City of Richmond

Report to Committee

To:	Planning Committee	**Date:**	September 22, 2010
From:	Joe Erceg, MCIP General Manager, Planning and Development	**File:**	
Re:	**The Methodology To Update OCP Environmentally Sensitive Areas (ESAs)**		

Staff Recommendation

That the methodology for identifying and mapping ESAs, as described in Attachment 3 in the staff report from the General Manager, Planning and Development, dated September 22, 2010, be endorsed.

Joe Erceg, MCIP
General Manager, Planning and Development

Att. 3

FOR ORIGINATING DEPARTMENT USE ONLY				
ROUTED TO:	**CONCURRENCE**		**CONCURRENCE OF GENERAL MANAGER**	
Law	Y ☑ N ☐			
Engineering	Y ☑ N ☐			
Environmental Sustainability	Y ☑ N ☐			
Parks Planning, Design & Construction	Y ☑ N ☐			
Development Applications	Y ☑ N ☐			
REVIEWED BY TAG	YES ☑	NO ☐	**REVIEWED BY CAO**	YES ☑ NO ☐

2982049

Staff Report

Origin

The purpose of this report is to propose a methodology for conducting the Environmentally Sensitive Areas Study which is part of the 2041 OCP Update.

Council Term Goal
The ESA Strategy, authorized by Council in 2009, is one of the main studies of the OCP Update and supports the following Council Term Goals:

- #3: *"Ensure the effective growth management for the city through updating of the OCP (and sub area plans) to reflect current realities and future needs,*
- *#7 Demonstrate leadership in and significant advancement of the City's agenda for sustainability through the development and implementation of a comprehensive strategy.*

Background

2041 OCP Update Progress
In mid 2009, work commenced to update the 1999 Official Community Plan. In May 2009, Council and staff discussed the OCP Update and Metro Vancouver draft Regional Growth Strategy to set Council's priorities for the 2041 OCP update. In October 2009, Council endorsed a preliminary OCP Update work program and terms of reference for the main OCP studies (e.g., ESA Management Strategy, Demographic and Employment Study, Employment Lands Strategy). In May 2010, Council approved OCP GHG targets. In June 2010, Council reviewed the progress regarding the 2041 OCP Update (various main OCP studies, the first round of public consultation findings and the next steps). In July 2010, Council received 2041 population, housing and employment projection, and housing type information which will be refined as the OCP is finalized. It is anticipated that the OCP with an accompanying DCC bylaw will be finalized in the Fall 2011.

Existing ESAs
The current OCP ESA policies, Development Permit guidelines and map were adopted in 1999 and are shown in **Attachment 1**.

ESA Strategy Preparation Phases
It is proposed that the ESA Strategy be prepared in the following phases: (see **Attachment 2**):

- Phase 1 - Getting the ESA Strategy Right - Jan - September 2010 (this report);
- Phase 2 – Final Field Work - Fall 2010;
- Phase 3 - Strategy Preparation - Fall 2010.

The original Strategy dates have been adjusted from the original anticipated work program to reflect the progress to date. Most of Phase 1 of the ESA Management Strategy is completed including: a review of existing ESA data, inventories and mapping, a review of available watercourse and habitat information and various Provincial, regional and City environmental studies, the identification of gaps in data, a review and selection of "best ESA management practices", creating a classification methodology, classification tables and a carbon storage methodology and digitized ESA mapping.

What Are ESAs?
ESAs are areas identified in the OCP as containing significant natural environmental features (e.g., vegetation, woodlots, waterways, wetlands) which are to be protected by the OCP ESA policies, development permit guidelines and map designations. The aim is to manage any potential negative environmental impacts of development, subdivision and alterations in ESA areas. ESAs are usually privately owned and it is not intended that the City will purchase ESA areas.

The General Application of ESAs and Compensation
General
Recent legal advice indicates that, if an area is designated in the OCP as an ESA, a Development Permit (DP) is required for all subdivision, construction, alterations of buildings and alterations of land designated ESA, unless the OCP or zoning bylaw provides an exemption for such activities (e.g., cultivation, farm soil filling, feedlots, drainage works). ESA requirements can be tailored as to how they affect farming to promote agricultural viability.

Where a site is designated ESA, the owner is entitled to use the land for the uses and at the (building) density permitted in the zoning bylaw. This includes authorizing any incursion into the ESA that is required to accommodate the land use and density (e.g., driveway access to a building). Regarding application of ESA tools, "density" refers to the building site coverage and floor area, and not the percentage of parcel area cultivated or logged.

