role in the future is likely to become ever more critical to persons attempting to do research on the diagnosis, treatment and prevention of microbial diseases in humans, animals and plants.

The Select Agent Program, mentioned in Section 2.2, is the most recent and most severe blockage to Canadian researchers who depend on imported cultures. Arranging the transfer of designated select agents is extraordinarily difficult, and most often simply impractical. Yet these very agents may be the most critical organisms to do research on. For example, attempts by Dr. Bill Kournikakis of DRDC to obtain a specialized anthrax-related strain from friendly long-time scientific collaborators at the US Army Medical Research Institute for Infectious Diseases (USAMRIID) ran into such profound obstruction from Select Agent Program authorities that he was eventually forced to do abandon the effort and laboriously construct his own parallel cell line within Canada (pers. comm.). Does the U.S. government intend to hinder Canada in developing its

defences against anthrax? Absolutely not. Yet, this is a logical outcome of its bioterrorism control measures. Several incidents similar to that experienced by Dr. Kournikakis provided considerable impetus to funding of the present feasibility study by CRTI (CBRN Research and Technology Initiative = Chemical, Biological, Radiological and Nuclear Research and Technology Initiative). Canada has to be able to defend itself against bioterror. Nationally based SBRCs are critical to Canada's biological self-defence efforts; however, this role entails that they need facilities, policies and procedures suitable for the handling of the highly dangerous organisms involved.

International SBRCs may also fall short of expected Canadian quality standards and be prohibitively expensive. The ATCC in particular has largely lacked scientific level control of its isolate identification and is a famous repository of misidentified cultures. For example, the disease-causing strain ATCC 48753 was identified and deposited by K.J. Kwon-Chung as *Acremonium strictum* in 1983, probably because the species that it truly represents, *Phialemonium curvatum*, was only described that year. It was later sequenced (GenBank sequence AY138486) but the record associated with the characteristic *P. curvatum* sequence is labelled *A. strictum* and the isolate is listed under a number other than its ATCC number. This information, then, is inaccessible to ATCC and is known only to some insiders like the present author, but the incorrect identification in the collection would have been corrected automatically in the course of any expert microscopic quality control assessment done in the last 23 years. There has not, however, been a fungal expert associated with ATCC in that time period qualified to do such an examination. This is radically different from the situation in European, Canadian and Japanese SBRCs, where expert scientific staff typically manage and curate the holdings. The base price of the misidentified isolate is USD $210, whereas ordering the equivalent correctly identified *P. curvatum* culture from the Canadian UAMH collection would cost CDN $75 for industry, but only $35 for non-profit agencies such as universities.

In practice, though researchers needing very small numbers of isolates for model-organism studies or standard quality assurance procedures can order from ATCC, and though there is often one specially low-priced Preceptrol® strain per economically

important species, it would not normally be feasible for Canadian researchers engaged in a survey study (e.g., antibiotic susceptibility study, fungicide testing, enzyme production study, biotyping/identification study) or a biosystematic study to order the necessary 20+ isolates from ATCC. The ATCC in practice serves a limited and specialized role of supplying materials to particular kinds of scientific and industrial studies using very restricted numbers of isolates. For Canadian research, indigenous SBRCs are the standard source of documented isolates for multi-isolate studies as well as for many studies requiring lower numbers of isolates. The loss of these isolate sources as Canadian SBRCs close up or become increasingly economically constrained will have very wide-ranging effects on the economics and capabilities of Canadian microbiological research.

2.4.2 International obligations and opportunities

Since 2000, the Organization for Economic Cooperation and Development (OECD; 30 member countries, with Canada as a founding member) has had a Task Force on Biological Resource Centres, in partnership with the EU project that founded the European Biological Resource Centres Network (EBRCN) linking the major European SBRCs. The mission of this task force is to extend and develop, on a global scale, the best-practice and credibility standards for SBRCs that were established by earlier European projects such as the Common Access to Biological Resources and Information (CABRI) network. A Global Biological Resource Centre Network (GBRCN) is envisaged that will coordinate and raise the standards of major SBRCs worldwide. Originally the Task Force considered erecting a stringent certification standard for SBRCs admitted to the GBRCN, but that goal has recently been revised in favour of a more “open and inclusive” approach (OECD, 2007). The task force has put forward several key documents such as Biological Resource Centres: underpinning the future of life sciences and biotechnology (2001), Review of the current status, activities and future of existing Biological Resource Centres (2001), and Guidance for the operation of Biological Research [*sic*] Centres (BRCs) (2004).

Although Canadian federal government representatives are involved in the OECD Working Party on Biotechnology that oversees the Task Force on BRCs, no Canadian

SBRC has been involved in any way in the planning of the GBRCN. SBRCs from Europe, the U.S., South Africa, Asia and South America make up the membership list of this club. At present, it looks very much as if a global network of SBRCs may be set up without Canadian representation of any kind, effectively excluding Canada as a serious player in the global SBRC network. Joining this network is not just a matter of indicating interest; it also requires a serious commitment to bringing an SBRC up to international quality standards such as the ISO standards relevant to laboratory operation (e.g. ISO 17025). Such upgrading requires considerable money and staff time and is well beyond the reach of most current Canadian SBRCs.

3 The proposed agency's program

3.1 Mission statement

The National Centres for Secure Biological Resources is a Canada-wide institutional network dedicated to: the secure and safe preservation of vital microbiological resources; the provision of these resources to Canadian and international science, medicine and industry; and the provision of related research data, online information, education, analytical services, administrative regulatory assistance and biosecurity management.

3.2 Overview of activities: the first 5 years

3.2.1 Securing funding – practical prior considerations

The present document is a prospectus intended as a framework to facilitate the preparation of more formal documents within the Government of Canada. Proposing a new structure under the auspices of the Canadian government is never easy, but it is particularly difficult when the proposed organization overlaps in its technical domain with multiple federal ministries and agencies. Canadian SBRCs serve the interests of the following ministerial interest areas at a nearly equal level of importance: Health, Agriculture, Defence, Industry, Environment and Natural Resources. The interest areas of certain specific agencies such as PHAC and CFIA are also strongly addressed. In addition, there is significant resonance with Public Safety, Fisheries and Northern Affairs.

In Europe, SBRCs tend to be funded by Ministries of Science or by Education ministries handling all scientific matters. France, for example, has a Ministry of National Education, Advanced Instruction, and Research which co-funds, with the Health Ministry, the Pasteur Institute, holder of the country's major SBRCs. The Dutch SBRCs obtain their base budget from the Ministry of Education. Canadian ministries, many of which are organized to manage lines of economic activity, have diverse claims on a function that serves so many different economic interests. One object of the present exercise is to avoid the proposal of an administrative "sitting duck" that would attempt to

find shelter in a particular ministry but that would have too much Health, Industry, Environment, etc., content to be stably supported on the Agriculture budget, too much Agriculture, etc., to be stably supported on the Health budget, and so on. This problem of the splintering of science and technology among many different ministries is generally solved by proposing an arm's length body such as a Crown Agency or a Secretariat reporting to Parliament through a designated Minister. For example, the Natural Sciences and Engineering Research Council (NSERC), a Schedule II crown agency, refers to itself as "a separate employer of the Government of Canada, reporting to Parliament through the Minister of Industry." The CRTI is a Secretariat "led by DND/DRDC on behalf of the [federal Science and Technology] community" (CRTI, 2002). Coming closer to a single-ministry enterprise, the recently constituted Agricultural Bioproducts Innovation Program (ABIP) is an office (officially referred to as a Secretariat) run by AAFC, but it has a steering committee including other Ministries and the university sector in order to provide an administration with a broad-ranging perspective. It receives $ 14.5M of its $ 82.5M in federal research funding from ministries other than AAFC.

Securing funding for the NCSBR depends on finding the correct form and ministerial linkage to make it a viable adjunct of the Government of Canada. One complication is that SBRCs are normally partially self-funding, since it is both sensible and administratively efficient to charge fees to those who request biological materials or related services. European SBRCs typically gain 10–30% of their annual budgets through cost recoveries based on sales of cultures and books, identification and industrial consulting services, safe deposit service for company-owned isolates, and so on. The topic of cost recovery within the Government of Canada and its Crown Corporations is very complex, but it is very clear that in much of the federal government, efficient, normal cost recovery is scarcely or not at all possible at this time. Though SBRCs could in theory eliminate this type of activity, in practice it is so natural and salutary to the growth and maintenance of the institutes that no economist would recommend cessation.

In summary, it would be optimal to architect a funding structure that allows cost recovery by an organization that serves the ends of multiple Ministries without being awkwardly over-dependent on one arbitrarily chosen Ministry. The solutions proposed here should

inform, but not limit, considerations made in later stages of this architecting of an SBRC network and centre.

The architecting of the general outline of an SBRC centre and network, combined with the determination of the optimal funding and administrative structure linking it to the Government of Canada constitutes phase I of the development of the NCSBR.

3.2.2 The Centre: Network head office

A proposed administrative structure for the NCSBR is shown in Fig. 2. This diagram shows a centralized administrative structure coordinating a group of core SBRCs as well as their associated smaller affiliate SBRCs. The central office has a staffing plan based in part on the model working successfully at the Belgian Coordinated Collections of Microorganisms (BCCM) and consisting of a scientific director, a network technical manager, a business officer with two admin support staff, and an IT staff member. Responsibilities for these positions are outlined in section 4.1 below. The network head office is expected to be an administrative space, yet it optimally it should also incorporate laboratory space allowing the scientific director to remain an active researcher. This type of ongoing research is useful for prestige and credibility with scientists as well as for maintenance of a very sharp perspective on trends and necessities in the always changing fields related to microbiology. Thus, it is recommended that the head office should be in an area with at least one major university suitable for academic cross-appointment. Also, as a network centre, it should ideally be near a major airport readily accessed from all over Canada at relatively reasonable prices. Close association with a core SBRC is a possibility that should be considered.

Setting up this central coordinating structure, exclusive of its IT component, is phase II of NCSBR development.

