Draft Background Document Only. Expect Summary Report in mid September.

Cereal competitiveness in western Canada
Executive summary

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1. Introduction

Global geo-politics, increased competition from low-cost producers and the ability of global competitors to deliver improved crop functionality into international markets have eroded traditional advantages for western Canadian cereal crops and reduced producers' access to global markets. To respond to these pressures, the Alberta Crop Industry Development Fund (ACIDF) and the Alberta Agricultural Research Institute (AARI) have joined forces in an effort to improve cereal crop functionality and to raise production levels in western Canada.

To drive industry competitiveness, ACIDF and AARI propose increasing the level of domestic value-added processing for crops such as barley, oat, rye, triticale and wheat, by targeting genetic research in these key crops and by proving leadership for various cereal commercialization programs. These initiatives are designed to increase the level of competitiveness of the western Canadian cereal industry in existing and emerging domestic and global markets. Benefits include providing end-users with access to competitive feedstocks while raising producers' gross margins and net on-farm returns. Cereal crop acreage should increase in the Prairie Provinces and end-users will add commercial value to these crops in western Canada

ACIDF and AARI put together a team of consultants to start this process: Mr. Carman Read C&N Partners Inc.; Dr. Keith Briggs, Professor Emeritus University of Alberta, CEO GrainTek and Edmonton Branch Representative Alberta Institute of Agrologists; and Mr. Ron Pidskalny, M.Sc., P.Ag., President Strategic Vision Consulting Ltd. and Director Board of Governors Agricultural Institute of Canada.

This initial study is focused on gathering information from senior leaders in the public and private sectors, the plant breeding community, downstream participants in the bioethanol and livestock feeding industries and key western Canadian cereal crop producers. ACIDF and AARI will share this study with a broader community of stakeholders that includes western Canadian research groups, policy makers, funding agencies, those contributing to the cereal value chain and producer groups.

In this study, the team has identified a number of initiatives that could form the basis for a consultative process between ACIDF and AARI and its current partners – after which the funding partners propose investing $10 million in plant breeding projects across western Canada over the next five years.

ACIDF and AARI see teams of stakeholders developing and ranking an array of long-term strategies from the information presented in this analysis. Stakeholder groups would be charged with choosing a course of action and taking the lead in areas in which they can apply their knowledge and expertise. ACIDF and AARI see this process leading to the development of a coalition of industry stakeholders in the private and public sector that secures funding and sponsors a 10-15 year strategic plan for cereal development in western Canada.

2. Strategy development

The strategy development process follows standard business practice:

- Identify an overarching goal
- Conduct a macro-environmental scan to identify issues and trends that will shape the cereal industry in five to 10 years (STEEP analysis)
- Conduct a competitive overview of the bioethanol and livestock feeding industries
- Prepare an overview of the capability of western Canadian producers to meet the cereal feedstock needs of bioethanol producers and the livestock feeding industry
- Prepare a SWOT audit to scrutinize potential strategic objectives
- Prepare a "gap analysis" to evaluate the ability of the public and private sector to the accomplish the strategic objectives
- List and rank potential strategies
- Recommend a course of immediate action
- Develop and implement longer-term objectives – The assembled team has developed a framework for the development and execution of long-term technical and business strategies. A number of possible long-term strategies have been proposed. This process will be initiated by ACIDF and AARI in the next phase of the cereal competitiveness process.

3. STEEP analysis

3.1 Why a STEEP analysis?

The nature of future markets influences current investment opportunities for organizations such as ACIDF and AARI. Business strategists often assess the future market by conducting environmental analyses on two levels – the macro, or national-global level; and the micro, or industrial level.

A macro-environmental scan identifies important issues and trends to consider in the development of a business strategy. The goal is to identify:

- Issues that may prevent the organization from achieving its objectives
- Opportunities that the organization may exploit in order to achieve its goals

While macro-environmental issues can affect ACIDF and AARI, these issues are out of the direct control of the organizations. As an example, ACIDF and AARI have no direct control over laws or the political environment – but both organizations will need to be flexible in order to adapt to changes in these areas. While the organization will work *with* government towards some common goals, ACIDF and AARI are still responding to change, rather than effecting change.

One tool that business analysts use to study the macro-environment is called a STEEP analysis. This analysis allows for a macro-environmental assessment of the realm within which an organization operates. The idea is to identify factors that influence the organization and elucidate a trend for each factor.

STEEP is an acronym that refers to five major areas of activity in contemporary societies. The analysis groups macro-environmental factors into five areas: **S**ociological, **T**echnological, **E**nvironmental, **E**conomic and **P**olitical-legal-regulatory. This expansive review is vital when the macro-environment is ambiguous – which is usually true in today's well-entrenched global economies. In terms of a Cereal Competitiveness Strategy, key sociological, technological, environmental, economic and political-legal-regulatory factors represent opportunities on which ACIDF and AARI may capitalize, and threats to which these organizations must respond.

3.2 STEEP executive summary

The trend to increased globalization, which has been developing for over 20 years, is likely to accelerate over the coming decades. This in turn, will affect global cereal stocks, global demand for cereal grains and global trade patterns.

3.2.1 Global cereal grain supply

Growth in global cereal production will likely continue at historical levels. More and more, the capacity to increase cereal production resides with developing nations. Developing countries have the capacity to adopt existing, proven technology – as opposed to having to create and commercialize new technologies. This puts pressure on developed cereal producing nations to continue to innovate, at great expense, to keep ahead of the developing world.

Growth in cereal yields should continue at historical levels, however; overall production may be more vulnerable to attack by pathogens and may be increasingly sensitive to variability in weather patterns. New technological breakthroughs in cereal production may be required to maintain and/or increase yield stability as well as remove major production risks associated with plant disease. The ability of the developing world to increase production through the adoption of existing technology will be tied to political stability and the recognition of intellectual property rights. Lower levels of corruption in developing countries, in conjunction with greater political stability will encourage increases in overall levels of cereal production.

3.2.2 Global demand for cereal grains

Global cereal demand will likely continue to be influenced predominantly by the food and feed sectors of the economy. Increasing demand for cereal grains, particularly corn from the bioethanol industry, will likely be influenced by national policies on a country-by-country basis – and will be directly related to the domestic supply of cereals as well as the ability of each nation to export surplus grain.

For grain importing countries and countries with little excess supply, policies will likely focus on ensuring a stable supply of cereal grain for the food and feed sectors. With the increase in cereal grain use by the bioethanol industry, new processing technologies, over time, may move the processing sector towards whole-crop utilization strategies.

Food and feed demand for cereals will increase along with global population growth. In developing economies, cereal demand will also increase as it is fed to livestock to meet consumer demand for high protein meat products. In developed economies, a higher percentage of cereals will be used to produce functional foods as well as more traditional and ethnic product lines. This trend in developing nations will address the movement towards healthier lifestyles as well as shifts in population demographics.

3.2.3 The global cereal trade

Global cereal trade is likely to continue in step with recent historical trends. By crop, wheat should continue its slow to flat growth. Higher brewing industry demand for malt barley, particularly in the developing world, should increase global barley trade. Oats are increasingly used as a component of healthier packaged food products – which should stimulate demand for food-grade oats and increase global trade in oats. For corn, demand for food and feed and the level of global trade in this crop should be reflected in global population growth. The supply, demand and trade dynamics for corn will continue to fluctuate as the bioethanol industry continues to develop and evolve.

