



## ARCHIVED - Annual Performance Report 2006-2007

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# **Genomics R&D Initiative**

## **Annual Performance Report (2006-07)**

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Working Group for the  
Genomics R&D Initiative

4 April 2008

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## Executive Summary

A Results-based Management Accountability Framework (RMAF) for the Genomics R&D Initiative has been completed in fulfillment of the requirements and guidelines of the Treasury Board Secretariat. The RMAF formalizes the commitment of the six departments involved in the Initiative regarding the common measurement and accountability requirements associated with the Initiative. The departments and agencies participating in the Genomics R&D Initiative have used this RMAF to guide the development of the fiscal year 2006-07 Annual Performance Report (2006-07).

In fiscal year 2006-07, year 2 of Phase 3 funding, participating departments have made excellent progress towards the overall objectives of the Genomics R&D Initiative. They have developed knowledge and innovative technologies targeted at improving human health, environmental management, agriculture and food safety, and improved sustainability and management of natural resources.

The NRC Genomics and Health Initiative (NRC-GHI) research programs resulted in the publication of 126 papers in refereed journals, 68 papers in peer reviewed conference proceedings, and 93 invited external presentations at conferences and symposiums. Twelve patent applications were filed with an additional 3 applications granted. As well, 3 licensing agreements were signed along with 3 material transfer agreements. As part of the NRC-GHI research program *Functional Genomics of Brassica Seed Development and Metabolism*, the cell biological bases for thinner and lighter seed coat in yellow-seeded canola were determined. This represents a major breakthrough that could lead to the development of more durable and productive Canola crops – a matter of growing importance in the global search for cost-effective and efficient renewable fuels.

Research from the AAFC Canadian Crop Genomics Initiative (AAFC-CCGI) programs resulted in the publication of 65 papers in refereed journals, 23 papers in peer reviewed conference proceedings, and 50 invited external presentations at conferences and symposiums. Twelve patent applications were filed with an additional 2 applications granted. As well, 7 public service invention disclosures and 2 licensing agreements were signed. AAFC has been a worldwide research leader on wheat leaf rust since the 1950s. As part of the AAFC-CCGI research program genomics tools were used to clone a leaf rust resistance gene – thus permitting further studies toward understanding the mechanisms of resistance that a plant can draw upon when challenged by this pathogen. Several new leaf rust resistance genes have been discovered and a leaf rust resistance gene, Lr1, has been cloned. Expressed Sequence Tag (EST) databases were generated for the leaf rust pathogen and molecular markers linked to key genes have been developed. This has resulted in the commercial release of wheat cultivars resistant to leaf rust.

Health Canada/Public Health Agency of Canada Genomics Initiative (HC/PHAC - GRDI) research programs resulted in the publication of 38 chapters in refereed journals, 15 publications in conference proceedings, 4 book chapters, 9 poster presentations at symposiums, 22 contributions at invited presentations, and 1 provisional patent application has been filed for distinctive markers that protrude from the surface of an antigen, and that alert the immune system to the antigen's presence for HIV-1. As part of the HC/PHAC-GRDI program there were a number of breakthroughs in the assessment of health and safety of biotechnology products, including improved methodologies to analyze the potency and quality of biotherapeutic interferon. Biotherapeutics like interferon may become the fourth type of treatment for cancer, after surgery, chemotherapy and radiation. In the area of public health genomics, researchers have completed whole genome sequencing of three *Streptococcus* species, recently identified as pathogens in Cystic Fibrosis patients. Genomes belonging to these species had not previously been sequenced. These genome sequences will be utilized for the development of novel diagnostic and therapeutic agents targeting these species.

The NRCan Canadian Forest Service (CFS) Genomics R&D Initiative generated 40 publications in refereed journals, 33 publications in conference proceedings, 1 national symposium report, 13 invited presentations, 1 technical report, 3 book chapters, 15 national conference presentations and reports, 34 international conference presentations and posters, 15 community presentations, 14 media interviews, and several genomics stories on the CFS corporate web site. Executive memberships of national and international networks and appointments as co-principal investigators on international initiatives were held by CFS scientists, extensive data were shared on international web sequence databases, formal collaborative agreements were initiated or continued with other government departments and agencies, universities, research institutes, provincial governments, the private sector, and international research organizations. The initiative allowed the training of 9 scientists, 8 technicians/biologists, 10 post-doctoral fellows, and 14 graduate students. Research has allowed investigating genes of economically important conifers and pest species; developing molecular tools to monitor forest pathogens and quarantine species, and; investigating novel biological control products. This work relates to boreal forest management and its impact is thus at a national scale.

Research conducted under the auspices of Environment Canada's Strategic Applications of Genomics in the Environment (STAGE) Program resulted in the publication of 13 papers in refereed journals, 2 papers in peer reviewed conference proceedings, and 6 invited external presentations at conferences and symposiums. The department completed four Standard Operating Protocols along with 2 collaborative agreements. As part of the STAGE program, toxicogenomic tools (microarrays and real-time PCR) were used to examine gene expression changes in fish following toxicant or effluent exposures. These studies generated predictive and diagnostic data ultimately used to prevent

pollution by minimizing the impact on aquatic species. EC scientists provided their expertise in co-authoring numerous chapters in the new release of a Society of Environmental Toxicology and Chemistry (SETAC) book “Genomics in Regulatory Ecotoxicology: Applications and Challenges”.

DFO Genomics R&D Initiative recipients contributed to the state of knowledge as it pertains to Canada’s aquatic resources. Several major initiatives are currently underway to profile the genomes of important aquatic resources including halibut and salmon. There was, and continues to be, research and development into genomic approaches for aquatic animal health as well as the development of tools to ensure aquatic ecosystem health such as the remediation of water contaminated sites due to oil platforms. GRDI funded projects produced 6 refereed journal articles, 6 papers in peer reviewed conference proceedings, a technical report, 4 book chapters, 2 invited presentations and several tours of genomics research facilities were conducted. The initiative also helped to foster 30 collaborations and partnerships with other federal departments and agencies, universities and the private sector.

## **1.0 Genomics R&D Initiative – Program Profile**

### **1.1 Background**

In March 1998, the National Biotechnology Advisory Committee (NBAC) released a report recommending ways to position Canada as a leading global player in biotechnology by the year 2005. As well, during the same period the National Research Council and the Medical Research Council consulted stakeholders as part of the Canadian biotechnology consultations. Genomics was clearly identified as the top priority for Canadian biotechnology research and development (R&D).

The NBAC recommended that a top priority be placed on several actions, including political championship, establishment of a federal government framework to regulate biotechnology, and increased funding to Canada's genomics R&D programs.

In January 1999, Cabinet approved a proposal to support intramural genomics research and the federal government committed \$55 million in new funding from April 1999 to March 2002. This fund was renewed from 2002 to 2005 (Phase II) and from 2005 to 2008 (Phase III) at the level of \$59.7 million per phase. The Genomics R&D Initiative funding is provided to the following departments and agencies: the National Research Council of Canada (NRC) – \$6M/year, Agriculture and Agri-Food Canada (AAFC) – \$6M/year, Health Canada (HC) and the Public Health Agency of Canada (PHAC) – \$4M/year, Natural Resources Canada (NRCan) – \$2M/year, Environment Canada (EC) – \$1M/year, and Fisheries and Oceans Canada (DFO) – 0.9M/year. Additional details on funding allocations are provided in Table 1.

### **1.2 Overview**

The Genomics R&D Initiative was established for the purpose of building and maintaining capacity inside government departments to do genomics research. As an enabling technology, genomics provides powerful tools and precise information to support operational mandates and upon which policy and regulatory decisions can be based. Federal science-based departments and agencies interact with partners, stakeholders and clients and link these enabling tools and technologies to value-added applications that enable Canada to respond to national priorities, deliver on government mandates and support the development of wealth for Canadians.

Applications range from international requirements for genomics enabled testing to support access to exported products; the ability to interpret and assess genomics information submitted with product information for regulatory oversight; the development of assays and products using genomics approaches for enhancing Canadian's lives, the environment and sustainability of human activities; socio-economic and ethical considerations related to the use and integration of genomics in health care, environmental sustainability activities, and consumer and industrial products and applications; as well as facilitating Canadians' access to accurate and understandable information concerning genome sciences.

Programs funded under the genomics R&D initiative are also used to strengthen human resources and help create partnerships with other government departments, universities, and industry (where applicable) through the sharing of technology platforms and by collaborating in research areas that cut across traditional departmental sectors.