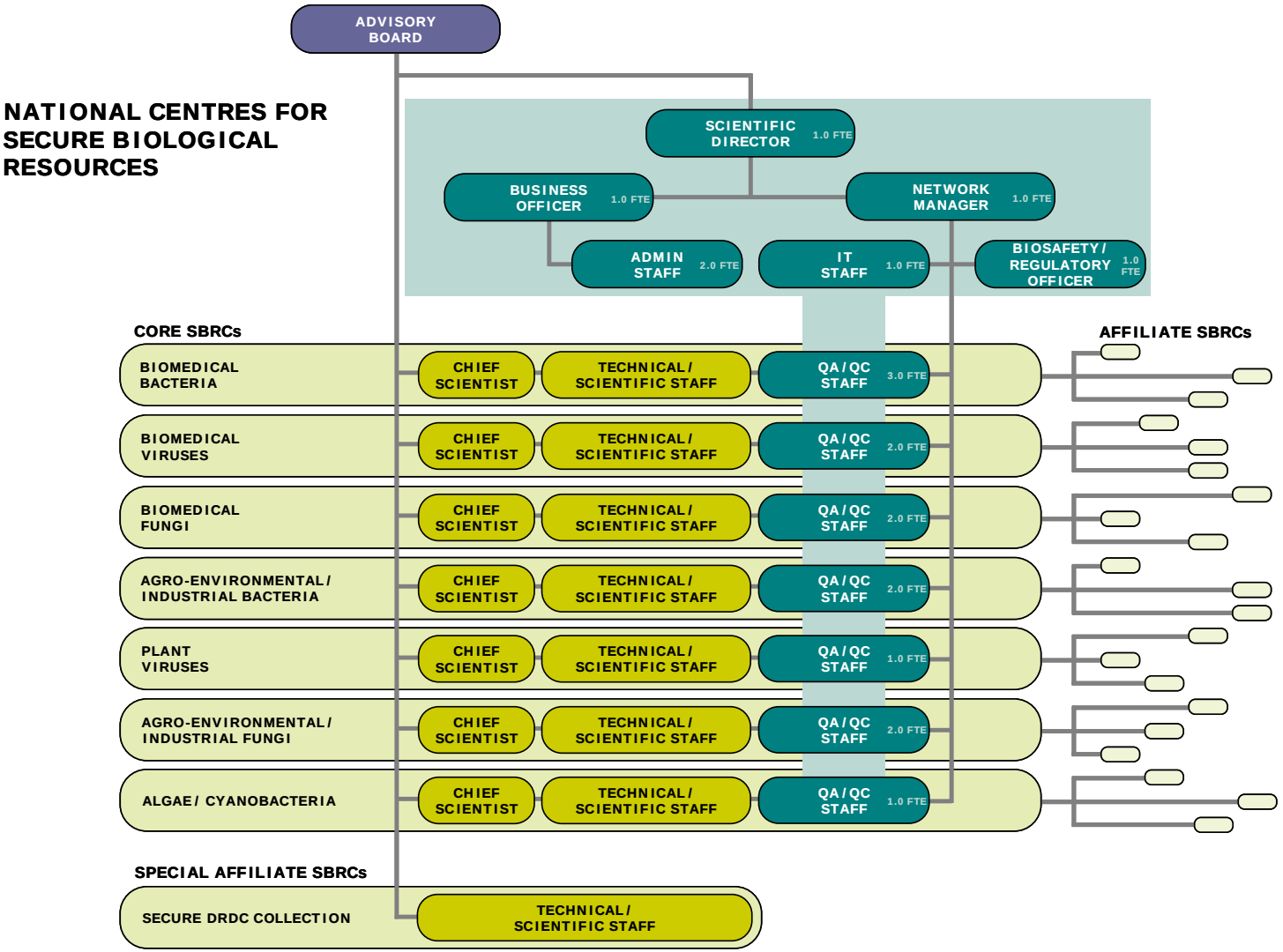


Fig. 2. Proposed model for National Centres for Secure Biological Resources (NCSBR). Positions funded by federal government as part of NCSBR (blue-green). Positions funded by host institute, research grant support, etc., (yellow-green).

3.2.3 Selecting and strengthening the core SBRCs

Fig. 2 shows the centralized administrative structure, outlined above, coordinating a group of core SBRCs as well as their associated smaller affiliate SBRCs. Significant investment (details, see section 5) is recommended in the limited group of core SBRCs representing essential elements of microbiology: biomedical bacteria, biomedical viruses, biomedical fungi, agro-environmental/industrial bacteria, plant viruses, agro-environmental/industrial fungi, and algae/cyanobacteria. The core areas represent the core areas of strength of key current Canadian SBRCs, excepting a recognized area of deficiency in environmental bacteria. Nonetheless, the SBRCs are not named, for reasons stated below. There is an additional SBRC linked to the network, the DRDC SBRC, which because of its high security level is treated separately. It can, however, be integrated with the network shown in some ways, e.g., via a common holdings database with varying levels of security clearance.

Fig. 2 shows not just the structure but also the human resources financing of the proposed organization, with staff funded by the NCSBR in blue-green and staff funded by host institutions (government departments, universities) in yellow-green. More details are given below.

What is important to note from the beginning is that the participation of host institutes in providing staff, space, facilities, general insurance coverage, general computer systems support, etc., to core SBRCs requires a renewal of commitment in at least some cases. It seems prudent for the NCSBR not simply to designate existing SBRCs, many of which have uncertain institutional commitment over a 5- to 10-year period, as core facilities, but instead to accept official applications for core SBRC status signed or co-signed by host institutions. Valid applications would need to demonstrate ongoing institutional commitment to a minimal contribution: salary/benefits of the chief scientist (= curator), adequate space, basic supplies and services given to other scientific facilities at the institute, and either additional technical staff or a conducive environment to support such staff through competitive grants. Demonstration of the institutional will to co-support a core SBRC would be an important criterion for admission to the core group.

Apart from that, it is clear that criteria for acceptance as a core SBRC must be tailored to accommodate the knowledge that few Canadian SBRCs have had the resources or institutional support in recent decades to attain, for example, European standards of collection size, quality control/assurance procedure, online information display, networking to global biological information initiatives, reliable and rapid shipping, state-of-the-art preservation, and so on. Some building is needed in Canada. Criteria cannot be overly stringent. Items to be taken into consideration in applications to serve as the core SBRC in one of the areas specified should be:

- possession of substantial and scientifically interesting holdings of unique organisms and/or their nucleic acids, proteomes, etc., or the possession of a valuable set of genetic stock cultures (e.g., transformed isolates bearing cloned gene inserts);
- number and diversity (biosystematic, ecological, geographic) of cultures/specimens;
- possession of a significant proportion of holdings particularly relevant to Canada, especially in SBRCs holding organism groups for which geographic specificity is highly relevant (e.g., arctic environmental bacterial, wood-decaying fungi);
- proportion of cultures/specimens identified at a high morphological/phenotypic (where applicable) or preferably molecular standard;
- an active accession policy (active uptake of important new isolates/specimens);
- availability of a data-entered catalogue, with public portion preferably already online;
- well-ordered documentation system encompassing SBRC holdings, associated specimens (e.g., herbarium specimens, tissue specimens), specimen locations,

accession information, photos and other descriptive information, shipping requests and fulfillment of these requests, etc.;

- track record of rapid and reliable shipping to external institutes based on the principle of providing materials to as many appropriate requisitioners as is practicable (i.e., not just favoured collaborators or other arbitrarily hand-picked recipients);

- appropriate facilities with reasonable security and biosafety standards for the organisms involved, suitable for upgrade to full modern standards without entirely de novo construction being done (unless it is at host institutional expense);

- where appropriate to the organisms involved, modern cryopreservation (lyophilization, liquid nitrogen) and DNA banking (- 80 freezer, dry DNA banking systems) facilities or at least space suitable for installation of such facilities;

- internationally recognized status as an SBRC as indicated by international citation of isolates/specimens under the SBRC's accession numbers, international publications mentioning the SBRC as an important resource or collaborative partner, etc.;

- possession of important type materials, important industrial isolates, isolates frequently used as identification or process standards, standard infraspecific biotype strains (e.g., phage types, mating types, vegetative compatibility standards, significant sequence variants), model organism isolates, wholly or partially genome-sequenced isolates, isolates that have been subjects of multiple or noteworthy publications, voucher isolates for important ecological or biodiversity works, and other scientifically 'distinguished' isolates or specimens;

- listing in the WFCC/MIRCEN list of world microbial SBRCs;

- distinguished track record of published research directly related to the SBRC's holdings by the SBRC's chief scientist(s) and affiliated students, postdoctoral fellows, technologists, scientific guests;

- existence and credible documentation of standard operating procedures, biosafety procedures, quality control and assurance procedures, regulatory compliance (e.g., WHMIS compliance), with preference given to facilities demonstrably working towards or attaining relevant ISO or equivalent international standards;

- track record of education in the area of biology served by the SBRC;

- provision of valuable services, e.g, identification, typing, industrial analysis, or industrial safe deposit, in reference to the organisms in the SBRC; and,

- establishment of an existing functional cost recovery mechanism.

It is, of course, possible for an existing SBRC to apply to fill more than one of the core facility niches.

Laboratory standards for higher biosafety containment levels have been upgraded since most existing SBRC facilities were constructed, and in the authors' recent site visits, we saw or were told of facilities that fell short of the latest, most stringent standards for imported cultures, particularly in regard to handling of risk group 3 organisms. Part of the process of strengthening the selected core collections is the upgrading of facilities to current standards relevant to international interchange of the types of organisms handled by the SBRC. A facility undertaking the role of a core SBRC must be fit to function for a number of upcoming years without being encumbered by insufficient investment in necessary facilities. CFIA is currently considering upgraded standards for the handling of agricultural pathogens, so the need for state-of-the-art facilities applies to all types of SBRCs, not just those handling medical organisms.

Selecting the core SBRCs for the network and evaluating their facilities vis-à-vis the containment level required for the organisms handled is phase III of the proposed plan.

A second component of strengthening the core SBRCs lies in the placement of NCSBR quality assurance/quality control (QA/QC) technical staff in the collections. These staff are dedicated to give the core facilities the extra technical support needed to adapt to upgraded facilities and upgrade practices to ISO 9000 or near-equivalent standards of practice. In addition, they can assist with the integration of orphan collections, maintaining and routinely extending the network database and in general giving the core SBRCs sufficient additional technical assistance to achieve world standards of SBRC performance.

Phase IV of NCSBR development consists of engagement of these QA/QC staff and the development of primary consensus QA/QC standards suitable for implementation, with the necessary technical changes being made, at all core SBRCs. See section 3.2.7 for additional details.

3.2.4 Supporting and training affiliate SBRCs

Canada has a moderate but important number of small, highly specialized SBRCs that would be difficult to integrate into core SBRCs for the following reasons:

- unique techniques and materials needed to maintain the repositories would be very challenging to integrate into a broader collection. (e.g. need to maintain specialized archaebacteria under exacting gas and chemical conditions, need to maintain arbuscular symbiotic fungi on host plant roots); and,

- the SBRCs may have been initiated by a research group expert on the organisms in question, and the SBRC may be best positioned for efficient exploitation and proficient oversight if it stays with that group.

Some of these specialized SBRCs may be relatively stable beyond the tenure of a single researcher, especially SBRCs sponsored by governmental departments or by the major research networks of Québec. Others may be under threat of becoming “orphaned” if their chief scientists retire, or if departmental priorities are reorganized, or if academic network funding moves on to newer trends. In cases where materials of highly significant ongoing scientific value to the greater research community are concerned,

rescue efforts may be needed. Still other small and specialized SBRCs may be viable, but they may contain materials that would be more efficiently and economically dealt with by being integrated into a core SBRC. Those that are self-standing may lack the staffing to integrate complex quality control procedures in a timely manner, or they may lack the funding to upgrade facilities to the latest regulatory specifications. Efficient shipping also always a challenge for small facilities, partly due to time constraints and partly due to regulatory complexity. The structure proposed here is designed to minimize the effects of these problems and gain the maximal value for Canada and its regions from the initiatives that have generated the various specialized SBRCs.

It is proposed that affiliated SBRCs should be brought into association with the NCSBR through any of the following mechanisms:

- show of interest in becoming a core SBRC in cases where core status cannot be granted;
- separate application to become an affiliated SBRC; and,
- strategic NCSBR invitation.

Since microbial collections range from well ordered SBRCs to ill-maintained depositions of individuals' research materials in rudimentary storage, stringent vetting would need to be done to determine which SBRCs or would-be SBRCs could productively be taken on as affiliates of the NCSBR. The criteria for recognition of plausible affiliate SBRCs are identical to those given above for core SBRCs except that an affiliate SBRC is expected to be smaller in scale than a core SBRC, both in relation to numbers of cultures/specimens held and in relation to the diversity of materials held. In particular, the majority of viable affiliate SBRCs should address a particular microbiological niche that is not handled at all, or cannot be handled at suitable scale, at one of the core SBRCs. Planned long-term affiliate SBRCs should have minimal overlap with any of the core SBRCs. There is also, however, a viable option for linking to SBRCs partially overlapping in scope with core SBRCs. Such SBRCs, usually initiated by active researchers or research consortia, can be connected to the NCSBR as affiliate SBRCs

with the expectation that in the future, if their local support is threatened, their content might be incorporated into the most closely related core SBRC. It would be advantageous to have these moderate-lifespan, strategic research SBRCs already integrated into the NCSBR information systems, maintaining compatible quality standards, etc., during the lifetime of their initial research development groups, so that the valuable materials drawn together by these projects can then seamlessly merge with a core SBRC later in the academic cycle. Core SBRC QA/QC personnel could train staff at these satellite SBRCs to adhere to the overall standards of the NCSBR.

A key idea illustrated in Fig. 2 is that affiliate SBRCs are not to be linked to the general governance structure as affiliates of the NCSBR as a whole, but rather as affiliates of the most closely compatible core SBRC. In this way, any issues specific to the groups of organisms and scientific disciplines involved can be closely coordinated, and there is a clear path for affiliate SBRCs that are ultimately to be merged with the core.