The flow of capital and technology between different regions of the world is likely to increase dramatically. Many countries will want to move to freer trade, however; domestic political realities will continue to play a significant role in the speed of movement towards complete trade freedom. A number of countries may get together to consider bi-lateral trade agreements as a mechanism for driving trade. This may ultimately create a framework for a larger world trade deal in agriculture.

We are moving towards a global society in which there will be significant differences in the pace of change between the G8 countries of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States, which represent about 65 percent of the world economy, and the rest of the world. Implications for cereal production and utilization will be discussed within each section of the STEEP analysis.

3.3 Social trends

Cereal production and utilization will be influenced by social trends that include an ageing population, increasingly diverse populations in G8 nations, global population growth, the consumption of higher levels of protein in diets and the consumption of healthier foods.

3.3.1 Percentage of population above 50 years of age

In the G8, the percentage of the population above 50 years of age is increasing. In the rest of the rest of the world, the percentage of the population above 50 years of age is stable. These trends suggest that the G8 may experience a lower demand for carbohydrates but more there may be more interest in functional foods. In the rest of the world, the growth in the consumption of carbohydrates should be tied to population growth.

3.3.2 Population diversity

Increasing diversity in countries of the G8 could create more demand for a broader range of cereal-based products. In the rest of the world, the level of diversity in the populations of each country is stable – suggesting that demand for traditional cereals and cereal-based products may not change substantially.

3.3.3 Population growth

Population growth is slow in Canada, declining in the remainder of the G8 countries and increasing in the rest of the world. The global population with become increasingly concentrated in countries outside of the G8. Currently, the G8 includes about one-sixth of the world's 6.6 billion people.

3.3.4 High protein diets
The consumption of protein in the diets of G8 consumers is stable – but it is increasing rapidly in the rest of the world. The demand for carbohydrates for human consumption outside of the G8 nations is not keeping up with population growth.

3.3.5 Healthier diets
The percentage of the population with access to healthier diets is increasing in G8 countries and is remaining stable in the rest of the world – suggesting that the G8 will demand healthier cereal-based products. Higher fibre content, processed food products with fewer calories, better tasting food and improvements in product consistency will shape processing and brand development.

3.4 Technological trends
Cereal production and utilization will be influenced by technological trends such as the development of new core technologies in the public and private sector, the convergence of plant breeding technologies on a global scale, advances in food processing technology and the convergence of food processing technologies on a global scale.

3.4.1 The development of new core technologies
In Canada, the development of new core technologies for cereal production and utilization is stable – but is increasing in other G8 countries and throughout the rest of the world. Canada will face competition from superior technological improvements as well as identity preserved (IP) traits in developed economies. The G8, with the exception of Canada, and the rest of the world will continue to build a competitive advantage in core technology development in cereals in both the public and private sector. These developments will enhance capacity in productivity and market functionality and could leave the Canadian cereal industry at a competitive disadvantage.

3.4.2 Global crop breeding technology convergence
Throughout the G8, there is still some level of differentiation between cereal-based crop platform technologies, but the level of differentiation is decreasing. In the rest of the world, access to technology for improving crop germplasm is increasing and many countries are developing locally adapted germplasm that meets the standards of the G8. In the future, competitive advantage in cereal crop quality may be based more on a local crop production practices, climate and genotype-by-environment interactions than on superior crop breeding technology.

3.4.3 Advances in processing technology and global convergence of processing technologies
Advances in processing technology are being noted throughout the world – and the rate of convergence of these technologies is increasing. This suggests that functional differentiation between crop cultivars, and even crop species, could erode as processing compensates for divergent quality and product attributes.

3.5 Environmental trends
In the developed world, cereal production and utilization will be influenced by environmental trends such as demands to address climate change. Water scarcity and the increasing intensity of commercial agricultural operations will be global issues.

3.5.1 Global demands to address climate change
Demands to address climate change have been escalating throughout the G8 – but this issue seems to be of minor importance throughout the rest of the world. Demands to address climate change could increase demand for cereal feedstock to produce bioethanol – a product that is perceived to be an environmentally friendly solution to climate change.

3.5.2 Water utilization
There is increasing competition for clean sources of affordable water throughout the world – which is slowing the development of irrigation in agricultural regions and reducing increases in crop yields globally.

3.5.3 Reducing the intensity of agricultural practices
In G8 countries, there is a trend to "optimizing" rural landscapes – which implies reducing the overall intensity of agricultural operations. This is not an issue in the rest of the world.

***3.6 Economic trend*s**
Cereal production and utilization will be influenced by economic trends such as growth in Gross Domestic Product (GDP), the increasing percentage of disposable income spend on food, the concentration of commodity buyers for the food industry, demand for "just in time" inventory management and the need to process foodstuffs closer to the customer.

3.6.1 GDP growth
GDP is growing slowly in the G8 and faster in the rest of the world. This is increasing the level of disposable income available for food purchases throughout the developing world.

3.6.2 The percentage of disposable income spent on food
The percentage of disposable income spent on food is stable in the G8 and decreasing in the rest of the world. As societies modernize, more disposable income tends to be spent on discretionary consumer products – suggesting that higher protein food products and more functional food products could drive consumption patterns in the future

3.6.3 The concentration of commodity buyers for the food industry
The concentration of commodity buyers for the food industry is increasing throughout the world – which means that demands for high quality, low cost production will likely increase. Differentiation of food products within food categories and company branding will become more important in capturing larger portions of food markets.

3.6.4 The demand for "just in time" inventory management
The demand for "just in time" inventory management is increasing throughout the world. Supply logistics may become increasingly important as a point of differentiation between competing exporters of processed food products. Western Canada will need to put a substantial amount of time, effort and resources into improving its ability to compete effectively with global food exporters.

3.7 Political, legal and regulatory trends
Future cereal production and utilization will be influenced by political, legal and regulatory trends. The world will likely see increased levels of protectionism of domestic production, the alignment of legal and regulatory frameworks for crop development along the lines of G8 countries and an increase in political stability that could lead to more comprehensive agricultural policies in developing countries.

3.7.1 Protectionism of domestic agricultural production
Protectionism for agriculture is stable throughout the G8 and increasing in the rest of the world. Despite attempts to liberalize world trade through the World Trade Organization (WTO), domestic political considerations seem to be taking precedence over the need to make quick progress towards liberalizing global trade in agricultural products.

3.7.2 Regulatory frameworks for crop development
Regulatory frameworks for crop development appear to be stable in G8 nations and are being developed throughout the non-G8 world – with most countries likely aligning themselves as closely as possible to the G8. Any significant regulatory framework changes in the G8 will likely prove to be slow.

3.7.3 Legal frameworks
Legal frameworks appear to be stable in G8 nations and are being developed more extensively throughout the rest of the world – most likely in the interest of ensuring access to proprietary technology.

3.7.4 Political stability and the creation of more extensive agricultural policies in developing countries
Politically, the G8 is relatively stable and political stability is increasing throughout the rest of the world. In terms of agricultural policy development, the existing frameworks are likely to remain in place in the G8

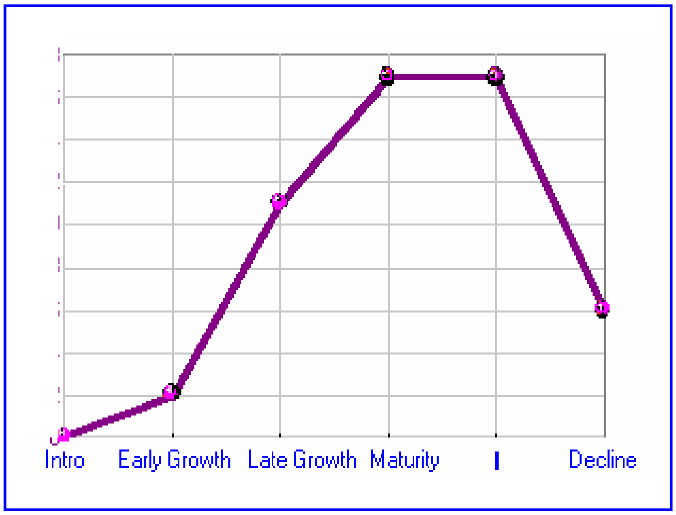
with modifications designed to align national policies with WTO negotiating positions or to meet the requirements of existing WTO agreements. In the world outside of the G8, there may be movement towards adjusting agricultural support to align with political realities. In non-G8 countries, food production stability and food affordability are very important, so governments will likely be considering the impact of industrial demand for agricultural commodities on food prices.