### **1.3 Governance**

An interdepartmental Genomics R&D ADM Coordinating Committee has been established to oversee the collective management and coordination of the federal Genomics R&D Initiative. The Committee ensures that effective priority setting mechanisms are established within departments, and that government objectives and priorities are addressed.

The Committee also ensures that common management principles associated with Genomics R&D management are implemented and horizontal collaborations between organizations are pursued wherever relevant and possible. The committee includes members from each of the organizations receiving funding, as well as a representative from Industry Canada.

An Interdepartmental Working Group (WG) supports the work of the committee. The mandate of the WG is to provide recommendations and advice to the ADM Coordinating Committee regarding strategic priority setting and overall management of the Genomics R&D Initiative. The WG also supports evaluation and reporting requirements related to the Initiative.

The National Research Council has been the lead agency in the development of the Results-based Management and Accountability Framework (RMAF) and TB submissions, and chairs the Coordinating Committee and the Working Group.



To ensure that the maximum possible benefit is derived from government investments in Genomics R&D, each department uses an internal competitive program proposal and approval process, as well as scientific peer review to evaluate the quality and relevance of research programs. All departments have levered the government's investment in genomics R&D by providing additional (or matching) funds by allocating A-base to supplement genomics R&D funding. Resources in each department are directed towards fulfilling specific mandate requirements. Successful collaborations are established where relevant and appropriate.

**Table 1: Funding Allocation**

Department/Agency	1999-2002	2002-2005	2005-2008
Agricultural and Agri-Food Canada	\$17,000,000	\$18,000,000	\$18,000,000
Environment Canada	\$3,000,000	\$3,000,000	\$3,000,000
Fisheries and Oceans Canada	\$2,500,000	\$2,700,000	\$2,700,000
Health Canada / Public Health Agency of Canada	\$10,000,000	\$12,000,000	\$12,000,000
National Research Council Canada	\$17,000,000	\$18,000,000	\$18,000,000
Natural Resources Canada	\$5,000,000	\$6,000,000	\$6,000,000
Medical Research Council*	\$500,000		
<b>Total</b>	<b>\$55,000,000</b>	<b>\$59,700,000</b>	<b>\$59,700,000</b>

\* Precursor to the Canadian Institutes of Health Research (CIHR) – one time allocation in fiscal year 1999-2000 to assist in the establishment and support of a Genome Canada Secretariat.

## 2.0 Results-based Management and Accountability Framework

A Results-based Management Accountability Framework (RMAF) for the Genomics R&D Initiative formalizes the commitment of the six departments and agencies involved in the Initiative regarding the common measurement and accountability requirements associated with the Initiative. The departments and agencies participating in the Genomics R&D Initiative have used this RMAF to guide the development of the fiscal year 2006-07 Annual Performance Report (2006-07). This report covers year 2 of Phase 3 funding.

The RMAF logic model reflects the overall objectives of the Initiative based on key results related to four important program areas: Management, Genomics R&D Capacity, Research and Development, and Outreach. The structure of the Annual Performance Report (APR) is based on the RMAF performance measurement strategy and related performance indicators. The key performance indicators under each of the key result areas are listed below:

- Management: Enhanced governance, coordination and science partnerships.
- Genomics R&D Capacity: Increased research capacity – increase of Highly Qualified Personnel (HQP) / training of HQP, and advancements in state-of-the-art infrastructure; increased participation in national and international genomics initiatives.
- Research and Development: Access to / sharing of technology and scientific knowledge; application of research results to develop innovative, new or improved methods, products, processes or technologies.
- Outreach: Increased awareness and understanding of genomics research results and applications.

Highlights from the 2006-07 APR are presented using these performance indicator categories. A summary of the RMAF, which includes the Logic Model and related tables of performance indicators, are provided in Appendix B.

### **3.0 Links to Departmental Objectives and the PAA**

A summary of the research activities within each of the departments participating in the Genomics R&D Initiative, including specific program objectives are summarized in the following section. These descriptions show the program linkages to departmental objectives and their respective Program Activity Architecture (PAA).

The Genomics and Health Initiative (GHI) is NRC's largest horizontal research and development (R&D) initiative; through its multi-disciplinary approach and research excellence GHI is making significant contributions to Canadian R&D priorities in health (chronic diseases and agri-food), in energy (biofuels) and for the environment (environmental technologies and bioproducts). This is achieved through the funding of research programs that are aligned with key industrial sectors, and focused on the translation of scientific and technical knowledge into social and economic developments. GHI is one means by which NRC partners with other government organizations, academia, and industry to provide an integrated approach to S&T initiatives.

AAFC has strengthened the Canadian Crops Genomics Initiative (CCGI) by additional investments in plant genomics and in the formation of multi-disciplinary teams across Canada to meet these priorities. Funding from the Genomics R&D Initiative has been used to support the advancement of technologies for developing toxin free cereals, the development of sustainable food and feed supply in cereals, pulses and oilseeds, as well as the introduction of crop platforms for the generation of industrial and biofuel products. The CCGI is a vehicle whereby integrated S&T teams have been developed within AAFC and in partnerships with Universities, the private sector, NGOs and highly regarded international genomic institutes.

Health Canada's (HC) role in the Genomics initiative is to generate knowledge that is essential to the effective regulation of products and technologies produced in the genomics field. HC's Departmental Framework for Biotechnology outlines the Department's biotechnology-related roles and responsibilities including providing leadership in policy and regulation development, ensuring an international position for Canada, and applying the benefits of biotechnology to HC's mandate. HC has developed four themes to guide research activities within the Genomics R&D Initiative: generation, use and societal impacts of human genetic information; health and safety of biotechnology products; human genomic applications and impacts related to diagnostics and disease; and, microbial genomic applications and impacts related to diagnostics and disease.

The Canadian Forest Service of Natural Resources Canada promotes the sustainable development of Canada's forests and the competitiveness of the Canadian forest sector. The Genomics R&D Initiative has developed the foundation for contributing to these strategic priorities through its efficient positioning at the leading edge of unique technological platforms for tree and insect tissue culture, molecular diagnostics, population genetics, biological control products and functional genomics. Resulting from this foundation is a critical mass of data, infrastructure, and partnerships that is starting to deliver important practical applications.

Environment Canada delivers its Genomics R&D funding through the *Strategic Applications of Genomics in the Environment (STAGE)* program. Under the aegis of this program, the Department has focused its STAGE funding on projects that examine how genomics tools and methods can be used to support their regulatory decision making, policy and enforcement mandates. More specifically, projects address the following Departmental priorities: Risk Identification/assessment/management, Improved Enforcement and Compliance, Conservation Biology and Wildlife Management.

DFO's Aquatic Biotechnology and Genomics R&D Program supports research that incorporates genomics into research and development activities related to responsibilities for fishery management, monitoring fish habitat, sustainable fisheries and aquaculture, and protecting marine resources. Specific goals for genomics and biotechnology enable research for aquatic ecosystems and organisms. They have been developed in order to strategically align research activities and the identification of R&D opportunities that support the Department's mandate and strategic objectives. Currently, targeted genomics funding helps support research within four DFO research centres across Canada. The genomics research is aligned within three inter-related research themes, each with specific objectives and goals.

## 4.0 Resources

Table 2 provides an overview of planned and actual resources in 2006-07, including leveraged funds. Leveraged funds represented approximately 46% of total GRDI investments.

**Table 2: Planned, Actual and Leveraged Resources (\$000)**

Department/Agency	Planned	Actual	Leveraged	Actual + Leveraged
National Research Council <sup>1</sup>	6,000	6,000	6,300	12,300
Agriculture and Agri-Food Canada <sup>2</sup>	6,000	6,000	2,450	8,450
Health Canada / Public Health Agency Canada <sup>3</sup>	4,000	4,000	588	4,588
Natural Resources Canada <sup>4</sup>	2,000	2,000	5,600	7,600
Environmental Canada <sup>5</sup>	1,000	1,000	845	1,845
Fisheries and Oceans Canada <sup>6</sup>	900	900	1,092	1,992
<b>Totals</b>	<b>19,900</b>	<b>19,900</b>	<b>16,875</b>	<b>36,775</b>

<sup>1</sup> NRC research institutes are required to contribute Abase funds (at least at matching levels).

<sup>2</sup> AAFC research centres leverage funding (Abase).

<sup>3</sup> HC Abase matching funds have been estimated.

<sup>4</sup> NRCan leverage funds are from Abase and external collaborators.

<sup>5</sup> EC leverage funds are from Abase.

<sup>6</sup> DFO leverage funds are from Abase and external collaborators.