Affiliate SBRCs would obtain not only the advantages of integrating into the NCSBR information and quality control systems, but also the right to participate in application for funding from the proposed Strategic Fund, detailed below in section 5.2.

Phase V of the NCSBR is the selection of affiliate SBRCs and development of mutually beneficial links with them. This phase includes also the special affiliate in section 3.2.5.

3.2.5 The DRDC Special Affiliate SBRC

One element of the proposed NCSBR is different enough in nature from the others that it is proposed for special status. The repository of the Chemical Biological Defence Section, DRDC, Suffield, works at an unusually high security level dealing with pathogens related to biowarfare and bioterrorism. Though some of the same pathogens are also dealt with in other secure facilities, this SBRC is a military-supported institution that is expected to fund its own specially security-cleared staff. What would link the DRDC Special Affiliate SBRC with the NCSBR is:

- common participation in information systems network, with DRDC likely taking a lead role in network design and extension (based on its existing system, see details in section 3.2.6);

- DRDC would be an equal partner in discussions of quality standards, methodologies, security, biosafety, etc.; and,

- eligibility of DRDC to apply to the proposed Strategic Fund.

Specific issues related to the DRDC Special Affiliate SBRC, in particular its relation to the information systems, are dealt with in relevant sections below.

3.2.6 Building and maintaining a secure, state-of-the-art information system for the NCSBR

One of the key advantages of networking SBRCs is that this greatly increases the potential power of information technology (IT) to assemble and display information related to the holdings. Internally, within the SBRC network, this gives the advantage of a combined database that allows all members of the network to know what is available at all individual SBRCs (at least at appropriate security levels, as detailed below). Similarly, it allows the central office to coordinate opportunities, inquiries, orders, etc. It also relieves each individual SBRC of the need to constantly redesign and renew its own individual database, which often has scope and powers limited by insufficient funding and time.

However, the most important advantages of a combined IT network system are external. One of the major projects of world governments in the last decade has been to get as much as possible of the non-confidential scientific data they have paid for (via university granting systems as well as government departmental budgets) out into the open so that maximal benefit can be derived from it. Information about SBRC holdings has been very high on the agenda, since it relates to many opportunities and responsibilities: most notably, new possibilities for industrial usage of strains, new scientific directions and ventures, and documentation of world biodiversity. The last has been a particularly high

priority for industrial nations as they have tried to manage problems related to biodiversity maintenance, ecological best practices, global warming, climate change, and habitat destruction. The European nations as well as some other industrial nations have strongly sponsored the Global Biodiversity Information Facility (GBIF) linking data from world SBRCs, herbaria, zoological research institutes, etc. A combined SBRC database is 'a natural' for linking to GBIF, particularly if the system is designed in advance to do so; in fact, some European governments have made this linkage of SBRC databases to GBIF and related networks a top priority. For example, the Dutch government (via the NWO – Netherlands Organization for Scientific Research) has funded the improvement and uploading of SBRC, herbarium and zoological databases to GBIF systems under its NWO-Groot (NWO large-scale) granting program, which only funds a very limited number of national top priority scientific investments per 3-year period.

In addition to mobilizing data into coordinated global projects such as GBIF and national projects, most major world SBRCs now make very large amounts of information public: for example, the Dutch SBRC Centraalbureau voor Schimmelcultures (CBS, combining the Fungal Biodiversity Centre and the National Culture Collection of Bacteria) has a diverse, massive website where browsers can obtain culture information, use online identification systems, find and compare DNA sequences, read the online academic journal *Studies in Mycology* at no cost, consult a variety of technical databases and documents, and read numerous scanned historical books. Maximal public benefit is derived from the information available at this facility. In addition, CBS cooperates with the UK's SBRC network in coordinating a world list of fungal names (Index Fungorum) and a world database of information about newly described organisms (Mycobank), two tools of immense scientific utility. Meanwhile, its database is linked to a number of coordinated world database services, such as the CABRI unified database for all major European SBRCs and the WFCC-MIRCEN database for SBRCs worldwide.

No Canadian SBRC has done anything remotely parallel, though the University of Alberta Microfungus Collection (UAMH) can be mentioned as having posted a highly useful interactive online database and considerable related information. However, Canadian SBRCs, if they can be networked, are poised to make a very strong entry into

this arena. In 2004, DRDC commissioned IT professional Sarah Cassady to design a system suitable for its own SBRC and also easily extendable to other networking SBRCs. Though the core of this system was designed to record the accession information, storage locations, and security conditions of stocks and specimens, the system also provides a secure online ordering system, a bar code system for labeling specimens, and "strain datasheets" that can record and display extensive scientific information about strains and specimens, including various kinds of data and expandable photographs and other relevant graphics. The same system can also be extended indefinitely with new modules and functions so that it can encompass all the special tools (e.g., organism identification tools, sequence comparisons), website management functions and other special features provided by the systems used at the European SBRCs.

There are alternatives available to the DRDC system, but our preliminary recommendation is to extend it to the NCSBR network.

The trajectory for introducing an IT network for the NCSBR can only be preliminarily sketched. The very strong advice of IT professionals consulted for the present document was: first, have a professional 'needs analysis' done. It will be necessary to determine how many core SBRCs are accepted, how many affiliate SBRCs, what the current condition of their databases is and how much more additional information needs to be incorporated into the system, as well as all relevant security stipulations, and internal needs (e.g., barcode labeling or not). At that point, a systems architecture can be designed to match the system needs, and recommendations can be made about how much of the needed work should be done as a one-time consulting project, how much by the IT staff at the network office, and how much by ongoing consulting or offsite application service providers.

A critical component of the online databasing system is security. In fact, however, IT systems professionals are fully prepared to meet the security needs of all the SBRCs, including those of the DRDC group. The health data security field within IT already possesses well designed systems with graded security access, authentication and accreditation for persons with log-on privileges to various security levels, secure

messaging, and extensive related security protocols. In any case, all SBRCs since the beginning of computer databasing have always had a split between public and secure SBRC information; for example, many strains and specimens are placed into the SBRC in the context of ongoing research by an important donor or by the SBRC's own chief scientist, but are not set out on the internet as generally available. Data are released to the public sector when the relevant scientific publications are in press or when a given time limit has passed. Also, incompletely identified strains/specimens may be stored but not released into the public database. Integrating this type of system with the types of high security used for military data or personal health data requires no technical or organizational novelty, but rather merely an application of existing, well-worked procedures. Exact details would again come from consultation with IT professionals competent in matters of privacy and security.

Completion of an IT needs analysis and design of an architecture would be a logical phase VI in construction of the network.

3.2.7 Quality management: Attaining and maintaining international standards

It is not the purpose of the present document to detail quality standards related to SBRCs. In general, however, what can be said about quality standards is similar to what was said in section 2.4.1 about international shipping: requirements in this area have become increasingly stringent and complex over the course of the last 20 years. The long-standing idea that procedures should be controlled and devices calibrated and checked to ensure proper performance has been supplemented with the idea that all of these checks should be regularly recorded. For example, it is not enough to disinfect a bacteriological transfer cabinet at the end of the working day; the information that this has been done must also be recorded, along with the identification of the person carrying out the procedure, and these records must be kept for a stated period of time. Upgrading from traditional high quality common-sense laboratory practice to an ISO 9000 standard or an American Good Laboratory Practices (GLP) standard requires highly significant staff time as well as training and constant updating.

SBRCs worldwide are upgrading quality control procedures to levels at or near the ISO 9000 standard. Indeed, this upgrading is fundamental to the OECD's global GBRCN network development, as well as to the inclusion criteria for top-level SBRC networks such as the European CABRI network. The documented high standards demanded by ISO and similar bodies go along with the provision of highly reliable materials, as well as safe and secure handling and the assurance that work was done in a safe workplace. The single most important, sine-qua-non component of the NCSBR is the provision to core SBRCs of a sufficient number of QA/QC-trained technical staff to ensure that:

- the upgrading of procedures to international quality standards can be assured, and the relevant documents (records, standard operating procedures, manuals, molecular and other laboratory protocols, etc.) can be kept current at an acceptable standard or better;
- the regular technical work of the SBRC can be kept at a high standard with excellent timeliness;
- the SBRC database can be maintained in a timely state of data entry;
- the national and international shipping and border/customs expertise of the SBRC can be maintained in an up-to-the-minute condition;
- affiliate collection staff can be trained at reasonable depth and with reasonable regularity; and,
- small incoming orphan collections or other major deposits of important isolates/specimens can be incorporated where necessary.

The main human resources outlay envisioned in the structure in Fig. 2 is the expenditure for these essential QA/QC staff. The aim of this prospectus is to raise Canadian SBRCs to the world level, and this staffing plan is a key component in allowing this. Staff employed, for example, by host universities on soft funding such as NSERC grants will never prove adequate to accomplish such a task, which requires persistence and the long-term ability to accumulate expertise and proficiency. The network manager at the central

network office will serve as an expert coordinator of the QA/QC staff, though they will each report administratively to the chief scientist of the SBRC where they work. Thus, as is necessary in QA/QC, all responsible staff at the various SBRCs, including trainees at affiliate collections, will work at or, at the beginning, towards a common set of standards. QA/QC staff at individual SBRCs can serve as highly qualified information sources both within the network and worldwide with respect to how these standards can be applied and adapted to the exact types of strains or specimens handled at the SBRCs. Indeed, they may well serve on international committees developing QA/QC standards, as may the network manager. One outcome of this participation may be the adoption of strains from the Canadian SBRCs as standard quality control strains in procedures used nationwide, continent-wide, or worldwide. Apart from being highly prestigious for SBRCs, this can also add appreciably to the budget as multiple orders for these QA/QC strains are received.

The implementation of network-wide QA/QC was mentioned above in section 3.2.3. as phase IV of NCSBR development, but this preliminary implementation would to be followed up by ongoing additional development.

3.2.8 Designing security, access, and management protocols

One major advantage of linking Canadian SBRCs is that this structure facilitates design of common national and institutional security protocols related to:

- staff accreditation for access to materials of different hazard levels and biosecurity significance;
- evaluation of appropriateness of requests from external laboratories, researchers and companies, e.g., in relation to possession of suitable facilities for safe handling, as well as absence of connection to problems related to national security breach, bioterror, nuisance, charlatanism, and other illegal or clearly inappropriate usages of cultures or specimens;

- physical design of facilities to allow safe and secure storage and manipulation of SBRC materials, e.g., design of locking cabinets, safe liquid nitrogen facilities including air nitrogen level alarms, fireproofing, entry doors, etc.

- duplication of materials for backup in case of natural disaster, vandalism, etc.; and,

- insurance conditions.

This type of coordination is a major strength of other government-sponsored SBRC networks. For example the United Kingdom National Culture Collection (UKNCC) uses a common registration form to evaluate new clients who wish to obtain cultures and also lays down conditions for receipt of hazardous cultures (http://www.ukncc.co.uk/html/Databases/Strain%20Info.htm). The procedures have been meticulously designed to coordinate with all applicable domestic UK legislation and licensing procedures as well as relevant international treaties and agreements. Developing and streamlining such legally sophisticated procedures is something best done by a coordinating central body, one cognizant of all relevant biosafety and security factors, but also of the need for science and industry to proceed without being hampered by excessive regulation.

In discussion with the authorities responsible for issuing permits to import pathogenic organisms into Canada, namely PHAC for biomedical pathogens and CFIA for agricultural organisms, we were told at a stakeholder's meeting by Kerry Holmes of CFIA that PHAC's Office of Laboratory Security and CFIA could envision an SBRC network "acting as a central hub, like a regulatory affairs position, to aid your clients who are importers with the regulatory process and try to simply the permit process for them." She noted that "Another thing that we could do and (that) we do all the time with distributors, for example, is in conjunction with our two agencies [CFIA and PHAC], we can work in advance to certify your facilities prior to importation or prior to distribution." This means that with suitable development and consultation with CFIA and PHAC, the NCSBR could become a central point streamlining the importation of difficult organisms and re-distributing them to Canadian clients under Canadian regulations. A precedent

has already been set by a few Canadian laboratory supply distributor companies who redistribute heavily used ATCC quality control isolates in Canada under license from ATCC (and subject to processing ATCC Materials Transfer Agreements [MTAs] with recipients) and under permit from PHAC and, where applicable, CFIA. These companies, however, only redistribute a very small number of very heavily used QC isolates, whereas NCSBR could deal with a broader scope of isolates from a variety of foreign sources, including strains issued under an MTA from countries protecting their rights under the Convention on Biological Diversity (CBD; popularly known as the Rio Convention).