4. A competitive overview of the bioethanol and livestock feeding industries

4.1 Bioethanol

The cereal-based bioethanol and livestock feed industries appear to be at opposite ends of the "product life cycle" – with the bioethanol industry at the "early growth" end of the spectrum and the livestock feed industry at the "maturity" end of the spectrum (Chart 1.)

Chart 1. Product life cycle chart



New industries, like the bioethanol industry, experience high initial rates of entry and innovation and the number of companies rises over time. Eventually, the number of companies declines over a long period of consolidation and maturity, despite continued growth. The rate of innovation slowly declines and companies begin to focus on making small, incremental changes in production processes. The livestock feed industry may find itself situated in the mature stage of this cycle.

How these industries view opportunities and threats reflects their relative positions on the product life cycle. The cereal-based bioethanol industry, for example, has many different product variations, changing production techniques, few companies and a high level of business risk. The mature livestock feeding industry, on the other hand, has customers that are sophisticated purchasers of the product, there is limited product differentiation, markets are segmented, there is some overcapacity in the industry and competitive costs and cost control are keys to success. Since the cereal grain-based bioethanol industry is an emerging industry, industry players may have access to some of the innovations developed by plant breeders while the industry is still in its infancy and in a state of technological uncertainty.

There is a risk in directing long-term plant breeding goals towards emerging industries. Emerging industries are under intense pressure to produce products and develop a customer base – so managers tend to deal with problems in an expedient manner and may not thoroughly analyze future needs. In addition, because the industry is growing quickly, companies tend to focus on resolving short-term issues rather than on creating long-term strategies. Another risk in funding specific research projects is that some of the companies that could benefit from the research may no longer be in business as the industry consolidates. On the positive side, emerging industries embrace technology and are willing to accept technological and product risk.

Success in the cereal grain-based bioethanol sector, according to industry participants, depends on the availability of high yielding, high starch content wheat cultivars. Those profiting primarily from the sale of bioethanol, and the sale DDGS as a by-product, cite these issues exclusively, to the exclusion of all others.

The process of bioethanol production turns one commodity, a cereal crop, into another commodity, bioethanol. If ACIDF and AARI are proposing to invest in the future of this industry, it may be prudent to invest in a comprehensive array of value-added opportunities for cereals within the bioethanol portfolio, rather than in a single opportunity.

By-product utilization and by-product market development are extremely important in driving the profitability of bioethanol producing facilities. In some cases, high value by-products are an important part of the bioethanol financial model and this area may very well hold the key to the profitable development of the biofuel industry as a whole. The development of these by-products, however, requires intense market opportunity analysis. Some suggest that these opportunities will only be available to large multinational corporations or those working in conjunction with large multinationals.

4.2 Livestock feed

Since the feed industry seems to be mature, industry players tend to have sophisticated customers in segmented markets in which product differentiation may be lacking. Competitive costs and cost control are keys to success and to profitability when margins are declining. The companies in this industry appear to have given considerable thought to technical issues that could drive business opportunities. A scan of the literature and the macroenvironment turns up additional opportunities and threats to the feed industry, but industry players have already considered many of these issues. Potential problem areas are extremely technical in nature and it may be a challenge to appreciate all of the subtle nuances of the feed industry's needs. Plant breeders may be able to provide more value to this industry through collaboration with animal nutritionists and animal physiologists.

Addressing issues key areas such as grain yield, grain supply, costs and the expanding bioethanol industry in the US and Canada, will help define success in the cattle and hog sectors in particular. All of those surveyed in the cattle and hog feeding industries cite specific issues in these areas to the exclusion of all others. One interpretation is that these issues may be so fundamental to the success of the sector that lack of resolution may usher in the demise of the industry in western Canada.

The issues collected from a survey of the livestock feeding industry are similar to those identified in the "Strategic research priorities for the feed grain supply and quality initiative" workshop. The most important items identified were new cultivars with higher yield potential that would lead to more energy harvested per unit area. Grain supply would need to be consistent and of high quality and the participants expressed a desire for new cultivars to address niche markets.

5. The ability of western Canadian producers to meet cereal feedstock needs

5.1 Canada and the US

The US produces almost all of its bioethanol from corn. The 18.2B L (4.8B US gallons) of bioethanol produced annually uses about 16 percent of the US corn crop – and accounts for only 3 percent of US annual gasoline consumption. If the US used all its annual corn production (10.7B bushels) to make bioethanol, this would only displace about 20 percent of all gasoline consumed.

In 2003, as part of a climate change strategy, the government of Canada initiated the Ethanol Expansion Program (EEP), made a commitment to a renewable content requirement in Canadian transportation fuel and created a federal excise tax exemption for renewable fuels. With these incentives in place, the government of Canada expects bioethanol production will increase to about 2.740M L (2.74 GL) by the end of 2010. Using the Husky Energy Inc. figures for 2006, this equates to 2.73 Mt (million tonnes) of DDGS produced annually in Canada from 7.38 Mt of feedstock. Government of Canada statistics suggest that 2.1 Mt of DDGS will be produced annually from 6.9 Mt of feedstock (4.6 Mt of corn and 2.3 Mt of wheat). Given that Canada produces about 38.8 Mt of wheat, barely, oats and rye annually, (Table 1) bioethanol production in Canada could consume about six percent of these crops by 2010.

Table 1. Tonnes of cereal grain produced annually in Canada*

Crop	Tonnes produced in Canada
Wheat	23,932,000
Barley	11,098,000
Oats	3,464,000
Rye	308,000
Total	**38,802,000**

*Five year average (2002-2006)

Some provinces have instituted road tax exemptions for bioethanol-blended fuels and the provinces of Manitoba, Saskatchewan, and Ontario have mandatory blending rates to encourage increased bioethanol production. With these types of initiatives in place, there is concern that there may be insufficient wheat or cereal feedstocks to meet demand.

5.2 Alberta

To put the quantity of feedstock required into perspective, Alberta's 10-year average for the production of all cereal grains is about 13 Mt (Table 2.) This suggests that the Husky Lloydminster bioethanol plant alone could consume almost three percent of Alberta's grain production. Five Alberta plants on scale of the Husky Lloydminster facility could consume over 13 percent of the province's grain production per year.