## 5.0 Research Program Plans and Activities

Projects funded by the Genomics R&D Initiative are focused on departmental mandates and government priorities, and are aligned with the strategies of their respective departments. Research projects support regulatory and policy development, and help support sustainability in several key Canadian industry sectors (e.g. forestry, agriculture, fisheries, and life sciences). Research project plans are established based on measurable outputs and performance indicators. The performance outputs are achieved through enhanced governance, cross-departmental coordination and science partnerships. Highlights of departmental plans and activities for 2006-07 (the second year of the third phase of research activity) are provided in the following sections. Additional details are provided in Annex 1 of Appendix A.

The NRC Genomics and Health Initiative continued to focus its efforts on six research programs oriented towards diagnosing, treating and preventing human and animal disease, developing technologies for pathogen detection, and advancing new technologies for cardiac care and the production of commercially valuable agricultural crops. The NRC-GHI Expert Panel conducted a formal mid-term review of GHI research programs in 2006-07 and recommendations were

made to NRC regarding changes to research objectives and direction as programs plans were established for the final year of GHI-3 (2007-08).

Intramural crop genomics form the AAFC Canadian Crop Genomics Initiative funded through the Genomics R&D initiative. Peer reviewed projects focus on functional genomics of disease and insect resistance, tolerance to stresses such as cold and drought, and enhanced quality attributes, in cereals (wheat and corn), oilseeds (Brassica/Arabidopsis) and legumes (soybeans). The Canadian Crop Genomics Initiative met to highlight progress of existing projects and develop guidelines for the next call for proposals in early October that will address evolving genomics requirements to support AAFC's expanded research priorities, particularly related to new opportunities in the bioeconomy.

Health Canada/Public Health Agency of Canada projects continued as planned, following guidelines and the overall objectives of the Initiative. These projects enhanced the regulatory agenda and the knowledge base of genomics within the Genomics R&D Initiative ensuring Canada's contribution to the biotechnology community.

The Genomics R&D Initiative at Natural Resources Canada continued to generate the scientific knowledge required for the development of tailored solutions to specific forestry issues, focusing on species and traits that are of economic importance. The following themes were supported: emerging environmental issues: to address novel forestry concerns such as monitoring and response to pests and pathogens; relationships between genomes: to study the genetic profiles and evolution of main pests, host defense mechanisms, host-pathogen interactions; and sustainable forestry and competitiveness: towards targeted improvements of tree growth, wood quality characteristics and resistance to biotic and abiotic agents.

Environment Canada has developed internal capacity in eco-toxicogenomics and is using this capacity to explore how best to use genomics to fulfill Environment Canada mandates to protect Canadian aquatic systems, terrestrial systems, and wildlife from the harmful effects of existing and emerging environmental stressors (chemical, biological, and physical). Environment Canada investigators in eco-toxicogenomics have formed alliances with broader national and international efforts in eco-toxicogenomics, and are acknowledged for their expertise in these disciplines and the value of their work.

At DFO, in addition to continuing to focus research within three themes, aquatic resource profiling, aquatic animal health and aquatic ecosystem health; a strategic decision to reorganize expertise and infrastructure was developed, during the second phase of Genomics R&D Initiative funding with the Maritimes Region, was undertaken. This reorganization has positioned the Maritimes Region to increase access to genomics expertise and infrastructure, facilitating

increased collaborations with DFO scientists within and external to the Region, and with external partners.

## 6.0 Performance

### 6.1 Introduction

Annual Performance Report data are presented using the performance indicator categories outlined in the Genomics R&D Initiative RMAF. As noted in the following sections, participating departments and agencies have made excellent progress towards the overall objectives of the Genomics R&D Initiative. This includes the creation of new knowledge and technologies targeted towards improvements in human health, environmental management, agriculture and food safety, and improved sustainability and management of natural resources.

### 6.2 Management

While good management is an important aspect of any government program, it is particularly important to recognize for the Genomics R&D Initiative because of the complex governance as well as its important contribution to results. There are six departments and agencies involved in the initiative and it is important that the practices are in place to support effective departmental and interdepartmental coordination. It is also critical that departmental and initiative priorities are well defined so that the projects are selected to ensure that government-wide priorities for genomics R&D are addressed. Table 3 provides a summary of collaborations during the review period (broken down by type and organization):

**Table 3: Collaborations by Type and Organization**

Type	NRC	AAFC	HC	NRCan	EC	DFO	Totals
OGDs	7	2	6	11	10	6	42
Universities (Canadian and International)	21	17	11	32	13	9	103
Other International Research Organizations	6	7	-	9	5	1	28
Other Canadian Research Institutions	-	-	4	-	-	8	12
Private Sector	4	23	-	2	-	5	29
Other Public Sector Organizations	-	-	6	-	-	1	7
<b>Totals</b>	<b>38</b>	<b>49</b>	<b>27</b>	<b>54</b>	<b>28</b>	<b>30</b>	<b>221</b>

Good complementarity and linkages have been also developed between federal departments participating in the Genomics R&D Initiative and Genome Canada. Several departments collaborate with external collaborators in projects funded by the regional Genome Canada Centres, as well as international Genome Canada

initiatives. For example, the NRCan Canadian Forest Service (CFS) is a strong collaborator in the Genome Canada/Genome Quebec project Arborea II, which identifies genes linked to the natural variability of growth and wood properties in a species of key economic importance, white spruce. The research is being led by researchers at Université Laval and 30% of the project team members are from the CFS.

As well, NRC and AAFC researchers are working collaboratively on projects managed by Genome Prairie and Genome Alberta (*Enhancing Canola through Genomics* and *Designing Oilseeds for Tomorrow's Markets*) to examine how gene expression is involved in Canola development. The research also involves the University of Alberta and several international collaborators. The objective of the research is to develop methods to improve seed quality and yield.

### 6.3 Genomics R&D Capacity

Capacity building was the focus of the earlier phases of this initiative and this capacity continues to be maintained and expanded in the current phase. The hiring of new highly qualified personnel (HQP) and training of existing personnel ensures that federal labs maintain their capacity to undertake research projects required to ensure the success of the initiative as well as be credible participants in genomics R&D and related applications. It is also critical to maintain existing infrastructure as well as acquire new state-of-the-art infrastructure to ensure that federal labs can continue to play their role in genomics research related the development of regulations, policies and other decisions.

During 2006-07 departments continued to invest in core infrastructure facilities: including DNA sequencing, proteomics and microarray. Funding was also allocated towards the purchase, maintenance and upgrading of laboratory equipment and facilities.

During the past year good progress was made towards the development of HQP that included post-doctoral fellows (PDFs), scientific and technical staff as well as students. The following list provides a summary by category for the Initiative (additional details broken down by department / agency are provided in Annex 2 of Appendix A):

- 78 PDFs;
- 94 Scientific and technical staff;
- 99 Students (B.Sc., M.Sc., Ph.D., and Co-op);
- 5 Visiting Scientists / Visiting Fellows.

### 6.4 Research and Development

R&D is the central component of this initiative. All activities surrounding the actual conduct of R&D, the transfer of the technologies developed and / or the

dissemination of the research results / scientific knowledge is critical to ensuring progress towards all outcomes and ensuing impacts.

A key element of the Genomics R&D Initiative is to ensure that Canada remains in the forefront as one of the world's major players in this new, emerging science. This is achieved through scientific publications and presentations at national and international conferences and workshops. Additionally, during the review period scientists in participating departments filed 6 patents, with another 24 applications in progress, and more than 100 patents active. The following list provides direct outputs related to R&D accomplishments (additional details broken down by department / agency are provided in Annex 3 of Appendix A):

- 286 chapters/papers in refereed journals;
- 99 papers in refereed conference proceedings;
- 48 papers in conference proceedings;
- 164 invited presentations;
- 20 technical reports;
- 28 participations in national conferences / workshops;
- 100 participations in international conferences / workshops;
- 36 participations in national/international committees and networks;
- 6 patents issued, 24 patent applications;
- 49 poster presentations.

As part of the 2006-07 Report on Plans and Priorities, the participating departments established a collective set of planned results. A summary of the results achieved are provided in Table 4 (following page).