In addition, should Canada in future seriously consider protecting its own CBD rights for indigenous microbes (something not done at present), the NCSBR could be a leader in developing procedures for linking exported microbial materials with appropriate regulatory and licensing procedures, as well as the principal body administering these procedures.

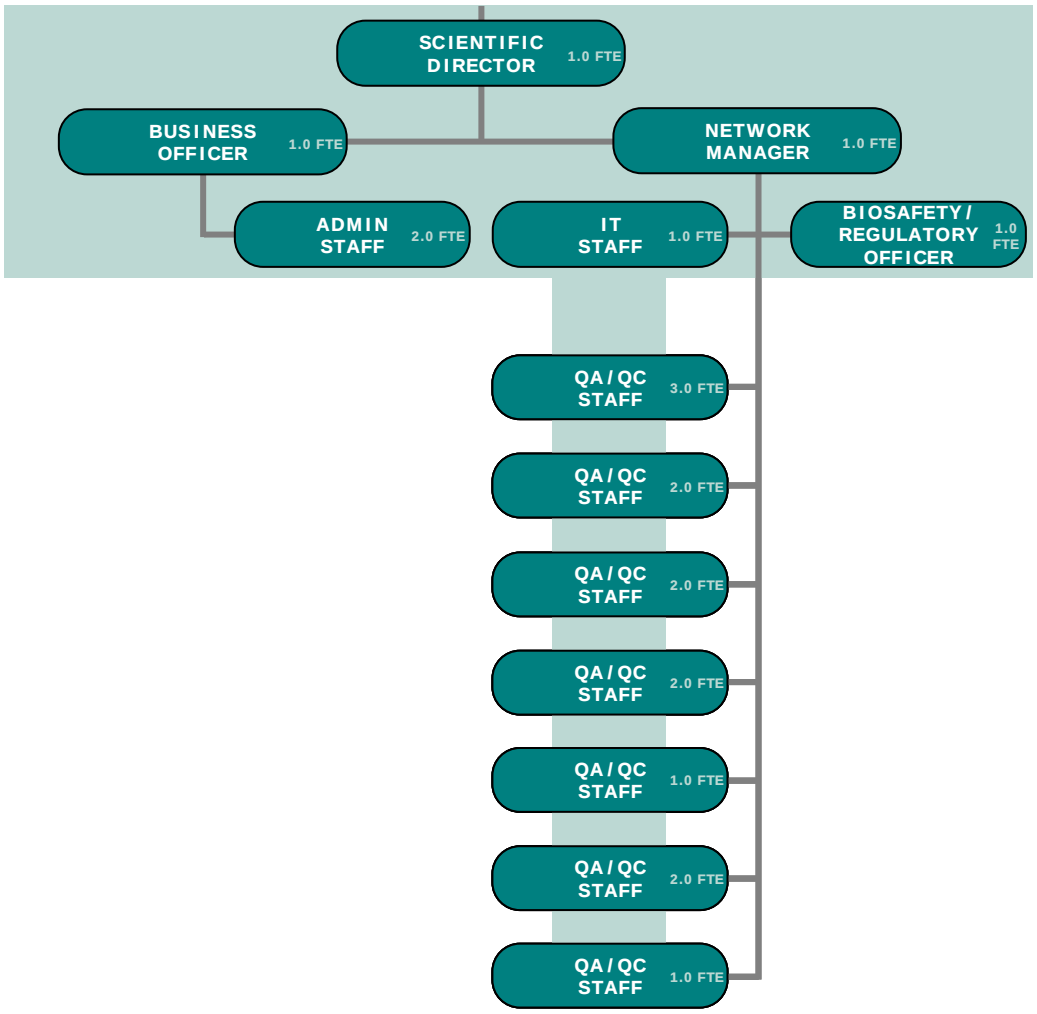
The timing of these security initiatives at the NCSBR would be contingent on the perceived adequacy, at least for the short term, of the procedures and facilities already in place for protecting sensitive materials and information at the selected core SBRCs. On the assumption that no core SBRC coming into the system would be catastrophically ill-prepared to handle and protect the organisms already within its system, a review of these matters can best be done after phases I through VI above are done, but prior to the upgrading of infrastructure as outlined in section 5.1, below. This review, then, is phase VII of the project.

4 Management of the NCSBR

4.1 Structure of organization

The management structure of the organization is shown in Fig. 3, which is Fig. 2 stripped of the components primarily financially supported by other organizations. A model from which this proposed structure has been modified to suit the Canadian academic, governmental and regulatory situation can be seen by comparing the Belgian SBRC network BCCM (http://bccm.belspo.be/about/consortium/structure_organisation.php; further details at http://bccm.belspo.be/about/coordination.php).

Fig. 3. Management model of NCSBR



4.1.1 Chief Administrator, 1.0 FTE

The chief administrator of the NCSBR as conceived here is the Scientific Director. This individual would ideally be an active biological researcher, but could also be a pure administrator as is the case in the Belgian system. The advantages of having an active researcher in the position are outlined in section 3.2.2 above. The chief administrative responsibilities of the Scientific Director are the:

- operating plan;
- strategic objectives;
- organizational structure and allocation of managerial responsibilities;
- leadership and co-ordination;
- review and approval of major projects; and,
- national and international representation.

4.1.2 Business Officer, 1.0 FTE

The business officer serves as a chief financial officer, responsible for:

- financial programs;
- ensuring compliance with federal budgetary reporting requirements;
- revenue, expenditures;
- financial reporting, internal audit; and,
- advising on strategic cost recovery.

4.1.3 Administrative Staff, 2.0 FTE

Under the supervision of the business officer serve two clerical and secretarial staff whose primary responsibilities are:

- office administration;
- bookkeeping;
- network communications;
- meeting and travel organization; and,
- secretarial assistance with publications and grant applications, regulatory paperwork, etc.

4.1.4 Network Manager, 1.0 FTE

The Network Manager is conceived of as a general manager and quality systems expert responsible for the coordination of QA/QC staff in the core SBRCs, as well as administering the NCSBR's mandate with relation to core and affiliate SBRCs. Primary duties are:

- manage day-to-day network operation;
- developing and auditing technical standards;
- participation in national and international bodies developing technical standards, administering certification or proficiency, etc.;
- coordinating IT needs; and,
- strategic cost recovery sourcing.

The last function relates to extensive networking with the industrial, academic and government sectors to ensure that the materials and services offered by the NCSBR are utilized to their full advantage, and to determine if there are unmet needs that the NCSBR could address on a cost-recovery basis.

4.1.5 Information Technology Staff, 1.0 FTE

This staff position, penciled into the organization structure pending an IT needs analysis as detailed above in section 3.2.6, is conceived of as a basic IT administrator responsible for:

- day-to-day IT support for SBRCs;
- hardware and general software support for head office;
- website maintenance; and,
- updating and modernizing of software or, in the event of major changes requiring consultant input, advising consultants of NCSBR needs, policies, procedures, etc.

The IT needs analysis should specify which individual on NCSBR staff is in the best position to manage the security aspects of database access, including acting as a user certification authority, controller of password access, etc. This function could also be managed by a contracted security firm outside the NCSBR. Note that it is assumed that the DRDC facility linked to the NCSBR as a special affiliate SBRC would have complete, independent administrative control over security access to its SBRC materials. The NCSBR IT staff person, however, may be a logical candidate to administer IT security functions for the non-military SBRCs in the network.

4.1.6 Biosafety/ Regulatory Officer, 1.0 FTE

This staff position is responsible for:

- ensuring all NCSBR components remain up to date with biosafety regulations and procedures related to infrastructure, operating procedures, and organism shipping and handling;
- ensuring that NCSBR components are up-to-date and in compliance with all regulations related to genetically modified organisms (GMOs);

- administering International Depository Authority regulations on behalf of NCSBR components;
- serve as designated contact person for CFIA and PHAC regulators; and,
- participate in development of national and international regulatory standards.

4.1.7 Core SBRC QA/QC staff, 13.0 FTE

The intended function of these staff has already been broadly outlined in section 3.2.7 above.

These staff, allotted to various SBRCs according to the size and workload of the biological resource repository, have the following duties:

- day-to-day QA/QC in SBRCs;
- general technical, customer relations and shipping work in support of high performance standards at the SBRCs;
- technical standardization (standard operating procedures [SOPs], manuals, protocols, etc.);
- database management; and,
- training of affiliate SBRC staff in NCSBR QA/QC standards and procedures.

4.2 Advisory board

The NCSBR is envisioned as having a broadly based advisory board, meeting once or twice per year to advise on present strengths/weaknesses and future directions. It may include:

- representatives of sponsoring federal Ministries;
- representatives from industry;

- representatives from academia (biomedical, environmental, agricultural, biotechnological); and,

- representatives of regulatory agencies involved with pathogenic organisms, inclusive of CFIA and PHAC.

4.3 Funding

4.3.1 Federal contribution and links with alternative governance structures

Funding for the NCSBR is the key problem addressed in this document. One relevant matter that is very clear, if comparison is made with viable, research-enabling SBRCs in other countries, is that national governmental support is critical for this category of ongoing infrastructure. European and Japanese SBRCs are at their current level of strength, quality and stability as a direct result of this support, as mentioned in section 3.2.1 above. The American ATCC, which has had diminished governmental support since the Reagan administration, has had to respond by adopting a pricing structure friendly to routine QA/QC (e.g., via supply of standard control strains) but hostile to research. The effect has been that most American researchers now obtain key materials from foreign SBRCs, while the holdings of the ATCC, shielded from most research activity, decline in value as minimal attention is paid to them over multiple years. For example, the American Fungal Tree of Life (AFTOL; http://www.aftol.org/) project, while funded by a very large U.S. National Science Foundation (NSF) grant, obtained most of its living culture research materials from the Dutch SBRC, CBS. (No reference for this assertion can yet be cited, but for example, if one searches on the name of J. Spatafora, AFTOL principal investigator for ascomycetous fungi, in GenBank gene sequence records, one finds records for 106 ATCC strain numbers and 514 CBS strain numbers, even though the two SBRCs involved have equivalent numbers of relevant holdings.) Thus, though it may be thought that the ATCC's inhibitory pricing structure for research materials is adapted to the general American post-Reagan-era policy of giving a very high proportion of scientific funding to a very small number of perceived

top-scientific applicants, in fact even the chosen few who obtain the high funding levels are driven to European SBRCs for research programs requiring multiple strains. Canada has a clear choice of either squeezing research in the same way as U.S. infrastructure does, or joining the Europeans in the possession of viable, research-friendly SBRCs.

As mentioned above, the number of federal Canadian ministry areas with a stake in SBRCs and their biomaterials is high: again, health, industry, environment, natural resources, agriculture, and defense are the major players. Extensive consultation with officials from the relevant Ministries as well as representatives of federal Agencies with a stake in this matter has yielded a number of high-quality recommendations about how to place the NCSBR in terms of federal core funding. The first of these recommendations is to present a range of potentially highly appropriate options rather than staking the future of Canada's SBRCs to a single recommended structure, vulnerable to any perceived deficiency. Therefore, three options are presented below.