No Financial Compensation Required
No financial compensation is required for an ESA designation:
- For Buildings and Density:
  - When buildings and their density are allowed, as permitted in the zoning bylaw (e.g., by still allowing the building floor area on the site, for example by locating it on the developable portion of the site), or
  - If the owner incurs some additional construction costs, where the whole parcel is not designated ESA.
- For Other Activities:
  - Where an ESA allows some cultivation or logging of a site, no compensation is required (see "density" above).

Possible Financial Compensation:
Financial compensation may be required for an ESA designation:
- For Building and Density:
  - When buildings and their density are not allowed, as permitted in the zoning bylaw.
- If A Whole Parcel Is Designated ESA:
  - Where the ESA designation affects the entire parcel, compensation may be required, as is it may be regarded as a "public use".
  - To reduce the chance that there will be a compensation claim, several options may include leaving a portion of the site to be developable, and exploring density transfer possibilities in the OCP.

The above interpretations are consistent with the *Agricultural Land Commission Act* and the Agricultural Land Reserve Use, Subdivision and Procedure Regulation. In applying ESAs, the City generally strives to avoid financially compensating owners.

Strategy Preparation Context
In establishing the Richmond ESA Strategy, it is important to not over-promise environmental protection but rather to balance it with realistic jurisdictional roles, the available City tools (e.g., OCP ESA designations, Development Permits, conditions), and find ways for owners to continue to use the land and/or to mitigate for the impacts of ESAs.

While the City can require that in ESA areas or portions thereof, land remains free from development, natural features be preserved, water courses dedicated, the environment enhanced and trees be planted, Council is aware that efforts need to be made to enable owners to use their land. The Strategy will identify a range of options to achieve this balance. It is not intended that the City purchase ESAs as it would be too expensive. In cases, where the impacts of development (e.g., construction) on ESAs cannot be mitigated and development is prohibited, the City may consider purchasing the ESA for City use (e.g., for City park).

It is also important to recognize that the City is only one of several government agencies which has a role in managing environmental lands. The other agencies include the Federal, Provincial, regional (e.g., Metro Vancouver) governments, as well as others (e.g., NGOs), for example:
- The Federal government manages The Specific species Act,
- The BC Ministry of Environment addresses environmental stewardship, water stewardship, certain parks and protected areas, and certain environmental protection matters,
- The Fraser Estuary Management Program (FREMP), which includes Environment Canada, Fisheries and Oceans Canada, Transport Canada, BC Ministry of Environment, Metro Vancouver, Port Metro Vancouver and the City, manage the following environmentally related topics: integration/ sustainability, water and sediment quality, fish and wildlife habitat, dredging and navigation, log management, industrial and urban development and recreation.

In some cases, several jurisdictions (e.g., federal, provincial, regional, municipal) may have overlapping authority. The Strategy will identify the roles, practices and lands which each manage. The Strategy is not intended to duplicate the efforts of these other authorities, as the City does not have the resources to do so. Rather, it will complement them by identifying the distinct City role, policies and areas for ESA management. This approach promotes jurisdictional responsibility, co-operation and co-ordination.

ESA Management Strategy Terms of Reference **(Attachment 2)**
The ESA Terms of Reference were prepared with input from the Agricultural Advisory Committee (AAC) and the Advisory Committee on the Environment (ACE), and endorsed by Council in October 2009. The Strategy will enable Council to establish an improved OCP ESA approach, for example:
- an improved OCP ESA vision, goals, principles, policies, management tools (e.g., zoning, development permit guidelines, covenants, caveats, performance requirements) and GIS based ESA maps;
- an improved ESA ongoing monitoring, protection and enforcement program; and
- possible incentives to better manage ESAs (e.g., in agricultural, industrial and urban areas).

Findings of Fact

Green Infrastructure Approach and Criteria For the ESA Strategy
Attachment 3 contains the proposed Methodology for Identifying and Mapping ESAs. It proposes a unique, scientific and flexible "Green Infrastructure" methodology that will, it is suggested, be used to identify, inventory and map ESAs. It also describes the various classifications (5 classes and 13 subclasses of vegetation and 3 vegetation modifiers and 19 sub modifiers) and other ratings (vegetation naturalness, forest age, forest density ratings and wetland classifications) that are believed to be relevant to the City of Richmond and will be used to prepare the ESA Strategy.