Table 2. Tonnes of grain produced annually in Alberta,* Saskatchewan# and Manitoba^

Crop	Tonnes produced in Alberta	Tonnes produced in Saskatchewan	Tonnes produced in Manitoba
Winter wheat	71,700	129,000	3,366,900
Spring wheat	5,661,700	8,435,500	88,700
Durum wheat	823,700	3,759,200	204,600
All wheat	***6,557,100***	***12,323,700***	***3,660,100***
Oats	814,700	1,427,300	908,200
Barley	5,491,000	4,523,000	1,474,200
Rye	63,500	119,800	64,400
Mixed grains	68,300	20,200	89,298
Triticale	32,900	25,900	~
Total	**13,027,500**	**18,439,900**	**6,196,198**

* Alberta 10 year average (1995-2004)
# Saskatchewan 25 year average (1982-2006)
^ Manitoba 10 year average (1995-2004)
~ Data not available

5.3 Saskatchewan

With Saskatchewan's 25-year average for the production of all cereal grains at about 18.5 Mt (Table 2), five plants on the scale of the Husky Lloydminster plant would consume over nine percent of the province's grain production each year.

5.4 Manitoba

With Manitoba's 10-year average for the production of all cereal grains at about 6.2 Mt (Table 2), five plants on the scale of the Husky Lloydminster plant would consume over 28 percent of the province's grain production each year.

Clearly, bioethanol production facilities will require large volumes of suitable grain feedstock in each of the three western Canadian provinces. The province of Saskatchewan is in the best position to supply grain to this industry.

6. SWOT analysis

A SWOT analysis addresses **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats facing an organization – letting the organization look analytically at all areas of its operations. A SWOT audit includes scrutinizing an organization's strategic objectives in order to create a clear picture of the processes that the organization must adopt to achieve them.

Strengths and weaknesses address *internal* organizational factors while opportunities and threats address *external* factors. The internal strengths of an organization put it in a position to exploit the trends identified in the STEEP analysis. Internal weaknesses, on the other hand will keep the organization from exploiting these same trends. Whereas external opportunities allow an organization to exploit the trends identified in the STEEP analysis, external threats hinder the exploitation of these trends.

6.1 Strengths

The strengths of the plant breeding and cereal development infrastructure will help increase the level of domestic value-added processing by targeting genetic research in key crops and by providing leadership for various cereal commercialization programs. This should increase the competitiveness of the western Canadian cereal industry by providing end-users with access to competitive feedstocks while raising producers' gross margins and net on-farm returns. Cereal crop acreage should increase in the Prairie Provinces as end-users add commercial value to cereal crops in western Canada.

- Most plant breeders are communicating directly with cereal end-users and have well developed programs that meet these customers' needs.
- Public breeding programs dominate cereal breeding in western Canada. These programs have accumulated a wealth of genetic resources for current and future deployment in breeding.
- The cereal cultivar development system produces very few recommendations for the registration of new cultivars compared to other crops. Many public plant breeders see this as strength. Market entry requirements are set high and new cultivars that do not represent a significant improvement over existing varieties do not clutter up the seed market.
- Agriculture and AgriFood Canada (AAFC) has built a strong team in support of cereal pathology, genetic discovery (including molecular level breeding) and grain quality in major wheat classes.
- Canada has gained a strong international reputation for the grain attributes of its registered varieties and for the constancy of quality which it delivers because of high registration standards set by its variety registration process
- Canada has maintained a well respected reputation for solving cereal disease and pest outbreaks by producing resistant varieties that are of production value to growers
- Adoption of newly released varieties is very efficient in western Canada because of a well-organized seed industry and extension processes that ensure growers are aware of new market opportunities with new varieties.
- Despite high registration standards that new cereal varieties have to meet, especially for disease resistance and grain quality type, rates of genetic yield increase in Canadian cereal grain classes have been competitive with genetic yield gains made in equivalent cereal classes in other parts of the world.
- Canadian public cereal grain breeding programs are recognized as amongst the world leaders in their areas of cultivar development.
- There is a substantial amount of diversity in the germplasm of cereal crops in western Canada that could be used to develop highly functional cultivars for food, feed or industrial markets.
- There is a capacity for the development of core technologies at institutions like the Plant Biotechnology Institute (PBI) in Saskatoon. These institutions could provide excellent structural and intellectual capital for the development of new traits for the cereal industry; however, these institutes do not focus on cereal development.
- Western Canada has internationally recognized research personnel working across most cereal platforms.

- Seed production and marketing capacity in western Canada is excellent, with seed growers through to multi-national companies working to bring new cultivars to the marketplace.
- The grain-handling infrastructure for western Canadian cereals is modern and second-to-none in its operational approach to maintaining grain quality.
- Canada has an excellent infrastructure for providing cereal production inputs that help optimize the yield potential of the genetic constructs bred into cereal cultivars.
- Western Canada has modern and highly adaptive farmers and a farming infrastructure that allows the rapid adoption of new crop production technologies.

6.2 Weaknesses

Deficiencies in the plant breeding and cereal development infrastructure that will impede the achievement of the stated objectives include:

- Limited research and development capacity for traits such as winter hardiness, cold soil performance or water use efficiency in western Canada.
- Insufficient capacity to improve and develop cereals in the area of plant pathology – making it less likely that plant breeders realize significant, positive change in the future.
- Yield productivity gains that have been steady but modest in western Canadian cereals, constrained at least in part by the short length of the growing season compared to that for many international competitors. Estimated gains are from one-half up to two percent per year, whereas inflation, or the cost of production, is growing at about two to three percent per year. In comparison, hybrid corn yield is the United States has typically increased about two to three percent per year. High yields from hybrid vigor are not available in the cereal grain crops available to western Canadian producers because no suitable genetic delivery system has been discovered.
- Many plant breeders in western Canada rapidly nearing retirement. There is a need to consider the number of plant breeders that will be required in western Canada in the area of cereal development, and to ensure smooth transitions between past and future breeders in public programs. Some cereal breeding programs have been closed recently when the incumbent breeder retired or was no longer in place. It will be important to continue to attract university undergraduate students to the plant breeding discipline, train and integrate these individuals into plant breeding networks, and create rewarding career paths that are not subject to intermittent funding of positions.
- Insufficient screening capacity to evaluate material from the myriad of plant breeding programs in western Canada. In particular, capacity to screen for plant disease resistance in summer disease nurseries as well as the capacity for quality trait evaluation at the Grain Research Laboratory (GRL) of the Canadian Grain Commission (CGC) and in other cereal research centres is insufficient. These limitations negatively influence the number of advanced lines that can be screened pre-Coop, and also limit the number of lines that can advanced to obligatory Coop trials.
- The need for additional support for plant breeders in three areas of biotechnology:

    - Genomics – a discipline dedicated to deciphering and understanding the genetic information contained in an organism. The discipline is broad in scope and relies heavily on data collection, analysis and information technology (bioinformatics). Genomics provides the scientific base for a range of biotechnological applications, including some very specific breeding and trait improvement objectives.
    - Proteomics – the quantitative and qualitative comparison of proteomes under various conditions to facilitate an understanding of biological processes. A proteome is the protein complement of a genome. Breeders could do a better job of genetically improving grain quality and other traits if they better understood functional proteomics (how the plant controls the chemistry that controls grain quality and other traits).
    - Bioinformatics – the application of computers to problem-solving in the area of molecular biology. Bioinformatics software can be expensive and scientists see a need for free, open-source software for molecular analysis in non-commercial operations. The extent of access to bioinformatics that could help plant breeders varies widely between public cereal breeding programs – and no one centre is doing a sufficiently comprehensive job for the *Triticeae.*