**Table 4: Planned versus Achieved Results (2006-07)**

Planned Results	Achieved Results
<p>1. Achieve commercially relevant advances in areas of genomics R&amp;D related to human health (e.g. genetic testing, diagnostics, microbial genomic applications, treating and preventing human diseases such as cancer and cardiovascular disease, and pathogen detection).</p>	<p>1.1 Cancer research is targeted at discovering gene/protein changes that either cause or provide signatures of cancer, and to use them as targets for therapeutic molecules and for imaging techniques that detect disease and track the efficacy of therapy. Work with glioblastoma cell models and clinical samples have resulted not only in the identification of biomarkers for the vasculature of brain tumors, but also in the identification of a family of markers with anti-angiogenic activities (i.e. ability to reduce the growth of new blood vessels): the Insulin-Like Growth Factor Binding Protein (IGFBP) family. A provisional patent has been filed that encompasses the utilization of these molecules and related peptides as anti-angiogenic molecules with potential applications in the treatment of cancer.</p>
<p>2. Realize crop value Improvements in cereals, soybean and canola through quality improvements in areas related to plant adaptation to biotic and abiotic stresses (e.g. resistance to disease, tolerance to drought and cold), as well as seed development and metabolism (e.g. related to oil content for biofuels and nutraceutical applications).</p>	<p>2.1 A functional analysis of Brassica (e.g. canola) seed development and metabolic processes is being undertaken with the goal of improving Brassica seed quality traits. The cell biological bases for thinner and lighter seed coat in yellow-seeded canola have been determined, providing a structural handle/target for further manipulation. Researchers have now shown that the development of seed coat is temporally and intimately related to embryo development in canola. The functionality of a promoter to a specific layer of the seed coat is now established, offering a tool for manipulating this part of the seed coat. This manipulation technique could lead to the development of more durable and productive Canola crops – a matter of growing importance in the global search for cost-effective and efficient renewable fuels.</p> <p>2.2 In order to develop new wheat breeding strategies for complex traits of economic importance and to uncover the genetic basis of these traits, progress has been made in relating the function of specific genes to the trait itself. This has been accomplished by creating a genetic map of gene expression during seed development and correlating it to a similar map for traits. This approach has identified several wheat chromosomal locations which are important regulators for economically important traits and also control the expression of many genes.</p> <p>2.3 Fusarium Head Blight (FHB) is a major wheat disease with food safety implications. In wheat, the locations of three genes which provide resistance to FHB have been precisely mapped. This has led to the development of</p>

Planned Results	Achieved Results
	<p>robust diagnostic markers for these important genes. The markers and genetic map information are now implemented in the wheat breeding process in Western Canada. This information has been passed onto European and US colleagues with similar interest in FHB resistance genes.</p> <p>2.4 Over 80 of the genes responsible for the seed gluten proteins have been sequenced. These proteins are the primary determinants of wheat bread making quality. Wheat collections were screened to determine the evolutionary mechanism that led to the development of this important seed quality trait. The genes responsible for another important seed quality trait, hardness, have also been identified and sequenced. Further investigation of these sequences will provide some insight into the evolution of this major seed trait.</p> <p>2.5 Wheat Leaf Rust, caused by the fungus <i>Puccinia triticina</i>, is a disease that is genetically well characterized and forms a useful disease model for cereals. Proteomics has been utilized to find out which proteins play a role in disease development and this study has been extended to characterize post-translational phosphorylation events, which are responsible for regulating biochemical processes, such as disease development and resistance.</p>
<p>3. Implement the sustainable management of aquatic resources through the use of genomics tools to: manage fishery openings; generate increased understanding of population genetics and structure; further understanding of behavioural, physiological and immunological responses to the environment; and through the management of aquatic animal diseases (e.g. vaccine development for farmed fish).</p>	<p>3.1 Research to develop efficient new tools and technologies for vaccine development and vaccine delivery in farmed fish (e.g. Atlantic Salmon) is targeted at reducing costs while increasing the value of the Canadian industry. The genome of a major pathogen that affects Atlantic salmon (<i>Aeromonas salmonicida</i>) has been annotated and submitted to GenBank. The program's first live attenuated vaccine candidates were tested in Atlantic salmon and three promising vaccine candidates were identified and proved to show significant protection during trials.</p> <p>3.2 Research to efficiently and effectively identify genetic differences between two morphologically similar mussel species <i>Mytilus edulis</i> and <i>M. trossulus</i>, and determine the relative distribution of these species within Nova Scotia is being undertaken, with support from industry and the province of Nova Scotia. Genetic markers have been developed and optimized for higher throughput analysis and for use in future selective breeding activities. Results indicate that there are very different species compositions at locations that are</p>

Planned Results	Achieved Results
	<p>adjacent to each other, and have identified sites suitable for mussel seed collection for use in aquaculture in Nova Scotia, thereby helping to overcome the impacts from the restriction of movement of species from areas with aquatic invasive species.</p> <p>3.3 In order to better manage fishery openings and understand the changing behaviour of fish stocks due to climate change and pollution, genomics tools including gene expression profiling are being used to determine physiological changes along the migration route to natal streams that is associated with early entry, a behavioral shift in late run Fraser River sockeye salmon. Results to date indicate that osmoregulatory readiness was not used to cue the timing of river entry but may be important to successful migration within the river. Predictive biomarkers are being developed for monitoring relevant genes to enable pre-season prediction of migration behaviour and fish survival for fishery managers.</p> <p>3.4 Infectious diseases present a significant economic burden to finfish aquaculture industries and there is concern that diseases may also negatively impact wild fish populations. Genomic approaches are being used to better understand the diversity of viral hemorrhagic septicemia virus (VHSV) and to relate this diversity to host responses to infection, disease development, and recovery or resistance to, clinical disease. Multiple isolations of VHSV from marine waters off the coast of New Brunswick, Nova Scotia and British Columbia have been genetically analyzed, and this information has been used to develop a database for use in rapid identification and analysis of isolates. Recently, VHSV has been detected in the Great Lakes region; this strain is most closely related to isolates from New Brunswick and Nova Scotia, suggesting introduction from an eastern reservoir. Research is continuing to better understand the genetic basis of virulence among strains identified in Canadian waters.</p>
<p>4. Position the Canadian regulatory system for health to enable innovation while minimizing the risks to Canadians through a focused genomics R&amp;D program aimed at strengthening capacity in priority areas such as</p>	<p>4.1 Federal scientists, together with local, national and international collaborators, continued their focus on microbial genomics particularly those related to common causes of food borne and waterborne infections. New tools were developed for genomic analysis of pathogens associated with different levels of virulence for humans. These are likely to prove effective in rapid detection, surveillance and risk assessment of subtypes of organisms with the greatest public health risk.</p>

Planned Results	Achieved Results
<p>genetic information, biotechnology products, human genomics and microbial genomics, on human, animal and environmental health.</p>	<p>4.2 Further research involved the development and application of "omics" tools to: reduce exposure to foodborne pathogens; assess and mitigate risks associated with food borne chemical contaminants; assess effects of nutrients or other food bioactives on health risks in Canadians and vulnerable groups with specific genotypes.</p> <p>4.3 A project has been extended to build on existing research initiative entitled "Evaluation of Environmental Toxicogenomics for Use in Regulatory Toxicology &amp; Risk". Toxicogenomics is the application of genetic methods to the study of toxicology. The results from the project have led to the development of processes that permits very low levels of toxicity to be measured. This approach is being studied to determine if this type of analyses can provide a more rationale, objective reference methodology for toxicological risk assessment in organisms.</p> <p>4.4 Genomics has played a critical role in facilitating new understanding of the health risks related to radiofrequency radiation (e.g. cellular phones, Product Safety Program-PSP); tobacco smoke (Tobacco Control Program); cannabis smoke (Drug Strategy and Controlled Substances Program); air pollution (Safe Environments Program-SEP; endocrine disrupters; microbial biotechnology products; and contaminated sites.</p> <p>4.5 Research continues on pharmacogenomic and biotherapeutics data. This data holds the possibility to influence human drug approvals in Canada. Health Canada recognizes the increasingly significant role that such data will play in future drug submissions. Research projects have led to a better understanding of the methods and data analyses involved in the generation of genomic/proteomic data with respect to biotherapeutics. This increased understanding helps position HC to meet the regulatory challenges of analyzing such data in order to issue sound, science-based decisions.</p>
<p>5. Increase knowledge of forest generation and protection methods, and for addressing environmental impact considerations, through a focused genomics R&amp;D effort on species and traits that are of economic</p>	<p>5.1 On the forest regeneration side, transgenic lines of white spruce and poplar over-expressing specific candidate genes involved in processes linked to wood formation and defense response were produced, as an innovative approach to functional and ecological analysis; some were transferred to partners for further investigations. Single nucleotide polymorphisms (SNPs) were analyzed for 144 candidate genes for wood traits in white spruce to compare gene frequencies in breeding</p>