4.3.1.1 Option 1 – Secretariat structure

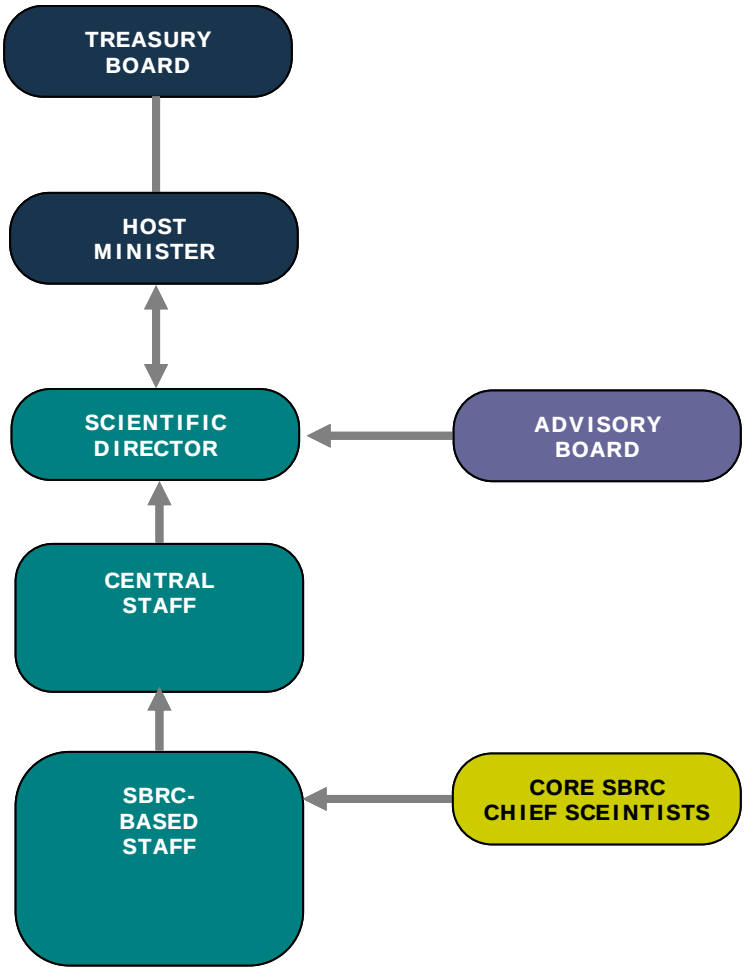
Option 1 is modelled on a number of existing Secretariats within the Canadian government. The term Secretariat is very broadly used, but in this case we are referring to a structure similar to the CRTI (see section 3.2.1 above), that is, a governmental body or council reporting to Parliament through a federal Minister, but having a budget separate from that of the Ministry involved. This budget is suggested to be allotted on a 5-year basis, as has been done with CRTI, and, like the CRTI's budget to be renewable. Renewal processes in this case may take into consideration the results of objective external review, as outlined below in section 6. A model organizational chart is given in Fig. 4.

Candidate Ministers responsible for the NCSBR are those of Industry, Health and Agriculture. Health and Agriculture are the prime movers of the current project, along with CRTI (representing the Defence interest). On the other hand, NSERC, a Schedule II agency dealing in scientific and industrial research interests much like those pertaining to the NCSBR, reports to Parliament via the minister of Industry. In this case, the interest

levels shown within individual Ministries for the furtherance of the NCSBR may be the best factor to consider in deciding which link to Parliament is chosen.

Secretariats may differ from federal government branches in being sufficiently separate from the government to be allowed to perform efficient, direct cost recovery for services rendered. For example, Natural Resources Canada's National Orphaned/Abandoned Mines Initiative (NOAMI) adds approximately $10,000 per year to its small budget by selling its reports on CD and charging for workshop participation. The ability of such organizations to subsidize their own budgets is very important for SBRCs, as detailed below in section 4.3.2.

Fig. 4. Secretariat model for NCSBR



4.3.1.2 Option 2 – Schedule II Crown Agency

Many federally sponsored bodies responsible for matters related to science, technology and research are constituted as Schedule II agencies, reporting to Parliament through a designated Minister. For example, NSERC, the main academic granting council for academic natural science and engineering is such an agency, reporting via the Minister of Industry. Similarly, the Canadian Centre for Occupational Health and Safety (CCOHS), an agency comparable in scale to the proposed NCSBR, reports to Parliament through the Minister of Labour. A major difference between a Schedule II Agency and a Secretariat is that the former is established by an Act of Parliament and added to the appropriate schedule of the Financial Administration Act. The question of which Minister the Agency should report through is addressed above in Section 4.3.1.1.

In terms of reporting structure, Fig. 4 applies to this option without change. Schedule II agency status is of high interest in connection with the NCSBR if it strongly facilitates cost recovery as outlined in section 4.3.2 below, particularly if it is superior to secretariat status in this regard. Determining this matter, however, requires consultation with government legal services, and this fell outside the scope of the present prospectus.

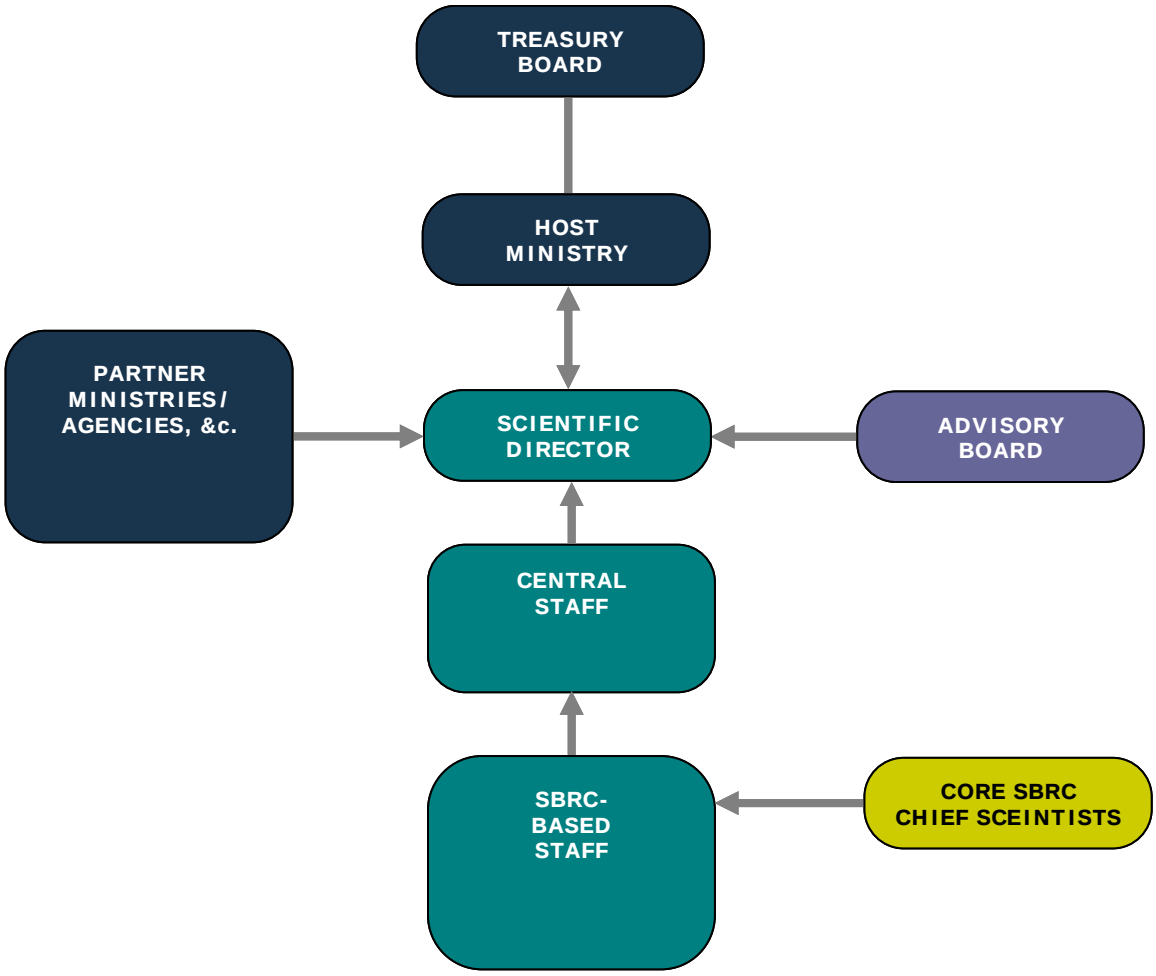
4.3.1.3 Option 3 – alternate Secretariat or Office modelled after the Agricultural Bioproducts Innovation Program (ABIP)

In this type of structure, the Secretariat or Office is integrated into an individual Ministry but is co-funded by other Ministries. As mentioned above, ABIP is integrated into its host Ministry, AAFC, but receives $14.5 of its $82.5 M in research funding from other ministries. Some funding also comes from universities, other publicly funded R&D institutions, and industry. ABIP has a federal budgetary allotment of 5 years, potentially renewable, and can disburse research funds to various government ministries as well as universities, agencies and industry. Its topic area is clearly agricultural, which makes its attachment to that Ministry obvious and conducive to good business. With the NSBRC, as discussed, there is no single Ministry quite so obviously poised to take it on within its structure – it combines the interests of much of the federal Science and Technology

community spread out over a maximal number of Ministries. If, however, a deeply involved Ministry such as Agriculture or Health were to show a profound interest in sponsoring the NSBRC on behalf of the Science and Technology community, then the ABIP model might be highly appropriate.

The relevant management structure is shown in Fig. 5. This is a new type of structure, and to our knowledge there is no precedent for such an internal secretariat being able to do cost recovery for services (section 4.3.2). The status of this important matter is not clear in relation to this type of governance.

Fig. 5. Alternative secretariat/office governance structure modelled after ABIP



4.3.2 Cost recovery

Unlike zoological museums and plant herbaria, which are essentially lending institutions, SBRCs send out material that is not recovered. Moreover, the shipping of living materials is relatively costly and time-consuming. For this reason, all serious, professional SBRCs worldwide have always charged most requestors a fee for sending a strain or other viable specimen. Exceptions may be made for researchers involved in what is normally a two-way exchange over the long term, or for collaborators in research projects involving the SBRC's chief scientist or other scientific staff (including students, postdoctoral fellows and academic exchange guests). The practice of cost-recovering for strains and specimens sent out is very advantageous in increasing the practicality of sending materials out on a non-discriminatory basis to all legitimate requestors, as well as in controlling the overall budget and deterring frivolously large requests. Additional services done for a fee, such as identification, strain typing, serological typing, DNA extraction, safe deposit of industrial strains, industrial process consultation, etc., can also conveniently earn up to 30% of a well-ordered SBRC's annual budget without disrupting core business. In fact, such endeavours assist the core business by ensuring that the SBRC's stay up to date, interactive with the scientific and industrial communities, high in quality, and innovative.

This cost recovery, however, is very difficult to perform in the context of most if not all federal government departments. A governance structure permitting this is therefore strongly recommended, though not obligatory. The structures presented above in section 4.3.1. are selected from models known to allow this or potentially allowing it.

If cost recovery is not to be done, then a 20-30% increase in the governmental base budget should be planned. Budgeting information presented below is based on the presumption that normal SBRC cost recovery mechanisms have remained in place for the core SBRCs of the NCSBR.

5 Program budget

The budget for the program can be broken down into two major components, start-up costs and ongoing costs.

5.1 Start-up costs

Since it is expected that existing SBRC's will be the only serious applicants for the status of core SBRC in the proposed network, start-up costs are divided into two major categories (Table 2):

- Start up cost for the network office, and
- Biosafety upgrading of the core SBRCs to current or anticipated standards.

The costs in Table 2 are given in 2006 dollars since these are firmly known values for the types of work proposed (Stark, 2006). Table 2 is a summary and details of all the expenditures listed are given in the detailed tables referenced in the footnotes. They will be discussed in reference to the detailed tables. As can be seen, however, a major portion of the costs shown are one-time costs for infrastructure, mainly consisting up upgrading SBRCs to comply with biosafety standards.