- Lack of cereal breeder support from biotechnologists to accomplish specific tasks: Gene cloning; gene identification and location; gene mapping; genetic transformation; molecular sequencing; marker development and marker assisted selection; the determination of molecular mechanisms of plant disease resistance; adaptation and stress tolerance;, and the development of DNA fingerprint databases for cereal breeding materials.
- Lack of plant breeder support in cereal quality analysis and research areas such as: Composition and functional characteristics of cereal grains and derivatives, for foods and feeds; starch functionality in wheat and barley; protein functionality, dough and baking studies in wheat; durum and pasta quality; oat quality research; nutritional quality and targeted grain components of nutraceutical value; food barley quality research: suitability of bread wheat for Asian noodle and pasta production; and identification of novel quality traits and new market uses.
- Lack of marketing tools and technique support for the development of near-infrared spectroscopy (NIRS) methodology for use in grain quality determination in breeding; and in commerce.
- A cultivar development system that produces very few recommendations for the registration of new cultivars compared to other crops. Many private plant breeders see this as weakness. The goal of private plant breeders is to release new cultivars annually.
- The narrow focus on high quality, end-use markets for Canada Western Red Spring (CWRS) that hinders the development of cultivars that have merit in other markets.
- A cultivar review system that is cumbersome. About 75 individuals, many of whom are competitors, control the process of voting for cultivars brought forward for recommendation. This process hampers the development and advancement of new genetic traits.
- A cultivar development system with limited ability to respond quickly to emerging market opportunities. The major cereal grades and/or classes and their requirements dominate this system. There is limited opportunity, except through the cumbersome Contract Registration system, to make room for unusual and new cereal types that could be a threat to the integrity of the major types
- Disease resistance in some cereal crops that is far from robust. The successful production of some western Canadian cereal crops may depend on the utility of only a few genes – creating a high level of risk to sustainable production.
- Requirements for Kernel Visual Distinguishability (KVD) that prevent the registration of cultivars that have merit in domestic feed and bioethanol markets, among others. The requirement for KVD in CWRS and Canada Western Amber Durum (CWAD) wheat places the full burden for the development of wheat for new markets into other classes of wheat. This creates a drag on the development and introduction of cultivars with a range of agronomic improvements for specific end-use domestic and international markets.
- The definition of "genetically modified" (GM). Where the EU (European Union) defines GM based on the technique used to produce a seed, the Canadian Food Inspection Agency (CFIA) bases its definition on the characteristic of the seed – and disregards the manner in which the seed is produced. The CFIA uses the term "Plant with Novel Trait" (PNT) and defines a PNT as a seed and/or plant characteristic that: "Has been intentionally selected, created or introduced into a distinct, stable population of cultivated seed of the same species through a specific genetic change," and "Based on valid scientific rationale, is not substantially equivalent, in terms of its specific use and safety both for the environment and for human health, to any characteristic of a distinct, stable population of cultivated seed of the same species in Canada, having regard to weediness potential, gene flow, plant pest potential, impact on non-target organisms and impact on biodiversity." This definition creates a situation in which Canada constrains the development of new crop traits for existing and emerging domestic and global markets – creating an unnecessary competitive disadvantage for the Canadian cereal industry.
- The focus with wheat and barley development primarily on the food sector. This focus is concentrated on the development of export markets for high protein wheat and malt barley – reducing emphasis on the development of cultivars for existing and emerging domestic markets.
- The need for cultivars to have suitable levels of disease resistance to pathogens that destabilize yield or cause significant loss of value in harvested grain – regardless of the market opportunities. *Fusarium* is one such example.

- Government policy that is expected to support the development of and the creation of a long-term, sustainable future for bioethanol producers. This support is needed to help smooth out uncontrollable market forces in order to successfully repay grants such as those provided through the ecoAgriculture Biofuels Capital Initiative (ecoABC).

6.3 Opportunities

Opportunities identify conditions external to the plant breeding and cereal development infrastructure that will help to achieve the objective. Opportunities have been categorized for each crop.

It will be important, once all of the opportunities have been identified, to prioritize the opportunities. This process should be run in conjunction with the process used to prioritize strategies.

6.3.1 All cereals

- Create sustainable genetic resistances for all priority 1 cereal diseases using new gene marker systems that allow gene pyramiding and other novel molecular based approaches.
- Target yield as a priority trait for western Canadian cereal crops for the bioethanol and livestock feeding industries.
- Change standards for cereal registration to "enable" the registration of new cultivars and speed up the registration process.
- Develop cereal varietal trials as a means of evaluating cultivars to ensure that producers have the best access to reliable, unbiased information.
- Develop enhanced nitrogen (N) use efficiency in all cereal crops. This provides an opportunity to reduce N inputs. However, crops could be bred to use excess N applied to the soil as hog or cattle manure – reducing the environmental impact of the application or the risk of application.
- Develop cereals with vigorous growth habits and early competitiveness against weeds; semi-dwarf crops or crops with better lodging resistance, especially in oat; resistance to sprouting and bleaching; and good harvestability with even dry down to reduce the need for a crop desiccant.
- Develop resistance to new insects and emerging diseases that can be incorporated into commercial cereal cultivars. Producers see the inclusion of disease and insect resistance in cereal cultivars to be one of the greatest benefits they derive from plant breeders.

6.3.2 Barley

- Increase Fusarium Head Blight (FHB) resistance and reduce deoxynivalenol (DON) levels by 50 percent in barley.
- Expand the capacity to determine phenotype for net blotch resistance in barley.
- Increase levels of β-glucan in barley. This is one compound of immediate commercial interest to bioethanol producers.
- Develop all barley cultivars grown for western Canada with low levels of phytate. This long-term opportunity (LTO) may take 10 to 15 years to develop.
- Develop barley varieties with over-expressed food and nutritional functionality for domestic and US markets (LTO).
- Increase forage barley biomass by 30 percent to increase barley competitiveness with open-pollinated corn for cellulosic bioethanol markets as well as for forage use (LTO).

6.3.4 Hulless barley

- For livestock feeders, develop hulless barley with high levels of feed energy. These cultivars would also produce high levels of feed intake in livestock and would be converted efficiently to protein.
- For bioethanol producers, develop compact, energy-rich hulless barely with low levels of undesirable, non-fermentable constituents. These attributes increase bioethanol yields, reduce grain freight charges, reduce the bulk of dry distillers' grains with solubles (DDGS) and decrease drying time.
- Increase levels of β-glucan for bioethanol producers that plan to extract this compound of barley as part of a value-added component

6.3.5 Oat

- Develop low acid detergent lignin hull, high groat oil (LLH-HOG) as a significant alternative whole oat cereal grain crop with the feed value of barley for ruminants, especially dairy, for national and international markets.
- Increase levels of β-glucan in oat for the bioethanol industry.
- Increase levels of avenanthramide (an oat polyphenolic compound) for the bioethanol industry.

6.3.6 Hulless oat

- Increase levels of β-glucan and avenanthramide (an oat polyphenolic compound) in hulless oat for the bioethanol industry.

6.3.7 Triticale

- Develop new cultivars of triticale (spring and winter) for feed and bioethanol industries by exploiting the high yield levels and high energy levels of triticale in comparison to wheat.
- Develop perennial triticale for feed, forage and for cellulosic bio-energy (LTO).

6.3.7 Winter triticale

- Increase winter-hardiness in winter triticale to take advantage of much higher yield levels compared to spring types. There are other potential advantages for grain and forage production with winter triticale.
- Develop winter triticale breeding programs to mesh with a goal of seeding 30 percent of western Canadian cereal acreage to winter triticale and winter wheat.

6.3.8 Wheat

- Focus on Canada Prairie Spring (CPS), Canada Western General Purpose (CWGP), soft white wheat and winter wheat to quickly improve yields and energy levels in wheat.
- Expand capacity to determine phenotype for stripe rust disease.
- Lower sulphur levels in wheat for the bioethanol industry.
- Develop wheat varieties with improved novel nutritional properties that designed for vertical integration into Canadian made cereal products for domestic and US markets (LTO).