Planned Results	Achieved Results
importance to Canada.	<p>and natural populations and three new genetic linkage maps were developed for quantitative trait loci (QTL) analyses. Molecular phenotyping was performed under controlled environmental conditions to assess molecular and biochemical changes occurring during bud set in white spruce. A web database was developed and transferred to the Genome Canada Arborea II project, allowing integration of information. A genetic linkage map of a blister rust resistance gene was constructed in western white pine, providing a molecular tool for marker-assisted selection in provincial (BC) breeding programs.</p> <p>5.2 On the forest protection side, CFS scientists co-lead initiatives to completely sequence and annotate the genome of forest pathogens (poplar rust and the mountain pine beetle fungal associate), and to analyze the genome of the invasive fungus causing sudden oak death. Protocols for transcriptome studies of host-pathogen systems were developed. As a result, several candidate genes involved in pathogenicity and elicitation of defense response in plants were identified (poplar rust, Douglas-fir laminated root rot, white pine blister rust); markers to characterize populations were validated; viral infection processes were better characterized (in spruce budworm); and the first report of baculovirus gene expression profiling using oligoarrays was published. The genome of a virus that specifically infects the balsam fir sawfly was completely sequenced and genomics-based evidence was used to assess its environmental safety and register it as a biological control product under the name Abietiv™. A spin-off company, Sylvar Technologies Inc., successfully commercialized Abietiv™ for large-scale application in balsam fir forests in Newfoundland. Finally, the unicellular microsporidia, a group of insect pathogens that are little known, are being considered for use as potential biological control agents and their taxonomic classification was verified through DNA sequence analysis.</p>
6. Develop genome-science applications to support regulatory and enforcement activities in key areas such as environmental risk assessment and management; enforcement and compliance; pollution	<p>6.1 Environmental genomics-based approaches were used to:</p> <p>(1) investigate molecular-level effects of environmental contaminants on wild species to improve environmental risk assessment/ monitoring;</p> <p>(2) conduct molecular characterization of communities of microbes in contaminated soil so as to enhance bioremediation;</p> <p>(3) detect pathogenic micro-organisms in wastewater so</p>

Planned Results	Achieved Results
detection, monitoring and prevention; conservation biology and wildlife genetics; technology forecasting and assessment; and the responsible and sustainable development and use of bio-based products and industrial processes.	<p>as to assess the effectiveness of sewage treatment;</p> <p>(4) Improve decision making regarding management and conservation of several species of concern (e.g. polar bears; various bird populations).</p> <p>6.2 Investments continued in environmental genomics foresight, knowledge development, and outreach (e.g. periodic comparative analysis of international environmental genomics activities via bilateral with US EPA, US DOE, UK, OECD and Society of Environmental Toxicology and Chemistry; preparation for future integration of genomics-derived data from notification packages submitted under CEPA; potential applications of genomics to harness microbial systems for bioremediation, bio-energy, and climate change mitigation).</p> <p>6.3 In accordance with DFO's mandate to protect fisheries habitat, genomics tools are being used to assess the health of aquatic ecosystems. As bacteria are responsible for the biodegradation and biotransformation of environmental contaminants and respond rapidly to their surrounding environment, research is being undertaken to assess the use of changes in aquatic microbial community structure and function as an indicator of environmental health and/or habitat recovery in contaminated sites.</p>

## 6.5 Outreach

While the previous three components are important to ensuring that the right research is done at the right time and that the research results are disseminated to the right people who use them the right way, it is also important for genomics to be well understood and accepted by Canadians. Direct and indirect public communications are therefore an important aspect of this initiative. During the review period there were 17 media interviews, 3 press releases and more than 17 community presentations. Additionally, departments maintain public websites, and have published pamphlets and brochures detailing genomics R&D results and achievements. Additional details broken down by department / agency are provided in Annex 4 of Appendix A.



## **Appendix A – Supplemental Performance Details**

### **Annex 1 – Project Activities by Department**

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#### NRC Research Programs

- Brassica Seed Development
  - The Functional Genomics of Brassica Seed Development and Metabolism Program represents a comprehensive functional genomics dissection of canola (and related *Brassica* spp) ranging from embryogenesis through maturation and germination.
- Pathogen Detection
  - This program is focused on developing new technologies that will facilitate rapid, cost effective biomolecular sensing for applications ranging from field devices to point-of-care analyses.
- Chronic Cardiovascular Disease
  - This program is aimed at developing improved imaging and diagnostic methods to assess patient response to treatments, to assist in planning and guidance of surgery as well as aid in the effective triage of patients.
- Kinase Signaling Networks
  - This research project seeks to evaluate the protein-protein interactions that link proteins in cell signaling systems as possible targets for small molecule therapeutics of human diseases.
- Aquatic Animal Disease Management
  - This program is focused on developing targeted antigens and delivery systems for vaccine development against pathogens affecting Atlantic salmon.
- Personalized Medicine for Cancer
  - The aim of this program is to discover gene/protein changes that either cause or provide signatures of cancer and to use them as targets for therapeutic molecules, and for imaging techniques to detect disease and track the efficacy of therapy.

#### AAFC Research Activities

- Biotic Stress
  - Disease and insect-resistance are important characteristics in all crops. Molecular biologists and entomologists are examining and developing a molecular basis for both antibiotic and antixenotic approaches to insect resistance. Research is ongoing to develop germplasm and varieties with resistance to economically important insects.

- Abiotic Stress
  - Cold and heat tolerance and freezing resistance are important characteristics for almost all crops and are of crucial strategic importance to Canada. Freezing resistance has a significant bearing on yield stability and cold tolerance and has a major influence on yield potential. Parallel gene discovery programs in different systems uncover novel and complementary avenues to engineering increased cold tolerance and increased frost resistance.
- Enhance quality attributes in cereals (wheat and corn), oilseeds (Brassica/Arabidopsis) and legumes (soybeans).
  - Demonstrated technologies for radically improving the nutritional quality of canola meal. AAFC has made a significant contribution to the international Brassica genome sequencing effort and success in Brassica genomics has prompted official UK-Canada cooperation Brassica functional genomics.
  - The recent discovery of a genetic factor in legumes that responds to signals from nitrogen fixing bacteria was significant. This factor is essential for nitrogen fixation by legumes. Plants that are able to make their own fertilizer will be a clear step towards reducing the use of fossil fuels and synthetic materials by agriculture.
  - Seed quality is a major component of all cereals, pulses, and oilseed crops. The genes that control seed development, carbon partitioning, protein quality, oil quality, starch quality, and the accumulation of anti-nutritional compounds are major targets for discovery and modification. This area includes compounds of nutraceutical interest, such as phytosterols, anthramides and glucans, etc.
- The annual meeting of Canadian Crop Genomics Initiative held September 12 and 13 in Penticton, B.C. highlighted progress of existing projects and developed guidelines for next call for proposals in early October that will address evolving genomics requirements to support AAFC's expanded research priorities, particularly related to new opportunities in the bioeconomy.
- Progress in extramural genomics was reviewed at the annual Canadian Plant Genomics Conference at Vancouver July 30-August 2.

#### HC Projects

- Validation of Toxicogenomics for Use in Regulatory Toxicology.
- Genomic-Guided Proteomic Analyses.
- Biological Validations of Instability in Tandemly Repeated Genomic Sequences in Rodent and Human Cells for Purposes of Regulatory Genotoxicity Evaluations.



- Application of the p53<sup>+/-</sup> transgenic mouse for alternative cancer bioassays: Genomic characterization of tissues from mice exposed to genotoxic and non-genotoxic carcinogens.
- Study of interferon-induced hepatic injury using genomic and proteomic approach.
- Biomarkers of Exposure and Effects of Inhaled Contaminants in Atherosclerosis and Asthma.
- Biomarker Discovery for Diagnosis of Prion Disease.
- Biotech 2005: A Genetic “Knock-Down” Approach to Identify host Cellular Factors Essential for Infectious Agent Replication and Pathogenesis.
- LFZ Salmonella Genomic Research Groups.
- Immuno-informatics for Epitope Discovery in Infectious Pathogens: Applications in Identification of Potential Diagnostic Markers and Vaccine Candidates.