Details of infrastructure investment are shown in Table 3. The specialized building industry involved in construction of scientific facilities publishes standard estimates of costs of upgrading typical existing laboratory facilities to state-of-the-art compliance with PHAC biosafety containment level 2, 3 and 4 space (Stark, 2006). The costs in Table 3 are for upgrading and not for new construction, as mentioned at the beginning of this section. Some candidate core SBRCs may already possess adequate facilities, particularly the relatively recently constructed NML in Winnipeg, and thus some of the costs shown may not be applicable. In general, however, because biosafety standards are in an ongoing process of becoming more stringent over time, significant upgrading is expected for most selected core SBRCs. Indeed, a major aspect of any project to perpetuate and modernize Canada's SBRCs must be this infrastructural upgrading. A

major threat to many existing SBRCs is that host institutions and academic research granting programs cannot reliably be drawn upon to do this.

Infrastructure costs for the national network centre are based on normal costs of converting leased office space to a functional office. Laboratory renovation for a research-oriented Scientific Director is not included, but could be added if space was not offered by a cross-appointing host institution such as a university.

Costs of initially establishing the IT network, including needs analysis, architecting and other start-up consulting costs as well as hardware and implementation, are included here as infrastructure costs.

Note that it is expected that Defence will continue to take complete fiscal responsibility for infrastructure at its highly secure DRDC collection facilities.

TABLE 2: NETWORK START-UP COSTS (2006 CDN $)

Item	Cost ($)	Total
National Network Center		
Operating **(1)**	1,631,702	
Infrastructure **(2) (3)**	1,715,750	
Strategic fund **(1) (4)**	438,391	
Subtotal	3,785,842	3,785,842
SBRCs		
Infrastructure **(3)**		
Biomedical bacteria	5,348,073	
Biomedical viruses	6,359,413	
Biomedical fungi	2,985,860	
Agro-environmental/industrial bacteria	2,985,860	
Plant viruses	1,210,109	
Agro-environmental/industrial fungi	2,070,838	
Algae/cyanobacteria	1,210,109	
Special Affiliate: Secure DRDC Collection	n/a	
Subtotal	22,170,262	22,170,262
TOTAL		**25,956,104**

Notes:

(1) per annum expense

(2) one-time expense

(3) see Table 3

(4) see Table 8

TABLE 3: INFRASTRUCTURE COSTS (2006 CDN$)

Budget item	Area (m2)	Cost ($/m2) (1)	Subtotal ($)	Total ($)
Biomedical bacteria **(2)**				
Administration	230	1,521	349,786	
CL2 lab space	457	4,917	2,247,202	
CL3 lab space	457	6,020	2,751,085	5,348,073
Biomedical viruses **(2)**				
Administration	230	1,521	349,786	
CL2 lab space	457	4,917	2,247,202	
CL3 lab space	457	6,020	2,751,085	
CL4 lab space	152	6,654	1,011,340	6,359,413
Biomedical fungi				
Administration	230	1,521	349,786	
CL2 lab space	350	4,917	1,721,052	
CL3 lab space	152	6,020	915,022	2,985,860
Agro-environmental/industrial bacteria				
Administration	230	1,521	349,786	
CL2 lab space	350	4,917	1,721,052	
CL3 lab space	152	6,020	915,022	2,985,860
Plant viruses				
Administration	107	1,521	162,727	
CL2 lab space	213	4,917	1,047,383	1,210,109
Agro-environmental/industrial fungi				
Administration	230	1,521	349,786	
CL2 lab space	350	4,917	1,721,052	2,070,838
Algae/cyanobacteria				
Administration	107	1,521	162,727	
CL2 lab space	213	4,917	1,047,383	1,210,109
National network center				
Administration	750	1,521	1,140,750	
I.T. consulting **(3)**			225,000	
I.T. capital costs			350,000	1,715,750
Special affiliate: secure DRDC collection	n/a	n/a	n/a	n/a
TOTAL				**23,886,011**

NOTES:

(1) Stark, Stanley. "Lab rehab costs trend upward along with new construction", Laboratory Design. August 2006.

(2) Medical bacteria and medical virus laboratories are housed together with shared CL4 space.

(3) Sextant Software Inc.

(3) Sextant Software Inc.

5.2 Operating costs

Table 4 shows projected annual operating costs for the federally funded elements of the NCSBR, including operating costs for the national network centre office and personnel costs for both the central office and the network personnel based at the various core SBRCs. Details of the personnel costs with appropriate federal public service classifications are shown in Table 5.

Because a 5-year funding model is proposed for the NCSBR, Table 6 is provided showing estimated operating costs over this period.

As a complement to this outline of federal government costs, estimated in-kind contributions from host institutions, including base costs of providing laboratory space suitable for upgrading, are given in Table 7.

In Table 2, an annual cost figure was given for a Strategic Fund. This is envisioned as an annual funding allotment to be disbursed within the NCSBR system based on project applications from core and affiliate SBRCs. Competitive applications would be prepared by these SBRCs and judged by a panel consisting of the Scientific Director, some or all members of the Advisory Board, and possibly other appropriate governmental or academic representatives (i.e., persons free of conflict of interest), appointed for a 3-year term. Applications might be for extra staffing for incorporation of orphan collections, infrastructural upgrading, special capital equipment beyond that budgeted for on an ongoing basis, stipendia and running costs for single- or multi-year student or postdoctoral projects, appropriate congress or workshop organization, travel to international academic conferences, and other related one-time expenses. The Strategic Fund is envisioned as being contributed to by both federal funds and SBRC cost-recovery, according to a calculation formula designed to keep it up to date with inflation and with the success of SBRCs in obtaining cost recovery income. With the latter, the formula is predicated on the idea that the NCSBR as a whole should positively contribute to the ability of the individual SBRCs to make budgetary contributions based on cost recovery, and therefore the SBRCs can contribute a proportion (10%) of cost-recoveries to the Strategic Fund. As cost recoveries fluctuate over time, so does the amount they

contribute to the Fund. Table 8, then, should be read as a calculation table as is seen in an income tax form, showing the base amounts of federal and cost-recovery contributions to the overall annual operating costs of the SBRCs in the centre column. In the right-hand column, the uppermost figure is equivalent to 10% of the federal contribution to the base budget of the NCSBR, and the calculated amount is then costed as an additional federal contribution to the NCSBR. The lower figure in the right-hand column calculates 10% of an annual cost recovery estimate, which in turn is based on the idea that each SBRC will gain at least 10% of its annual operating budget through cost recovery. The $25,201 in the right-hand column is a Fund contribution subtracted from the estimated $250,201 cost-recovery earnings figure. In summary, then, the federal Strategic Fund contribution is additional to the federal operating cost contribution shown in the middle column, while the SBRC Strategic Fund contribution is extracted from total annual SBRC cost recoveries.

Other means could be envisaged for calculating a floating Strategic Fund that would remain proportional to other financial realities at the NCSBR and in Canada as a whole, but the model present here is simple and workable.

TABLE 4: OPERATING COSTS- NATIONAL NETWORK CENTER FEDERAL CONTRIBUTION (2006 CDN $)

Budget Item	Cost	Total
Leasehold expenses **(1)**	67,000	67,000
General office **(1)**	40,000	40,000
Human resources		
Central office personnel **(2)**	543,810	
Network SBRC personnel **(2)**	736,492	1,280,302
Laboratory materials **(3)**	10,400	10,400
Travel **(3)**	39,000	39,000
Capital equipment **(3)**	195,000	195,000
TOTAL:		**1,631,702**

Notes:

(1) Source: Sporometrics Inc. operating budget, 2005-06

(2) Source: Treasury Board

(3) Source: Centraalbureau voor Schimmelcultures

TABLE 5: HUMAN RESOURCES BUDGET (2006 CDN $)

Budget Item	Pay Scale	FTE	Salary	Benefits	Subtotal	Total
National network center staff						
Scientific Director	EX-02	1.0	115,000	23,000		
Business Officer	FI-3	1.0	69,185	13,837		
IT staff	CS 03	1.0	63,912	12,782		
Network Manager	SE-REM 1	1.0	68,760	13,752		
Secretary	ST-SCY-2	1.0	37,894	7,579		
Bookkeeper	CR-2	1.0	31,910	6,382		
Biosafety Officer	EG-10	1.0	66,514	13,303	543,810	543,810
Core SBRC network staff						
Biomedical bacteria	EG-4	3.0	47,211	9,442	169,960	
Biomedical viruses	EG-4	2.0	47,211	9,442	113,306	
Biomedical fungi	EG-4	2.0	47,211	9,442	113,306	
Agro-environmental/industrial bacteria	EG-4	2.0	47,211	9,442	113,306	
Plant viruses	EG-4	1.0	47,211	9,442	56,653	
Agro-environmental/industrial fungi	EG-4	2.0	47,211	9,442	113,306	
Algae/cyanobacteria	EG-4	1.0	47,211	9,442	56,653	
Special affiliate: secure DRDC collection	n/a	n/a	n/a	n/a	n/a	736,492
TOTAL						**1,280,302**

TABLE 6: NETWORK OPERATING COST PROJECTION -FEDERAL CONTRIBUTION (2006 CDN$) (1)

Budget Item	(Base Costs)	Year 1	Year 2	Year 3	Year 4	Year 5
Leasehold expenses	67,000	68,366	69,761	71,184	72,636	74,118
General office	40,000	40,816	41,649	42,498	43,365	44,250
Human Resources						
National Network Centre Personnel	543,810	554,904	566,224	577,775	589,561	601,588
Network SBRC Personnel	736,492	751,516	766,847	782,491	798,453	814,742
Laboratory materials	10,400	10,612	10,829	11,050	11,275	11,505
Travel	39,000	39,796	40,607	41,436	42,281	43,144
Capital equipment	195,000	198,978	203,037	207,179	211,406	215,718
TOTAL:	**1,631,702**	**1,664,988**	**1,698,953**	**1,733,612**	**1,768,978**	**1,805,065**

Notes:

(1) Percentage increase is average inflation rate from previous 5 years (2.04% from 2002-2006)
Source: Statistics Canada, Canadian Statistics Consumer Price Index Historical Summary, Update: May 2005

TABLE 7: ESTIMATED HOST INSTITUTION IN-KIND CONTRIBUTION (2006 CDN$)

Budget item	Area (m2)	Cost ($/m2) (1)	Subtotal ($)	Total ($)
Medical fungi				
Administration	230	336	77,280	
CL2 lab space	350	336	117,600	
CL3 lab space	152	1,230	186,960	381,840
Environmental fungi				
Administration	230	336	77,280	
CL2 lab space	350	336	117,600	194,880
Environmental bacteria				
Administration	230	336	77,280	
CL2 lab space	350	336	117,600	
CL3 lab space	152	1,230	186,960	381,840
Medical bacteria **(2)**				
Administration	230	336	77,280	
CL2 lab space	457	336	153,552	
CL3 lab space	457	627	286,539	517,371
Medical viruses **(2)**				
Administration	230	336	77,280	
CL2 lab space	457	336	153,552	
CL3 lab space	457	627	286,539	
CL4 lab space	152	1,932	293,664	811,035
Plant viruses				
Administration	107	336	35,952	
CL2 lab space	213	336	71,568	107,520
Algae				
Administration	107	336	35,952	
CL2 lab space	213	336	71,568	107,520
Special affililiate: secure DRDC collection	n/a	n/a	n/a	n/a
TOTAL				**2,502,006**

NOTES:

(1) Canadian Science Centre for Human and Animal Health, 2005-06 budget.

(2) Medical bacteria and medical virus laboratories are housed together with shared CL4 space.

TABLE 8: NETWORK STRATEGIC FUND (2006 CDN $)

Item	Amount	Portion contributed to strategic fund
Federal contribution to strategic fund based upon **(1)**:		
Operating costs		
Network **(2)**	1,631,702	
Core SBRCs **(3)**	2,502,006	
Subtotal	4,133,708	413,371
Core SBRC contribution to strategic fund **(4)**		
Cost recovery **(5)**	250,201	
Subtotal	250,201	25,020
TOTAL		**438,391**

NOTES:

(1) Federal contribution = 10% of combined operating budgets for network and core SBRCs

(2) Federal funding

(3) Host organization funding

(4) Core SBRC contribution = 10% cost recovery funds generated by core SBRCs

(5) Cost recovery estimated at 10% of Core SBRC operating budgets

6 Performance indicators and evaluation

Performance indicators for the NCSBR are based in part on normal indicators for scientific institutions and in part on the procedures of the European CABRI network of major microbial SBRCs (CABRI, 2004). CABRI monitoring of its member SBRCs includes:

- examining common representative organisms from each of the collections to compare methods and results;
- an annual internal audit randomly checking delivery performances and other customer responses to measure customer satisfaction; and,
- periodic external audits by a CABRI Technical Committee (done for one or more randomly selected member SBRC[s] each year) to check a selection of processes as well as delivery performance, upkeep of protocols and procedure manuals, security procedures etc. (Biosafety is normally separately inspected by inspectors engaged by or assigned to the host institutions.)