6.3.9 Soft white wheat

- Make a major investment in soft white spring (SWS) breeding at the AAFC LRC. Program size has been very small and most wheat breeders feel that major yield gains can be made in this class, especially as adaptation is sought for dryland areas where it may be widely grown to support the bioethanol industry. Soft white wheat is one of the first choices of grain for bioethanol feedstock.
- Improve disease resistance in SWS wheat for feed and bioethanol industry sectors.

6.3.10 Canadian Western Red Spring

- Breed a high yielding, midge-resistant, Canadian Western Red Spring (CWRS) wheat with good standability for the central prairies.

6.3.11 Winter wheat

- Increase winter-hardiness in winter wheat to take advantage of much higher yield levels compared to spring types. There are other potential advantages for grain and forage production with winter wheat.
- Develop winter wheat breeding programs to mesh with a goal of seeding 30 percent of western Canadian cereal acreage to winter triticale and winter wheat.

6.3.12 Feed grains

- Develop a cereal grain to optimize livestock production. These cultivars would have high energy levels, an average minimum protein level of about nine percent, would convert efficiently to protein and would provide for better feed intake. Livestock producers rate net energy (NE) as the most important measure of energy, followed by metabolizable energy (ME) and then digestible energy (DE).
- Invest in genetic research and methodology development for determining the phenotype for digestible energy in feed – building on recent innovations with NIRS technology at FCDC and AAF Lacombe.

- Create a feed grain that contributes positively to animal health – specifically, a feed grain that improves intestinal health, lowers the risk of acidosis in livestock in the beef or dairy industries, or improves intestinal health in hogs.
- Develop feed grains that contribute positively to the environment or provide a social benefit by limiting noxious or greenhouse gas producing emissions, reducing odour levels emitted from livestock facilities, lowered levels of phosphorous compounds excreted from livestock or increase the amount of manure that could be used in crop production systems by lowering phosphorous levels in manure.
- Develop a NIRS assay to identify and quantify traits in whole cereal grains. NIR can be used to determine the value of grain as livestock feed. The feed energy of grain, as an example, could be determined on delivery, providing a direct correlation between the value of the grain delivered and the price paid by the end-user
- Develop a feed silage cereal cultivar specifically for the beef and dairy industries.

6.3.13 Bioethanol projects

- Develop a cereal grain to optimize bioethanol production. This grain would have elevated levels of High Total Fermentables (HTF) and produce greater amounts of ethanol per unit of feedstock.
- There may be an opportunity for plant breeders to work with bioethanol producers to develop value added co-products that can be extracted during the bioethanol distillation process. Projects that fall into this category include, but are not limited to, organic acid by-products such as acetic acid, citric acid and lactic acid, the separation of milled bran prior to fermentation or the secondary processing of DDGS.
- Develop a system to measure total fermentables in cereal grains. When HTF seed is delivered to the bioethanol facility, the producer is paid based on HTF content in the grain. With this technology, there is a direct correlation between the value of the grain delivered and the price paid by the end-user.

6.3.14 Alternative crops for the production of cellulosic bioethanol

- Cereal straw traits that would be required for cellulosic bioethanol (CEtOH) have been well documented; however, cereal straw may not be a preferred feedstock for CEtOH production. Alternative crops such as switch grass or tall fescue may be better choices for this market.

The consulting team has listed a number of opportunities. The process for opportunity prioritization, selection and development will be initiated by ACIDF and AARI in the next phase of the cereal competitiveness process. This process can be based on the priorities identified by end users in the bioethanol and livestock feeding industries in the surveys summarized by Strategic Vision Consulting Ltd.

6.4 Threats

Conditions external to the plant breeding and cereal development infrastructure that could impede the achievement of the objective include:

- The low level of investment in cereal research and development by the private sector – making it a challenge for industry to move or respond to new opportunities. Private industry investment may be low because there is no way to capture value from this market.
- A gap between private sector investment in cereal crops and crops such as corn, canola and soybean that continues to widen.
- The level of public funding needed to make progress in cereal breeding programs. With the cost of running a single plant-breeding program at over $1M over 10 to 12 years, all cereal checkoff dollars in Alberta would not be sufficient to fund much of an effort.
- The need to separate GM-cereals from “conventional” cereals where the end-product is destined for some export food markets. This is not likely to be the case for exports to the US or most of the developed world. It may be desirable to target North American markets and not segregate cereals at all – then the cereal industry will not be burdened with unnecessary costs.
- Feed grains that contribute positively to animal health or to the environment that it may not be possible to register in Canada under current Canadian Food Inspection Agency (CFIA) guidelines.
- The need for livestock that have consumed genetically modified (GM) feed ingredients to be excluded from human consumption in some global markets.

- The need to develop value-added opportunities for which there is no existing market or for markets that may develop slowly over a long period of time.
- Value-added opportunities that may be profitable only if the technology fits into high-value markets.
- Value-added opportunities that may only be developed if a commercial partner is willing to invest in the project and oversee the commercialization of the technology.
- Value-added opportunities that may require strategic public funding directed at building an industry.

7. Produce strategies from the SWOT analysis

Strategies can be developed from the SWOT analysis if Strengths and Opportunities outweigh the Weaknesses and the Threats. The goal is to create strategies that will help achieve the objective. In developing potential strategies, the idea is to:

- Take advantage of Strengths
- Mitigate the effects of Weaknesses
- Exploit Opportunities
- Defend against Threats

It is important to pay particular attention to Strengths and Opportunities. The Canadian cereal industry will need to focus on Strengths that differentiate Canadian cereal grains from those of its competitors. The industry also needs to consider Weaknesses and Threats that could threaten Canadian cereal competitiveness at a global level.

Strategies may be grouped in the same five categories that define a STEEP analysis: Social, Technical, Economic, Environmental and Political/legal/regulatory.

7.1 Social

- Increase investment in training for new plant breeders and highly qualified technologists to support future cereal research and breeding programs. This should be coupled with an increase in long-term funded, career track, opportunities for such personnel in public breeding programs.
- Ensure continuity of professional plant breeder staffing in key public cereal breeding programs, including the barley program at the University of Saskatchewan.

7.2 Technical

- Develop the areas of genomics, proteomics and bioinformatics to mesh with plant breeding objectives that are designed to meet market needs.
- Set up a biotechnology breeding support structure in which biotechnological and plant breeding goals mesh seamlessly to meet market needs.
- Chose a crop platform for each strategy. Potential platforms include barley, barley (hulless), oat, oat (hulless), rye, triticale (spring and winter), wheat (hard red spring), wheat (hard white spring), wheat (hard red winter), wheat (soft white winter), wheat (Canada Prairie Spring, CPS), and wheat (Canada Western General Purpose, CWGP).
- Invest in the development of a high-capacity cultivar development and screening processes that focus on evolving needs in the livestock feed and bioethanol markets to provide rapid plant breeding progress for these market segments. This would include reinstatement of full activity level for the hulless feed barley program at CDC, Saskatoon.

7.2.1 Improvements in Infrastructure designed to increase technical capability and capacity

- Develop a multi-institutional western Canadian Triticeae Excellence Centre for Cereals (TECC) that includes functional genomics, plant physiology, plant pathology and plant breeding methods. TECC would focus on gene discovery, the basic and applied servicing of cereal breeding programs and personnel training.