#### NRCan Projects

- Nucleopolyhedrovirus functional and comparative genomics.
- Functional genomics of Choristoneura fumiferana multicapsid nucleopolyhedroviruses (CfMNPV): role of all the open reading frames in the infection process.
- Transcriptomics analysis of insect molting.
- Effects of the larval host on genomic variation and evolution of insect viruses: implications for pest control.
- Molecular tools for studies on the ecology and phylogeny of microsporidia in forest defoliators.
- A tree functional genomic platform for gene function discovery.
- Genome-wide scan to reveal genes underlying growth productivity traits in white spruce (*Picea glauca*).
- Association mapping of wood characters in white spruce.
- Fungal genomics for protection and conservation.
- Interacting genomes.
- Molecular and genetic characterization of conifer host-laminated root rot (*Phellinus* spp.) pathosystems.
- Molecular analysis, elicitor activity, isolation of functional R genes and genetic engineering of white pine resistant to blister rust fungus.

### EC Projects

- Application of genomics to monitor the health and activities of microbial communities in contaminated soils and stressed riverine environments
- Development and standardization of test methods using environmental genomics techniques
- Application of genomics methods and end-point measurements for aquatic toxicological testing and environmental effects monitoring
- Development and application of novel genomics-based techniques for the detection of environmental microorganisms and the assessment of chronic toxicity in wastewater
- Gene expression technologies – application of genomics to wildlife toxicology
- Development and validation of a lobster eco-toxicogenomic array – correlation of gene expression profiles with traditional toxicological end-points for contaminant exposure, histological effects, and behavioural changes
- Environmental safety of biotechnology to aquatic ecosystems – impacts of transgenic crops and commercial bacterial consortia to aquatic invertebrates
- Validation of genomics tools for the prediction of environmental effects: response of fish to contaminated sediments
- Application of genomics to microbial source tracking: identification of genetic markers specific for animal fecal pollution in aquatic environments.

### DFO Projects

- Phylogeography and pathogenomics of viral hemorrhagic septicemia virus (VHSV) and salmon anemia virus (ISAV) in Canada in order to better understand the diversity of VHSV and ISAV and to relate this diversity to finfish host responses to infection, the development of disease and the recovery from or resistance to, clinical disease.
- Novel recombinant vaccines against Infectious salmon anemia virus (ISAV): conception and efficacy of a novel Heat-Shock Protein-peptide vaccine for Infectious salmon anemia virus using fish cell line models.
- Application and validation of metagenomics for monitoring aquatic ecosystem health: metagenomics analysis for defining impact zones from produced water discharges around offshore oil production platforms.
- Development and use of comparative molecular markers to assess levels and patterns of genetic diversity in winter skate (*Leucoraja ocellata*) in order to investigate the level of population subdivision of winter skate, ranging from special concern to threatened under COSEWIC, from Nova Scotia and the Gulf of St. Lawrence.
- Genetic profiles of *Mytilus edulis* and *Mytilus trossulus*: To validate existing DNA based species identification methods, optimize suitable markers

for higher throughput use and utilize these optimized markers to determine the relative frequency of the two species (and their hybrids) at several mussel seed collecting locations.

- SNP development for Atlantic cod to allow for comparison of stock structuring and gene flow estimates among several key populations and for use in evaluation of future applications for stock identification purposes.
- Sequence-level comparison of Atlantic and Pacific salmon growth hormone gene genomic regions in order to examine the utility of genomic information emerging for Atlantic salmon for application to Pacific salmon genetics and physiology research.
- Identifying Conservation Units Among Wild Anadromous Atlantic salmon through assessment of microsatellites variation between New Brunswick and Nova Scotia populations.
- Expression profiling of Fraser River late run sockeye salmon: migration physiology uncovered using cDNA microarray technology.

## **Appendix A – Supplemental Performance Details**

### **Annex 2 – HQP by Department**

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NRC – 59 new research & technical personnel were active under the Initiative:

- 22 PDF
- 23 technical officers
- 3 computer services personnel
- 7 research officer/research council officers

AAFC – 22 new research & technical personnel were active under the initiative:

- 33 PDF
- 3 visiting scientists
- 61 University students
- 25 Scientific & Technical Staff

HC – 36 new research & technical personnel were active under the Initiative:

- 9 PDF
- 2 Term positions
- 3 indeterminate positions
- 16 students (M.Sc. and Ph. D. candidates)
- 6 technical positions

NRCan – 50 research & technical personnel were active under the Initiative:

- 10 PDF
- 9 research scientists
- 8 technicians/biologists
- 22 university students (M.Sc. and Ph. D. Co-op)
- 1 Visiting fellow

EC – 9 new research & technical personnel were active under the Initiative:

- 3 PDF
- 2 research scientists
- 1 Engineering and Scientific Support
- 2 term positions
- 1 NSERC Visiting Fellowship

DFO – 4 new research & technical personnel were active under the Initiative:

- 1 Post-Doctoral Fellows
- 1 Technical Staff (temporary)
- 2 Scientific Staff (permanent)

## **Appendix A – Supplemental Performance Details**

### **Annex 3 – R&D Outputs by Department**

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#### NRC

- 126 papers in peer reviewed journals
- 68 papers in referred conference proceedings
- 93 invited presentations
- 3 technical reports
- 42 other publications
- 13 participations in national conferences / workshops
- 66 participations in international conferences / workshops
- 5 participations in national committees and networks
- 10 international committees and networks
- 2 genomics related databases
- 10 active patents
- 12 patent applications
- 3 patents issued
- 3 Material Transfer Agreements
- 38 Formal Collaborative Agreements

#### AAFC

- 65 papers in refereed journals
- 23 papers in referred conference proceedings
- 50 invited presentations
- 9 technical reports
- 12 book chapters
- 56 other publications
- 7 Public Servant Invention disclosures
- 112 active patents, 12 patent applications, 2 patents issued
- 2 licenses issued

#### HC

- 38 chapters in print in refereed journals
- 22 contributions at invited presentations
- 4 book chapters
- 9 posters in presentations
- 15 publications in conference publications

#### NRCan

- 40 publications in referred journals
- 33 publications in conference proceedings
- 1 national symposium report
- 13 invited presentations
- 1 technical report

- 3 book chapters
- 15 national conference presentations and posters
- 34 international conference presentations and posters
- 1 provisional US patent was granted and a full US patent is at the final processing stage

EC

- 11 papers in refereed journals (hard copy / electronic)
- Information about journals available on request, 2 are in preparation
- 2 papers in refereed conference proceedings
- 6 invited presentations
- 6 technical reports
- 10 other publications

DFO

- 6 papers in refereed journals
- 6 papers in refereed conference proceedings
- 1 technical report
- 4 book chapters
- 2 invited presentations
- 15 participations in national committees
- 6 participations in international committees

## **Appendix A – Supplemental Performance Details**

### **Annex 4 – Outreach by Department**

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#### NRC

- 1 media interview
- 1 press release
- 2 websites (internal and external)
- Several community presentations and tours are conducted at NRC-GHI participating institutes across Canada (Partner's in Education, Discovery Day, Science Fairs, etc)
- NRC-GHI Phase III brochures were developed and are available for conferences,
- Workshop participation with fact sheet made available as handouts

#### AAFC

- 2 media interviews
- 1 press release
- 2 fact sheets and related databases
- Demonstrations to public through open house
- Presentation in public schools
- Participation in science fairs

#### HC

- Increasing the internal and external awareness and understanding of genomics research results and applications is the main outreach objective of several HC projects
- Intergovernmental conferences have occurred detailing genomics research results and achievements

#### NRCan

- 14 media interviews
- 15 community presentations

#### DFO

- 1 press release
- 2 community presentations
- 1 fact sheet
- 3 tours

## Appendix B – Genomics R&D Initiative: RMAF Overview

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In fulfillment of the requirements and guidelines of the Treasury Board Secretariat, a Results-based Management and Accountability Framework (RMAF) has been developed for the interdepartmental Genomics R&D Initiative. The RMAF formalizes the commitment of the six departments involved in the Initiative regarding the common measurement and accountability requirements associated with the Initiative.

A logic model has been developed (Figure 1) that reflects the overall objectives of the Initiative, recognizing that there are significant differences in particular needs and priorities of each department. Nevertheless, the intended goal of the Initiative is to build capacity inside government laboratories to do research related to genome sciences in order to support the achievement of departmental mandates, strengthen the regulatory system and bring the benefits of revolutionary advances in research and technology to a variety of Canadian industry sectors and regions. Key results are related to four important program areas:

- **Management** – while good management is an important aspect of any government programming, it is particularly important to recognize for this initiative because of the complex governance as well as its important contribution to results. In terms of governance, there are six departments and agencies involved in this initiative and it is important that the practices in place support effective departmental and interdepartmental coordination. It is also critical that departmental and initiative priorities be well defined so that the projects are selected to ensure that government-wide priorities for genomics research information are addressed. Without this, the genomics research results may inadequately support regulations, policies and other types of decisions. Without this important program component, some of the outcomes and ensuing impacts may not occur.
- **Capacity Building** – capacity building was the focus of the earlier phases of this initiative and it is critical that this capacity continue to be maintained and expanded. Without the hiring of new of highly qualified personnel (HQP) and training of existing personnel, the federal labs may lose some of their capacity and no longer be able to undertake the type of research projects required to ensure the success of the initiative as well as be credible participants in genomics research and applications. In order to continue to maintain the federal research capacity, it is also critical that the existing infrastructure be maintained and that new state-of-the-art infrastructure be acquired to ensure that federal labs can continue to play their role in genomics research to inform regulations, policies and other decisions. Without continued capacity building, some of the outcomes and ensuing impacts may not occur (or not be as successful).