Concrete performance indicators include:

- number of isolates or specimens shipped out;
- numbers of new accessions;
- numbers of research publications (peer-reviewed and other) with SBRC staff as authors;
- numerically estimable quality/prestige component for the above publications, as gauged by journal impact factors, book sales, awards;
- numbers of peer-reviewed research publications citing SBRC accession numbers for strains or specimens;
- strain citations in patents;

- use or published recommendation for use of strains or specimens in standard quality control procedures (diagnostic tests, materials testing, proficiency tests, etc.);
- demonstrated use (open or confidential) of strains in economically important industrial procedures;
- use of strains in microarrays, macroarrays, bead arrays, etc.;
- whole genome or partial sequencing of strains or specimens (including “DNA barcode” generation, i.e., strategic sequencing of single genes for accurate identification);
- numbers of novel taxa (species, genera, etc.) described, as well as number of major genetic subgroups (sequence types, serotypes, phage host types, etc.) newly recognized; and,
- service work done: identifications, serotyping, industrial consulting contracts, etc.

In addition to periodic internal NCSBR audits of SBRCs, at least once every 3 to 5 years an external audit should be arranged, bringing together a committee based on a small number of representatives including at least one from each of:

- SBRCs outside Canada;
- representatives of important academic and/or industrial user groups; and
- representatives of interacting federal government ministries.

This external audit should consider the national centre as well as at least one randomly selected core SBRC.

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ANNEX A

LIST OF RESOURCES REVIEWED

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ANNEX B.1

WORKSHOP AGENDA

CRTI Workshop Agenda

February 13-14, 2007
Ottawa Marriott, Wellington & York Salons

Tuesday February 13, 2007		
8:00	Participant registration & breakfast	
8:45	Welcome & opening remarks	Kathy Bernard, PHAC/ André Lévesque, AAFC
9:00	Background to project	Lynne Sigler, University of Alberta Microfungus Collection
9:30	Review of Canadian collection data (1994-2004)	Carolyn Babcock, Canadian Collection of Fungal Cultures, AAFC
9:45	BCCM (Belgian network; structure, org, funding)	Wendy Untereiner, Brandon University
10:00	CBS & other European systems (structure, org, funding)	Richard Summerbell, Sporometrics Inc.
10:30	Refreshment break	
10:50	AMRiN (Australian network; structure, org, funding)	Lindsay Sly, Australian Microbial Resources Information Network (AMRiN)
12:00	Lunch break	
1:15	Overview of working groups	James Scott, Sporometrics Inc.
1:30	Working groups	
	1. Participation, organization, governance	Wellington Salon, 3rd floor
	2. Funding/ revenue, cost recovery	York Salon, lower level
3:15	Refreshment break	
3:30	Wrap-up presentations from working groups	
4:30	Questions and discussion	
4:45	Adjourn	

Wednesday February 14, 2007		
8:30	Participant breakfast	Wellington Salon, 3rd Floor
9:00	Information systems: DND Suffield database system	Sarah Cassady
9:30	Information systems: BioloMICS	Vincent Robert, Bioaware Bioinformatics/ CBS Fungal Biodiversity Center, The Netherlands
10:00	Importing pathogens into Canada: what you need to know	Kerry Holmes, CFIA; Andréanne Bonhomme, PHAC
10:30	Refreshment break	
10:45	Bioaccess and biosecurity – diverse statutory aspects	Donald Netolitzky
11:15	Other international regulatory issues	R. Summerbell
11:45	Overview of proposed Canadian model	J. Scott
12:00	Lunch break	
1:15	Overview of working groups	J. Scott
1:30	Working groups	
	3. Database requirements for network	Wellington Salon, 3rd floor
	4. Quality systems, standardization, regulatory issues	York Salon, lower level
3:15	Refreshment break	
3:30	Wrap-up presentations from working groups	
4:30	Questions and discussion	
4:45	Closing remarks	R. Summerbell
5:00	Adjourn	

ANNEX B.2

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ANNEX C

MARKET ASSESSMENT

National Centres for Secure Biological Resources

Background information: value of Canadian SBRCs to research and industrial communities.

In addition to the survey of Canadian SBRCs conducted by PHAC and AAFC (Bernard et al. 2007), a small separate survey was done by the compilers of this report. A questionnaire was sent out to all university- and governmentally-based Canadian SBRCs. It was worded as follows:

> Dear curator/ collection manager,
>
> In connection with the ongoing CRTI sponsored project directed towards forming a microbial culture collection network in Canada, we are in the process of producing a prospectus based on our recent Ottawa meeting and additional consultation and research. The RFP we received from the CRTI obliges us to summarize some important information showing the importance of collections. Some of this information has already been collected in the form of the recent survey compiled by Carolyn Babcock of AAFC, but we must also ask you a few additional questions in order to fulfill the requirements of the RFP. These requirements are directed towards providing an accurate representation of the existing and potential importance of Canadian collections.
>
> Important note: if you find that the answers to some or all of these questions are sufficiently addressed in your website, your annual reports, previous funding proposals, or other documents you have already prepared, please attach or send these documents and just answer the questions with "see document(s)." If you send multiple documents, please indicate which one answers the question.
>
> 1. How many cultures (real number if possible or approximate) did your collection ship out to other institutions in the last year (calendar or fiscal, whatever is more convenient)?
>
> _____
>
> How many would you state or estimate were sent out in the last 5 years? (Ballpark figure is quite OK).
>
> _____
>
> Can you break the 5-year number down (approximation OK) into the number of cultures sent out to recipients based at:
>
> University/College sector _____
>
> Government sector _____

Medical sector (non-government) _____

Industry _____

2. How many cultures in your collection do you know of as being currently utilized by industry in some sort of saleable product or service?
_____

Can you give examples of the two strains in your collection that you know or estimate to be of significant economic importance in an industrial setting? In the case of strains deposited in multiple collections, just mention cases where the industrial institution obtained the strain from your collection or deposited the strain in your collection.

Strain: _____ Utilizing company or institute
_____

Product or service involved _____ Annual dollar value of product if you know or can reasonably estimate _____ (otherwise we can search web, you don't need to do this)

Strain: _____ Utilizing company or institute
_____

Product or service involved _____ Annual dollar value of product if you know or can reasonably estimate _____

3. Can you give examples of strains from your collection that are used as research model organisms by multiple laboratories or as quality control or other standard strains by multiple users? (Give the 5 most extensively used ones if there are too many examples to conveniently list)

_____

_____

_____

_____

4. Do you keep a list (or lists) of the scientific publications (including your own) known to have cited strains from your collection in the last 5 years? [If you do not regularly collect this information and aren't able to conveniently assemble it now, please just state "information not collected."]. If so, can you supply it to us or give us a link? In the case of strains deposited in multiple collections, just mention publications citing your accession number or naming your collection as a culture source.

5. Who are your collection's main regular clients and important users? What do they principally need? (Note: please answer if at all possible. This question comes straight from our working group's RFP: "Generate a limited market survey by identifying the main regular clients and important users of collection and by defining their needs. Core collections will be able to provide a list of important clients")

Not all SBRCs queried responded. Responses from those that did, however, do include the most active SBRCs and give an excellent indication of the importance of these institutions to Canadian and international research.

Table 1. SBRC strain utilization in the last five years.

SBRC	# cultures/ specimens shipped out (1 year, 5 years)	Strains shipped in 5 yrs: university/ government/ medical/ industry	# SBRC strains known to be utilized by industry in saleable product or service	Major industrial strains and their uses	Top 5 major research model organism strains or quality control strains
University of Toronto Culture Collection of Algae and Cyanobacteria (UTCC)	401, 1740	1230; 200; –; 310	25	1. Strain: UTCC 37, *Pseudo-kirchneriella subcapitata*, user Golder-EVS, Stantec and others: Ecotoxicity testing 2. Strain: UTCC 490, *Lemna minor* User: Pollutech Group Inc, CANTEST and others: Ecotoxicity testing.	UTCC 90 *Chlorella vulgaris*, UTCC 420 *Dunaliella tertiolecta*, UTCC 299 *Microcystis aeruginosa*, UTCC 160 *Nitzschia palea*, UTCC 344 *Rhodomonas minuta*
University of Alberta Microfungus Collection and Herbarium (UAMH)	268, 1349	not calculated, see annual reports[1]	not known	1. UAMH 7863 used by US EPA for Taq Man PCR quantitative identification assay method 2. UAMH 7863 *Geotrichum candidum* strain used as above	UAMH 4828 *Tolypocladium inflatum* for cyclosporin production
Felix d'Hérelle Reference Center for Bacterial Viruses, Université Laval	221, 714	283; 73; –; 358	not known, but some bacterial strains are so used	Strain numbers used not known, but 1. *Lactococcus lactis*, etc., used by the dairy industry to produce an array of fermented dairy products 2. Recombinant *E. coli* strains used for biotechnological products	Phage lambda; Phage T4; Phage T7; Phage MS2; Phage PRD1
National Microbiology Laboratory, Winnipeg, Public Health Agency of Canada (PHAC)	<10, <50	not compiled	none	N/A	N/A
Université Laval, CEF collections	65, >100	>80, – , >5, >10	none yet	Two strains are being developed for use in revegetation, but strain identities are confidential	Complete genome sequence strains of *Ophiostoma novo-ulmi*,

Table 1. SBRC strain utilization in the last five years.

SBRC	# cultures/ specimens shipped out (1 year, 5 years)	Strains shipped in 5 yrs: university/ government/ medical/ industry	# SBRC strains known to be utilized by industry in saleable product or service	Major industrial strains and their uses	Top 5 major research model organism strains or quality control strains
					O. ulmi, *Laccaria bicolor*
North East Pacific Culture Collection	40, 225	198; 2; 16; 9		Strain: *Skeletonema*, used by Vizon Scitec Inc.; Strain: *Thalassiosira* used by Bioriginal Food & Science Corp	*Prorocentrum*, *Amphidinium*, *Alexandrium*, *Emiliania*, *Aspergillus*
National Research Council of Canada Biotechnology Research Institute	60, 250	100; 50; 50; 50	10	1. Strain: HEK293 cell line, used by (Confidential) for production of recombinant proteins; value per year over $500 K 2. Strain: E. coli, used by (Confidential) for production of research reagents; value per year over $200 K	HEK293 cell line *Methylobacterium extorquens*, *Pediococcus acidilactici*, *Pseudomonas* sp., *Methylococcus trichosoporium*
Yeast collection University of Western Ontario	60, 300	100, 100, –, 100	none known	none known	none known, but complete genome sequencing planned for some strains
Canadian Collection of Fungal Cultures/DAOM	330, 1560	500, 800, –, 260	Some mushroom strains used, also some plant pathogen strains used for fungicide testing	none explicitly known	*Fusarium graminearum*, *Fusarium culmorum*, *Fusarium sporotrichioides*, *Fusarium verticillioides*, *Trichoderma harzianum*, *Pythium ultimum*

Footnotes: 1. http://www.devonian.ualberta.ca/uamh/activities.htm, pdfs showing numbers of cultures sent out per year also attached as appendices to this report.