- Amalgamate all four western Canadian winter wheat breeding programs into one pooled program, sharing resources and capabilities, with leadership provided from the fulltime program at the AAFC Lethbridge Research Centre (LRC). The total breeding effort to date with winter wheat has been limited and major potential yield gains are forecast for winter wheat, for feed and industrial use, if there is significant investment made now. New funds should be directed to program core needs in pathology, winter hardiness and regional adaptation, as different types are needed in different parts of the prairies.
- Rebuild full infrastructure support for the triticale feed and forage breeding programs at the Field Crop Development Centre (FCDC, AAF) Lacombe and expand the core program significantly. This should include linkages with Functional Genomics Centers, and pre-breeding with rye and wheat to make new primary triticale lines, and to expand the germplasm base. "Breeding of high energy triticale is the best investment towards increasing biomass, for grain, forage, feed and bio-ethanol."
- Increase technical support for wheat breeding at CDC Saskatoon.
- Link the AAFC, Brandon, forage barley program with the Alberta Agriculture and Food (AAF) Lacombe program, and with the cattle industry, for funding and direction. These programs target forages for feed energy as well as cellulosic bioethanol.
- Develop sustainable genetic resistance for all Priority 1 cereal diseases. This can be achieved using new gene marker systems that allow gene pyramiding and other novel molecular based approaches. These methods depend on access to molecular assay methods and specialist labs for large numbers of samples on a routine basis, and expanded capacity to phenotype cultivars.
- Create regional centers for product development to pull improved genetics through the food chain – including the creation of more pilot scale testing facilities for use by cereal breeders. Examples of areas in which regional and pilot scale testing facilities are required include bio-fermentation, bio-processing, bio-product development and specialty food product development.
- Move AAFC cereal breeding programs outside of government and out of direct federal oversight. A Canadian Cereal Breeding Institute run jointly by public and private interests would meet cereal breeding program needs for western Canada.

7.3 Economic

- Focus plant breeding objectives based on meeting market needs, rather than diluting efforts across fragmented programs designed to develop barley traits within specific classes.
- Enter into strategic partnerships with small plant breeding companies that have started developing cereal cultivars with high energy content and high yield. This should increase the speed of cultivar development and commercialization.
- Raise the level of investment in cereal breeding by the major users of cereal grains in western Canada, including the milling and food industry, and the feed and livestock industry.
- Funding agencies need to find ways to strengthen support of core infrastructure needs in breeding programs, and to avoid the past discontinuities associated with short-term funding for "trait-based" breeding projects. Most public programs are suffering some shortfalls in required facilities, permanent technical support, or equipment maintenance and/or modernization, which limits the ability to add new traits to the programs.
- Substantially increase investment levels in all aspects of pathology, disease monitoring and disease resistance breeding support for breeders. Ideally, this should be linked to development of the proposed TECC Chair in Cereal Pathology, but this is urgently needed even if there is no such new chair.
- Complete a multi-year, multi-location study at locations proximate to new and planned ethanol plants to compare new varieties of winter and spring cereals for their grain productivity and for potential ethanol production. This should also include the evaluation of high yielding hulless barley cultivars such as McGwire.
- Develop new brewing and malting industry resources as partners to fully support malt barley breeding at the Field Crop Development Centre (FCDC) Lacombe. Otherwise, reposition the limited available funding for the genetic work in malt barley at CDC, Saskatoon, with the role of FCDC, (AAF, Lacombe) re-focused on disease assessment and/or field screening of novel disease resistances and adaptation of breeding lines.

7.4 Environmental

- Develop enhanced nitrogen (N) use efficiency in all cereal crops. This provides an opportunity to reduce N inputs.
- Develop crops that could use high levels of N applied to the soil as hog or cattle manure. This could reduce the environmental impact of manure applications or possibly lowering the risk of application.
- As an alternative to pesticides, resistance to new insects and emerging diseases can be incorporated into the plant. Producers see the inclusion of disease and insect resistance in cereal cultivars to be one of the greatest benefits they derive from plant breeders.
- Create a feed grain that contributes positively to animal health. Feed grains with these attributes could reduce the cost of antibiotics as well as meet consumer demand to lower levels of chemical additives and drugs in food production. Some speculate that the Canadian Food Inspection Agency (CFIA) or other national regulatory agency would not allow these types of crop traits to be registered in Canada.
- Develop a feed grain that contributes positively to the environment or provides a social benefit by limiting noxious or greenhouse gas producing emissions, reducing odour levels emitted from livestock facilities, lowering levels of phosphorous compounds excreted from livestock or increasing the amount of manure that could be used in crop production systems by lowering phosphorous levels in manure. Again, some speculate that the Canadian Food Inspection Agency (CFIA) or other national regulatory agency would not allow these types of crop traits to be registered in Canada.

7.5 Political/legal/regulatory

- The federal government should fully and separately fund the resources necessary to collect the data for the cooperative (Coop) registration system, and transfer the responsibility for it from the public and private cereal researchers and breeders to a newly constituted federal office. Public programs could still conduct trials under the terms of the Prairie Grain Development Committee (PGDC) on a cost recovery basis, but would not bear the management burden for the Coop testing system – freeing them for full-time innovative breeding research. Another alternative would be to contract out the entire process, charging entries full cost recovery, or for the federal government to cover that full cost, since the Federal government requires the system.
- Develop guidelines for the market acceptability of advanced genetic techniques for cereal breeding in Canada. Guidelines should reference at least the following techniques: Gene cloning, gene identification and location, gene mapping, genetic transformation, molecular sequencing, marker development and marker assisted selection.
- Create a cereal grain crop energy delivery initiative, using a framework similar to that used for the triticale bio-refining initiative. Leadership with a vision and focus is required to develop and introduce technology in cereals for the development of energy. Without leadership and resources, advances in cereal development for emerging domestic markets will continue to move slowly.
- Replace the Kernel Visual Distinguishability (KVD) system in wheat with a system based on variety identification plus statutory declaration, or one based on sample functionality. Many producers have suggested that there are various means of identifying or preserving the identity of crops and that the Canadian Seed Growers' Association (CSGA) has been successfully doing so for years.
- Replace the current Federally legislated but scientifically invalid definition of Plant with Novel Traits (PNTs) with one based solely on food, health and environmental safety
- Establish an annual (or standing) western Canadian forum for coordinating all western Canadian cereal research funding and cereal breeding resource sharing throughout the region, with greater scope than the WGRF and Alberta Barley Commission (ABC) managed check-off funds or the Alberta Funding Consortium (AFC).
- The focus with wheat and barley development is targeted on the food sector and is concentrated on the development of export markets for high protein wheat and malt barley – reducing emphasis on the development of cultivars for alternative existing and emerging domestic markets. Enter into strategic partnerships with small plant breeding companies that have started developing cereal cultivars with high energy content and high yield, to address regulatory hurdles that may hinder or even prevent the commercialization of new cultivars for domestic markets.
- Modify the Canadian cultivar registration system to leave more flexibility for the successful breeding, approval and commercial use of cereals that do not fit into the grade standards defined by Canadian Grains Commission (CGC) and the Canadian Wheat Board (CWB.) This is a long-term strategy.

- Create a national voice for the cereal grain industry along the lines of the Canola Council of Canada or Pulse Canada.

8. Prioritizing technical and business strategies

The consulting team has proposed a number of strategies and key tactics. The process for strategy prioritization, selection and development will be initiated by ACIDF and AARI in the next phase of the cereal competitiveness process.