- Research and Development – Research and development is the central component of this initiative. All activities surrounding the actual conduct of R&D, the transfer of the technologies developed and / or the dissemination of the research results / scientific knowledge is critical to ensuring progress towards all outcomes and ensuing impacts.
- Outreach (communications): While the previous three components are important to ensuring that the right research is done at the right time and that the research results are disseminated to the right people who use them the right way, it is also important for genomics to be well understood and accepted by Canadians. Direct and indirect public communications are therefore an important aspect of this initiative.

### **Performance Measurement Plan**

Table 3 outlines the performance indicators, sources and responsibility for the outcomes outlined in the logic model presented in Figure 1, which will be reported upon in the annual performance report. All information outlined in this table will be collected and reported annually.

Table 4 outlines the performance indicators, sources and responsibility for the outcomes outlined in the logic model which should be examined at the time of a future impact evaluation. While information in this table may be collected annually, it will be analyzed and reported upon at the time of the impact evaluation.

Individual departments may also report on their individual progress in their Departmental Performance Report and use the information to adapt their programming and priorities.

Tables 3 and 4 therefore outline specific data that needs to be collected by all departments, where appropriate. While some of the data will only be collected and / or analyzed at the time of the impact evaluation, the tables outline the following ongoing departmental requirements:

**Interdepartmental information:** Departments must maintain a record of all minutes of meetings, decision records, planning documents, etc. of an interdepartmental nature that has affected the way in which the initiative has been implemented in their own departments.

**Departmental information:** Departments also need to maintain a record of internal information that has affected the way in which the initiative has been implemented in their department. This includes program-level funding information (A-base and B-base funding), human resource information (hirings,

training), non-project specific participation in national / international committees, conferences and networks, website statistics.

**Project-specific information:** This includes the following information on projects:

- project applications (proposals, peer review assessments, etc.)
- projects approved (title, scope, \$ funded, description, objectives, lead scientist, team members)
- interdepartmental projects (title, scope, \$, # of departments, description, objectives, lead scientist, team members)
- partners, collaborators on projects (names, type, \$ contribution, in-kind contribution, role)
- regulators, policy makers, others accessing research results (names, titles, contact information)
- use of project funds (budgets vs actuals including any overhead charges or corporate taxes )
- infrastructure projects (types, \$, % of total)
- # of papers in refereed journals (names of journals)
- # of papers in refereed conference proceedings
- # of invited presentations
- # of technical reports
- # of book chapters
- # of other publications
- # and type of participation in national / international committees, conferences and networks related to projects
- # and type of genomics related databases, libraries, etc. resulting from projects
- application of research results / technology transferred
- new products, tools, processes developed
- spin-off companies (#, types, names, contact information)
- # of disclosures
- # of active patents, patent applications, patents issued
- # of licenses issued
- # of Material Transfer Agreements (MTAs)
- # of formal collaborative agreements
- # of standard operating protocols

Figure 1 – Logic Model for the Interdepartmental Genomics R&amp;D Initiative

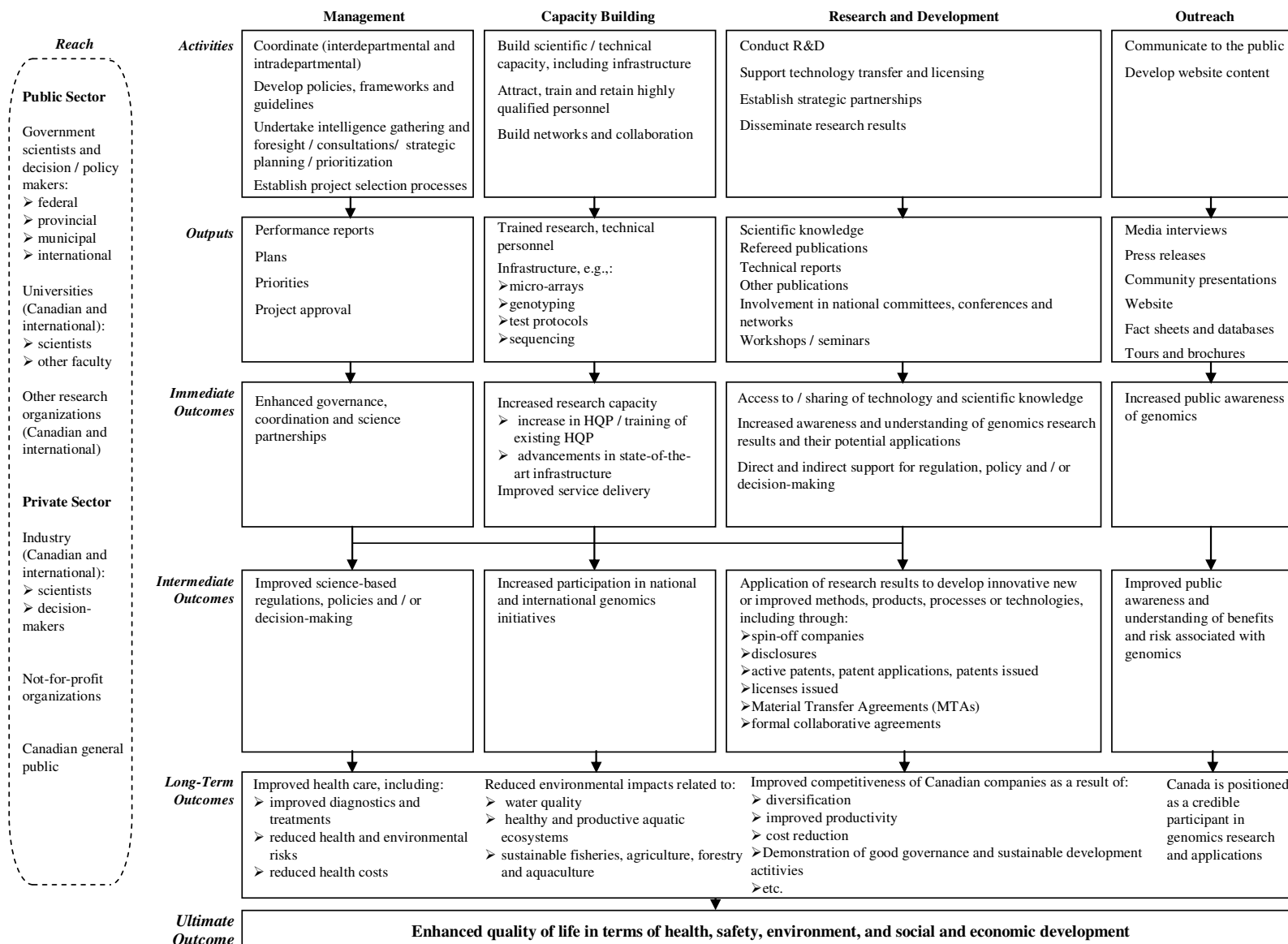


Table 3: Annual Performance Measurement Strategy

Area	Ongoing Indicators	Sources	Responsibility
<b>Immediate Outcomes</b>			
Enhanced governance, coordination and science partnerships	# of interdepartmental research initiatives (table summarizing initiative, scope, \$, # of departments involved, description)	Project information	Departments
	# of partnerships / collaborations on projects by type, e.g.: < OGDs < universities < international organizations < private sector < Genome Canada < etc.	Project information	Departments
	Internal \$ leveraged: < A-base and B-base funding	Departmental records	Departments
	Other funding and in-kind contributions by type (complementary to previous information on collaborations), e.g.,: < OGDs < universities < international organizations < private sector < Genome Canada < etc.	Project information	Departments
Increased research capacity: < Increase in HQP / training of existing HQP	# and type of new research personnel: < permanent and temporary (PDFs, students) < scientific and technical support	Departmental records	Departments
	\$ and % of allocation to training and related HQP activity	Departmental records	Departments
	# of existing staff trained (genomics related)	Departmental records	Departments
	# of existing departmental staff working on Genomics R&D funded projects (increasing expertise by doing research)	Departmental records	Departments