In addition, below, SBRCs listed in the same order as seen in Table 1 present their comments on important clients and the use of SBRC isolates in publications. Note that to avoid excess text in this document, SBRCs were encouraged to cite websites instead of sending lists where possible. Actual lists that were sent, however, are appended with this document for additional information

University of Toronto Culture Collection of Algae and Cyanobacteria, main regular clients

Arnott, Shelley	Biology Dept., Queen's University, Kingston ON K7L 3N6
Bayer, Barbara	ALS Laboratory Group, 1329 Niakawa Rd., Winnipeg, MB R2J 3T4
Berges, John	Biological Sciences, U. Wisconsin at Milwaukee,.Milwaukee, WI 53211
Bhatti, Shabana	Dept of Biology, York University, Toronto
Bastien, Christian	Centre d'expertise en analyse env.du Quebec, Complexe sci., Ste-Foy, PQ
Carleton-Dodds, Ingrid	Hydroqual Labs, #3, 6125- 12th St., Calgary AB T2H 2K1
Cheung, Alice	Dept. of Ecol. & Evol. Biology, University of Toronto, Toronto ON
Colman, Brian	Biology Dept., York University, 4700 Keele St., Toronto, ON
de Rosemond, Simone	Tox. Res. Centre, U. Saskatchewan.,Saskatoon, SK S7N 5B3
Durand, L.	Universite du Quebec a Montreal, Dept of Bio Sci, Montreal, PQ H3B 3H5
Fortin, Claude	U. du Québec,Institut National de la Recherche Scientifique ,Québec G1K 9A9
Fouche, Anja	Golder -EVS Assoc., 195 Pemberton Ave, North Vancouver, BC V7P 2R4
Fussmann, Gregor	Biology Dept., McGill University, Montreal, PQ H3A 1B1
Goldman, Corey	Dept. of Ecol. & Evol. Biology , BIO150, U. Toronto, Toronto ON
Gosselin, I.	Natural Resources Canada, 555 Booth St., Ottawa, ON K1A 0G1
Greenberg, Bruce	University of Waterloo, Waterloo ON N2L 3G1
Guildford, Stephanie	Biology Dept., University of Waterloo, Waterloo ON
Harris, Gary	Harris Industrial Testing Services, Rawdon, NS B0N 1Z0
Herndon, Jack	Civil & Environmental Engineering, U. Washington, Seattle, WA
Huras, Craig	ASI Group Ltd., 250 Martindale Rd., St. Catharines, Ontario
Hyrn, David	NWRI, University of New Brunswick, 10 Bailey Dr., Fredericton, NB
Jackman, Paula	Env. Can.,Environmental Science Centre, Moncton, NB E1A 3E9
Jenkins, Steve	Ontario Ministry of Environment, Toronto ON M9P 3V6
Johansen, Jeff	Dept of Biology, John Carroll University, University Heights, OH USA
Juneau, Phillipe	Universite du Quebec a Montreal, Dept of Bio Sci, , Montreal, PQ H3B 3H5
Keeling, Patrick	Botany Dept., University of British Columbia, Vancouver BC
King, Morgan	Natural Resources Canada, Receiving, Ottawa, ON K1A 0G1
Kuntz, Tim	Biology Dept., University of Waterloo, Waterloo ON
Kwiatkowski, Derrick	Biol. Dept, Lakehead University, Thunder Bay,ON P7B 5E1
Lamberti, Gary	Biology Dept.,Notre Dame University, , Notre Dame, IN 46556
Larson, Don	IRC Ltd, 14480 River Rd. Suite 160, Richmond, BC V6V 1L4
Lavoie, Michel	INRS-EAU Terre Env., U. du Quebec, Quebec G1K 9A9
LeBlanc, Susan	Biology Dept, University of Ottawa,150 Louis Pasteur, Ottawa, ON
Lee, Carol	Dept of Zoology, University of Wisconsin, , Madison WI 53706
Lentini, Andrew	Toronto Zoo, 361 Old Finch Ave., Toronto, ON M1B 5K7
Linteau, Isabelle	U du Quebec a Trois-Rivieres, Trois-Rivieres, Qc G9A 5H7
Liu, Jiny	Prime Chorella, 234-5149 Country Hills Blvd. NW, , Calgary AB T3A 5K8
Lombaert, Gary	Health Canada, Health Products & Food Br, Winnipeg, MB R2J 3Y1
Lorrain, Lucie	Lab-Bell Inc., 2263 ave du College, Shawinigan, Quebec G9N 6V8
Lynch, Trenton	Mech. Eng., Engineering Cntr, U. of Colorado at Boulder, Boulder CO
Maxwell, Chris	Biology Dept., Trent University, Peterborough, ON K9J 7B8 (UTCC 314)
McCauley, Ed	Dept of Biol. Sci, 2500 University Dr. N.W,.U. of Calgary, AB T2N 1N4
Metzger, Brian	Dept of Zoology, University of Wisconsin, , Madison WI 53706
Miller, Tony	Biology Dept., St. Francis Xavier University, Antigonish, NS B2G 2W5
Molot, Lewis	Faculty of Environmental Studies,.York University, Toronto ON M3J 1P3
Moody, Mary	Saskatchewan Research Council, 125-15 Innovation Blvd., Saskatoon SK

Muller, Kirsten	Biology Dept, University of Waterloo, Waterloo, ON
Narwani, Anita	Biology Dept, University of Victoria, Victoria BC
Occhifinto, R.	NVE Pharmaceutical, 33-08 Newton Sparta Rd., Newton, NJ 07860, USA
Olaveson, Mary	UTSC, Life Sciences Div., Scarborough, ON
Owttrim, George	Dept of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9
Pasiak, Edyta	Pollutech Enviroquatics, 122-704 Mara St., Point Edward ON N7V 1X4
Pick, Frances	Dept of Biology, University of Ottawa, Ottawa, ON
Pickard, Janet	CANTEST, 3650 Wesbrook Mall, Vancouver, BC V6S 2L2
Planas, Dolors	GEOTOP-UQAM-McGill, U.de Québec à Montréal,
Poulin, Jaques	Mag. des fournitures de lab., Min. des Services gouv., Sainte-Foy PQ G1P 3V5
Rein, Kathleen	Florida International U., Chemistry OE316, Miami FLA
Robillard, Annie	GDG, 105 rue Phillipe-Francoeur, Trois-Rivieres, Quebec G8T 9L7
Rooney, Neil	Dept of Integrative Biology, University of Guelph, Guelph, ON N1G 2W1
Roshon, Roxana	Stantec, 11B Nicholas Beaver Road, RR#3 Guelph ON N1H 6H9
Ross, Sara	Dept of Biology, U. Waterloo, Waterloo ON
Sage, Tammy	Botany Dept., University of Toronto, Toronto, ON
Schroeder, Grant	Pacific Environmental Science Centre, Env.Canada, N. Vancouver BC
Schwartz, Melissa	CANMET Lab, Natural Resources Canada, Ottawa, ON K1A 0G1
Sheehan, Lia	Kinectrics Ltd, 800 Kipling Ave, Bldg. KJ132, Toronto, ON M8Z 6C4
Skvarenina, Anthony	FESKO, 8515 9th Ave., Montreal, PQ, H1Z 2Z6
Slaveykova, Vera	EPFL ENAC ISTE CECOTOX, Stn 2 CH-1015 Lausanne, Switzerland
Smith, Debbie	Regional Water Supply Systems, St. John's NF A1C 5M2
Smith, Ralph	Biology Dept., University of Waterloo, Waterloo ON
Softcheck, Katherina	Springborn Smithers Laboratories, Wareham MA 02571, USA
Stoll, Rhonda	AEGIS Environmental Management, Midland, MI 48642, USA
Tillmans, Angeline	Biology Dept., U. of Ottawa, Ottawa ON
Trick, Charlie	Biological and Geological Sciences Bldg, U.Western ON, London ON
Twiss, Michael	Biology Dept., Clarkson University, Potsdam, NY 13699 USA
Vanlerberghe, G.	Life Sciences, University of Toronto at Scarborough, Toronto ON
Veilleux, Stephan	Bodycote Essais de Materiaux Canada Inc., Ste-Foy, Quebec
Walker, Brian	Environment Canada, St. Lawrence Ctre, 105 McGill St., Montreal
Watson, Susan	NWRI, Environment Canada 867 Lakeshore Rd., Burlington, ON L7R 4A6
Wickham, Steve	Organismiche Biologie, U. Salzburg, Hellbrunnerstr. Salzburg, Austria
Wilson, Harry	Maxxam Analytics Inc., 9331-48st, , Edmonton, Alberta T6B 2R4
Wright, Jeffrey	Center for Marine Science, U. of N. Carolina at Wilmington, NC 28409
Yan, Norman	FLAMES Lab, 1026 Bellwood Acres Rd., Dorset ON P0A 1E0

Cultures are requested for the following types of research and testing:

- Ecotoxicity testing
- Testing herbicides, pesticides
- Analytical Standards for toxins
- Ecological studies, particularly in the Great Lakes
- Taste and odour in drinking water
- Physiology of algae
- Molecular Taxonomy
- DNA barcoding
- Biofuel research
- Biocontrol of toxic cyanobacteria
- Screening for anti-cancer, anti-bacterial and anti-fungal properties
- Positive controls for screening for microcystin
- Pigment analysis
- Food for invertebrates

University of Toronto Culture Collection of Algae and Cyanobacteria: Publications in peer-reviewed journals citing UTCC strains

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Also many presentations, non-refereed publications, theses.

University of Alberta Microfungus Collection and Herbarium, Main clients and lists of citing publications:

See annual reports at http://www.devonian.ualberta.ca/uamh/activities.htm (portions with strains received and sent out appended with this document as pdfs)

See UAMH publications at: http://www.devonian.ualberta.ca/uamh/publications.htm

Félix d'Hérelle Reference Center for Bacterial Viruses, main clients

In keeping with the nature of the collection, the SRBC does not have "main regular clients" nor does it have particularly "important users". Requests in the last 5 years came from over 130 research laboratories in 21 countries

Université Laval, CEF collection cluster, main clients

The main clients are coming from University/college sector. They are from North America and Europe.

North East Pacific Culture Collection clients

Mostly university research and teaching labs strains of fungi, marine and freshwater algae that exhibit characteristic morphology

and toxic strains

National Research Council of Canada Biotechnology Research Institute clients

1. Research collaborators
2. Researchers all over the world wishing to use strains for their work
3. Researchers/companies wanting to use specialized tool box items (via MTAs)
4. College/university teachers (for classroom experiments)
5. Companies linked by contractual/collaborative agreements

University of Western Ontario Yeast Collection

Clients are mostly academic researchers looking for natural isolates of yeasts. I maintain a large collection of strains isolated from nature. Example: G.I. Naumov (Russia) has published many papers based on my strains of *Saccharomyces, Kluyveromyces*, and *Arthroascus*, among others). Some of my *Saccharomyces* strains are slated for whole genome re-sequencing.

Canadian Collection of Fungal Cultures/DAOM

1) Taxonomic Group, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada (6 mycologists)

2) AAFC researchers in Ottawa and across the country (25 + researchers)

3) Private Industry (information protected)

4) Universities (national and international)

5) Diagnostic Laboratories

SYNOPSIS

The above compilation, though based on information too partial to allow overall estimates about nationwide SBRC value, shows that Canadian SBRCs make a highly significant contribution to research and industry both in this country and internationally. They hold numerous important industrial isolates, though much of the time the industrial users have not informed them exactly which strains are used or what value is derived from them. Algal and fungal SBRCs are particularly active, but some smaller bacterial SBRCs are also strongly supportive of industrial and research activities. It is likely that over 5000 strains were sent out to researchers and other clients by Canadian SBRCs over the last 5 years; academic researchers, government researchers and industrial researchers were all strong clients. Reading between the lines, the strong particular dependence of Canadian medical bacteriology on foreign collections, most notably ATCC, can be inferred. It is not clear whether this is cause or effect of the relative lack of Canadian medical bacteriology alternatives; most likely both cause and effect are linked in a vicious cycle. Most other Canadian sectors utilize Canadian SBRCs relatively heavily. It is very likely that the reduced costs and difficulty of obtaining medically important bacteria from Canadian sources would also activate a strong client base in this area from any SBRC funded to become an active and reliable supplier.