In ranking strategies (or technologies), each idea must be weighed against a set of criteria. Some criteria are more important than others and need to be weighted. Each strategy should be measured across a number of areas. The consulting team proposes starting with five criteria:

- Stage of technological development
- Acceptance of the technology by the end-user and the cereal producer
- Commercial considerations
- Regulatory acceptance
- Competitive forces
- Local availability of the technology

8.1 Stage of technological development

For a strategy to advance quickly the technology supporting the strategy must be proven to work in a commercial environment – it cannot be just in the hypothesis stage or even in the final stages of development. Technologies that have been proven to work commercially generally produce positive short-term results. Those that are less well developed should be considered only as part of longer-term strategies.

8.2 Acceptance of the technology by the end-user and the cereal producer

Technologies destined for commercialization must be accepted by the end-user and the cereal producer. If the technology is considered acceptable, those advancing the strategy should have credible market data that support an anticipated share of the market. Market share demonstrates the value of the new technology relative to what is currently available.

8.3 Commercial considerations

Ideally, technologies should follow a path to commercialization that is clearly understood so that the product reaches the market within a reasonable period of time. Barriers to commercialization need to be identified and an action plan to overcome these barriers must be in place. Business relationships and partnerships must be well defined, all intellectual property issues must be resolved and there must be freedom to operate.

8.4 Regulatory acceptance

Each technology must be accepted by the regulatory system in the jurisdiction in which the technology will be introduced. Specific regulatory requirements for registering the technology must be met and outstanding regulatory issues need to be addressed. There must a high probability that the technology will not encounter regulatory barriers that impede or prevent commercialization.

9. Competitive forces

In optimizing cereal competitiveness, assume that the goal is to maximize cereal producer returns over the short term while maintaining sustainable returns over the medium to longer term. A concurrent goal is to optimize competitiveness for the end-users of the cereal grains in western Canada – livestock producers and bioethanol manufacturers.

Consider the Five Forces that drive competition from the perspective of the cereal producer:

- New entrants to a market (countries entering a market with the same product)
- Suppliers
- Buyers
- Substitutes (technologies or products that replace what farmers currently produce)
- Industry competitors (other local farmers)

Optimizing cereal competitiveness is a complex issue in western Canada. If we optimize the competitiveness of cereal producers (suppliers) to the detriment of end-users such as livestock producers and bioethanol manufacturers (buyers), then the end users are put at a competitive disadvantage relative to the market in which they compete. If we reduce the power of the suppliers of the grain (cereal producers), the competitiveness of livestock producers and bioethanol manufacturers increases – but it puts crop producers at a competitive disadvantage. At some point, these three groups will have to come to a mutually beneficial arrangement in which no single group is at a competitive disadvantage. This is particularly important given that bioethanol manufacturers and livestock producers may find themselves competing for specific cereal grains like high-energy hulless barley or wheat to optimize production in both industry sectors.

10. Local availability of the technology

If the cost of development of a technology is high, ACIDF and AARI could consider purchasing the technology in the global marketplace, from any number of commercial organizations or research institutions.

11. Developing action plans

Once strategies have been prioritized, action plans will need to be developed for the most attractive strategies. Criteria for developing action plans could include:

- Benefits – what is expected if the strategy is successful?
- Actions – what will be done?
- Team – who will be in charge and who will be on the implementation team?
- Timing – when will the program start and end?
- Resources – what will be needed?
- Controls – how will results be measured and reported?
- Contingency plans – what will happen if the expected results do not materialize?
- Synergy – are the action plans synergistic and do they increase the probability of achieving the goal?

12. Suggestions for immediate action

The consulting team has a number of objectives may need to be accomplished *immediately* in order for strategy development to prove successful.

- Funding agencies need to find ways to strengthen support of core infrastructure needs in breeding programs, and to avoid the past discontinuities associated with short-term funding for 'trait-based' breeding projects. Most public programs are suffering some shortfalls in required facilities, permanent technical support, or equipment maintenance/modernization, which limits the ability to add new traits to the programs.
- Ensure continuity of professional plant breeder staffing in key public cereal breeding programs, including the barley program at the University of Saskatchewan
- Develop a multi-institutional western Canadian Triticeae Excellence Centre for Cereals (TECC) that includes functional genomics, plant physiology, plant pathology and plant breeding methods. TECC would focus on gene discovery, the basic and applied servicing of cereal breeding programs, and personnel training.
- Replace the current federally legislated but scientifically invalid definition of Plant with Novel Traits (PNTs) with one based solely on food, health and environmental safety.
- Replace the Kernel Visual Distinguishability (KVD) system in wheat with a system based on variety identification plus statutory declaration, or one based on sample functionality.

- Set up a biotechnology breeding support structure in which biotechnological and plant breeding goals mesh seamlessly to meet market needs.
- Develop sustainable genetic resistance for all Priority 1 cereal diseases. This can be achieved using new gene marker systems that allow gene pyramiding and other novel molecular based approaches. These methods depend on access to molecular assay methods and specialist labs for large numbers of samples on a routine basis, and expanded capacity to phenotype cultivars.
- Substantially increase investment level in all aspects of pathology, disease monitoring and disease resistance breeding support for breeders. Ideally, this should be linked to development of the proposed TECC Chair in Cereal Pathology, but is urgently needed even if there is no such new chair.
- Raise the level of investment in cereal breeding by the major users of cereal grains in western Canada, including the milling and food industry, and the feed and livestock industry.
- Rebuild full infrastructure support for the triticale feed and forage breeding programs at the Field Crop Development Centre (FCDC, AAF) Lacombe and expand the core program significantly. This should include linkages with Functional Genomics Centers, and pre-breeding with rye and wheat to make new primary triticale lines, and to expand the germplasm base. “Breeding of high energy triticale is the best investment towards increasing biomass, for grain, forage, feed and bio-ethanol.”
- Invest in the development of a high-capacity cultivar development and screening processes that focus on evolving needs in the livestock feed and bioethanol markets to provide rapid plant breeding progress for these market segments. This would include reinstatement of full activity level for the hulless feed barley program at CDC, Saskatoon.

12.1 Producer priorities
- Develop enhanced N use efficiency in all cereal crops. This provides an opportunity to reduce N inputs; however, crops could also be bred to use excess N applied to the soil as hog or cattle manure – reducing the impact of manure applications to the environment.
- Develop cereals with vigorous growth habits and early competitiveness against weeds; semi-dwarf crops or crops with better lodging resistance; resistance to sprouting and bleaching; good harvestability; even dry down; and resistance to new insects and emerging diseases.
- Develop a western Canadian cereal varietal trial system to provide a reliable, unbiased means of evaluating cereal cultivars for producers.

12.2 Livestock industry priorities
- Create feed grains with high levels of feed energy that improve feed intake and are converted efficiently to protein. Livestock producers identify hulless barley as the most important crop in which these traits would be desirable, though this trait is very important for all feed grains.
- Develop feed grains that contribute positively to the environment by lowering levels of phosphorous compounds excreted from livestock and/or increase the amount of manure that could be used in crop production systems by lowering phosphorous levels in manure.

12.3 Bioethanol manufacturer priorities
- Develop a cereal grain with elevated levels of HTF that produces greater amounts of ethanol per unit of feedstock.
- Develop hulless barley with low levels of undesirable, non-fermentable constituents and soft white wheat specifically for use as bioethanol feedstock.
- Increase levels of β-glucan in barley, hulless barley, oat and hulless oat and increase levels of avenanthramide in oat and hulless oat – compounds of immediate commercial interest the industry.

12.4 Enabling technologies
- Develop a system to measure HTF in cereal grains.
- Develop a NIRS assay to identify and quantify traits in whole cereal grains to help provide a direct correlation between the value of the grain delivered and the price paid by the end-user.