Table 3: Annual Performance Measurement Strategy

Area	Ongoing Indicators	Sources	Responsibility
< advancements in state-of-the-art infrastructure	Type of infrastructure: < acquired < adapted < upgraded < maintained	Project reports	Departments
	\$ and % of allocation to infrastructure	Departmental records	Departments
Access to / sharing of technology and scientific knowledge	# of papers in refereed journals (hard copy / electronic) < information about journals available on request	Project reports	Departments
	# of papers in refereed conference proceedings	Project reports	Departments
	# of invited presentations	Project reports	Departments
	# of technical reports	Project reports	Departments
	# of book chapters	Project reports	Departments
	# of other publications	Project reports	Departments
	# and type of participation in national / international committees, conferences and networks	Project reports Departmental records	Departments
	# and type of genomics related databases, libraries, etc.	Project reports	Departments
Public awareness of genomics	Web presence / # website hits / other website statistics	Analysis of website statistics	Departments
<b>Intermediate Outcomes</b>			
Increased participation in national and international genomics initiatives	Extent to which scientists in departments participate in other projects < national vs international < role on projects < leveraging < # of partners < OGDs vs universities vs private sector vs Genome Canada vs others < etc.	Project information	Departments
	Other types of participation in national and international genomics initiatives < number of initiatives < types of initiatives < role of departments / scientists	Departmental records	Departments

**Table 3: Annual Performance Measurement Strategy**

Area	Ongoing Indicators	Sources	Responsibility
Application of research results to develop innovative new or improved methods, products, processes or technologies, including through: < spin-off companies < disclosures < active patents, patent applications, patents issues < licenses issued < Material Transfer Agreements (MTAs) < formal collaborative agreements	Description of application of research results (internal and external) and / or technology transferred	Departmental records	Departments
	# and types of spin-off companies	Project reports	Departments
	# of disclosures	Project reports	Departments
	# of active patents, patent applications, patents issued	Project reports	Departments
	# of licenses issued	Project reports	Departments
	# of MTAs	Project reports	Departments
	# of formal collaborative agreements / # of standard operating protocols	Project reports	Departments

**Table 4: Impact Evaluation Performance Measurement Strategy Requirements**

Area	Evaluation Indicators	Sources	Responsibility
<b>Immediate Outcomes</b>			
Enhanced governance, coordination and science partnerships	Evidence of coordinated planning (interdepartmental and intra-departmental), priority setting and management approaches (e.g., Genomics ADM Committee, Genomics R&D Working Group, linkages to CBS Fund and CRSB)	Minutes of meetings, decision records, planning documents, etc.	Departments and Genomics R&D Working Group
	# of interdepartmental research initiatives (table summarizing initiative, scope, \$, # of departments involved, description)	Project information	Evaluators based on departmental information
	# of partnerships / collaborations on projects by type, e.g.: < OGDs < universities < international organizations < private sector < Genome Canada.	Project information	Evaluators based on departmental information
	Internal \$ leveraged: < A-base and B-base funding	Departmental records	Evaluators based on dept information

**Table 4: Impact Evaluation Performance Measurement Strategy Requirements**

<b>Area</b>	<b>Evaluation Indicators</b>	<b>Sources</b>	<b>Responsibility</b>
	Utilization of funds for intended purposes	Project information	Evaluators based on dept information
Enhanced governance, coordination and science partnerships (continued)	Other funding and in-kind contributions by type (complementary to previous information on collaborations), e.g.,: < OGDs < universities < international organizations < private sector < Genome Canada.	Project information	Evaluators based on departmental information
Increased awareness and understanding of genomics research results and their potential applications	Extent to which projects have addressed key genomics information needs within the departments	Comparison of project objectives to dept priorities; interviews with departmental managers	Evaluators based on departmental information
	Extent to which regulators, policy makers, decision-makers are aware of projects, their results and their potential applications < within departments < in other departments < in other levels of government < in other organizations	Interviews with regulators, policy makers, other managers and others	Evaluators based on departmental information
Direct and indirect support for regulation, policy and / or decision-making	Extent to which scientific evidence related to genomics is available and used in the development of regulations and policies as well as in other types of decisions < within departments < in other departments < in other levels of government	Interviews with regulators, policy makers and other managers, review of decision records, discussion documents, White Papers.	Evaluators based on departmental information
Public awareness of genomics	Level of public awareness of genomics	Survey of general public	Evaluators
	Web presence / # website hits / other website statistics	Analysis of website statistics	Evaluators based on dept information

**Table 4: Impact Evaluation Performance Measurement Strategy Requirements**

Area	Evaluation Indicators	Sources	Responsibility
<b>Intermediate Outcomes</b>			
Improved science-based regulations, policies and / or decision-making	Evidence of contribution of scientific evidence to regulatory, enforcement, environmental assessment, public health and policy discussions and decisions < within departments < in other departments < in other levels of government	Interviews with regulators, policy makers and other managers, review of discussion documents, White Papers.	Evaluators based on departmental information
Increased participation in national and international genomics initiatives	Extent to which scientists in departments participate in other projects < national vs international < role on projects < leveraging < # of partners < OGDs vs universities vs private sector vs GC vs others.	Project information, interviews with scientists and partners	Evaluators based on departmental information
	Other types of participation in national and international genomics initiatives < number and types of initiatives < role of departments / scientists	Dept records, interviews with dept reps / reps of other initiatives	Evaluators based on departmental information
Application of research results to develop innovative new or improved methods, products, processes and technologies through: < spin-off companies < disclosures < active patents, patent applications, < licenses issued < Material Transfer Agreements < formal collaborative agreements	Description of application of research results (internal and external) and / or technology transferred	Departmental records	Evaluators based on departmental information
	# and type of products, tools and processes developed due to application of research results; description of use	Departmental records, interviews with recipient organizations	Evaluators based on departmental information
	# and types of citations	Citation analysis	Evaluators based on departmental information
Public understanding of genomics as an important contributor to their quality of life	Change in the level of public understanding	Survey of general public	Evaluators
	Change in media reporting	Content analysis of newspapers, other publications	Evaluators



**Table 4: Impact Evaluation Performance Measurement Strategy Requirements**

Area	Evaluation Indicators	Sources	Responsibility
<b>Long-Term Outcomes</b>			
Improved health care, including: < improved diagnostics and treatments < reduced health and environmental risks < reduced health costs	Extent to which research results are used for diagnostics, treatments, prevention, etc.	Case studies, interviews	Evaluators based on departmental information
	Specific health care impacts (refer to Departmental RMAFs for specific indicators)	Case studies, analysis of secondary data on health care	Evaluators
Reduced environmental impacts related to: < water quality < healthy and productive aquatic ecosystems < sustainable fisheries, agriculture, forestry and aquaculture	Extent to which research results are used to refine environmental regulations and improve pollution detection, monitoring, and enforcement activities	Case studies, interviews	Evaluators based on departmental information
	Specific environmental impacts (refer to Departmental RMAFs for specific indicators)	Case studies, analysis of secondary data on environment	Evaluators
Improved competitiveness of Canadian companies as a result of: < diversification < improved productivity < cost reduction < demonstration of good governance and sustainable development	Extent to which research results are used by Canadian companies	Case studies, interviews	Evaluators based on departmental information
	Performance of companies using research results vs others in that sector (refer to Departmental RMAFs for specific indicators)	Case studies, analysis of secondary data	Evaluators
	Improved performance of specific sectors affected by research results	Case studies, analysis of secondary data	Evaluators
Canada is positioned as a credible participant in genomics research and applications	Level of participation in international initiatives	Departmental records, interviews with departmental reps and reps of other initiatives	Evaluators based on departmental information
	Opinions of experts regarding participation of Canada	Literature review, interviews with experts	Evaluators based on departmental information
	Level of public and private investment in genomics R&D	Case studies, analysis of secondary data	Evaluators

**Table 4: Impact Evaluation Performance Measurement Strategy Requirements**

Area	Evaluation Indicators	Sources	Responsibility
<b>Ultimate Outcome</b>			
Enhanced quality of life in terms of health, safety, environment, and social and economic development	Miscellaneous quality of life indicators (e.g., improved health services / treatments, employment opportunities, lifestyle improvement, environmental benefits, etc.)	Case studies, secondary data, special studies, etc.	Evaluators