Aspects of Green Infrastructure
- "Green Infrastructure" is as an interconnected network of natural ("green") elements that occur at a variety of scales – site/building, neighbourhood, community-wide, regional, and beyond.
- A "Green Infrastructure" assessment uses a geographic information system (GIS) and the principles of landscape ecology and conservation biology to identify a connected network of natural and semi-natural lands most critical to an area's long-term ecological health.
- Sites will be prioritized for their relative importance within the ESA network and will emphasize the spatial relationships between natural and semi-natural areas and their important functional role in landscape processes, such as sustaining natural flows of water, nutrients, and energy;
- An important aspect of the "Green Infrastructure" approach is the identification of:
  - "Hubs", the largest intact patches of naturally functioning ecosystems, and
  - "Corridors", which provide important physical or functional linkages between hubs of similar or different ecosystem types. Some sites may be more or less important to the ESA network;
- Restoration and enhancement possibilities and priorities will also be identified to improve the overall functioning of the ESA network.

The "Green Infrastructure" approach and criteria have been successfully applied elsewhere in Surrey, Maryland and Florida.

Green Infrastructure ESA Review Criteria and Inventory
It is proposed that the ESA review criteria and inventory be based on the following:
1. Primary Criteria:
   - biodiversity and wildlife habitat (e.g., animal and plant species, ecosystems); and
   - watersheds, watercourses, and wetlands (riparian, fish species, soils, geology).

2. Secondary Criteria:
It is proposed that in addition to the Primary Criteria, once designated, ESAs will be analysed in terms of their other key functions, namely:
- human benefit such as recreation and the enjoyment of natural areas; and
- carbon sequestration and storage.

The impact of these criteria and proposed areas will be assessed and recommendations for how they can be mitigated will be addressed in the Fall 2010 report.

Analysis

ESAs In Agricultural Areas
It is important to review how ESAs apply in agricultural areas because:
- Approximately 37% of the existing ESAs occur within the ALR;
- The existing OCP does not specifically exempt agriculture from the need to obtain an ESA Development Permit (DP); however, based on past legal advice, City practice has been to not directly limit agricultural cultivation in ESAs and farmers may clear ESA areas for farming purposes without going through the ESA DP process;
- The current Richmond Agricultural Viability Strategy similarly promotes this flexibility.
- In view of recent new legal advice, that agricultural activity can be regulated based on an ESA designation, this practice will be reviewed with care later in the study review process.

Currently, the following approach is taken in applying ESA policy in agricultural areas:
- when subdivision and construction activity are proposed, an ESA Development Permit is required and attempts are made to preserve the environmental resources in a balanced manner (encourage no the net loss of ESAs, natural corridors, storm water retention, replanting), and
- when land is proposed to be cleared (e.g., trees), to raise agricultural crops and for grazing, it is City practise that an ESA Development Permit is not required and all or some of the environmental resource may be disrupted or lost; however, City staff encourage farmers to first discuss their clearing plans to see if, voluntarily, some of the ESA can be conserved (e.g., leave an ESA along a fence row, or consider retaining a portion of the ESA).

The ESA field work will explore the potential for ESAs in agricultural areas. Once assessed, a report will be brought back to Council for review and consideration as to where and how ESAs may apply in agricultural areas.

The Garden City Lands (GCL)
As previously reported to Council, due to the ongoing litigation involving the Garden City Lands (GCL), this site will be identified as "Subject to Further Study", within the OCP Update and excluded from this study, it is noted that this approach is consistent with the City Centre Area Plan (CCAP).

Summary
Staff recommend that the proposed "Methodology for Identifying and Mapping ESAs" by HB Lanarc dated May 17, 2010 (**Attachment 3**) be endorsed.

Next Steps
Field assessments have commenced to review and clarify air photo based land cover mapping, and to visit and characterize representative habitats. As Phases 2 and 3 are conducted, the Advisory Committee on the Environment (ACE) and the Agricultural Advisory Committee (AAC) will be kept updated. The final ESA Strategy will be presented to Council in Fall 2010 for consideration and approval. The approved ESA Strategy findings will be incorporated into the final OCP update in 2011.

Financial Impact

None, as the ESA Strategy preparation is funded from existing budgets.

Conclusion

This report presents a recommended approach for the ESA Strategy.

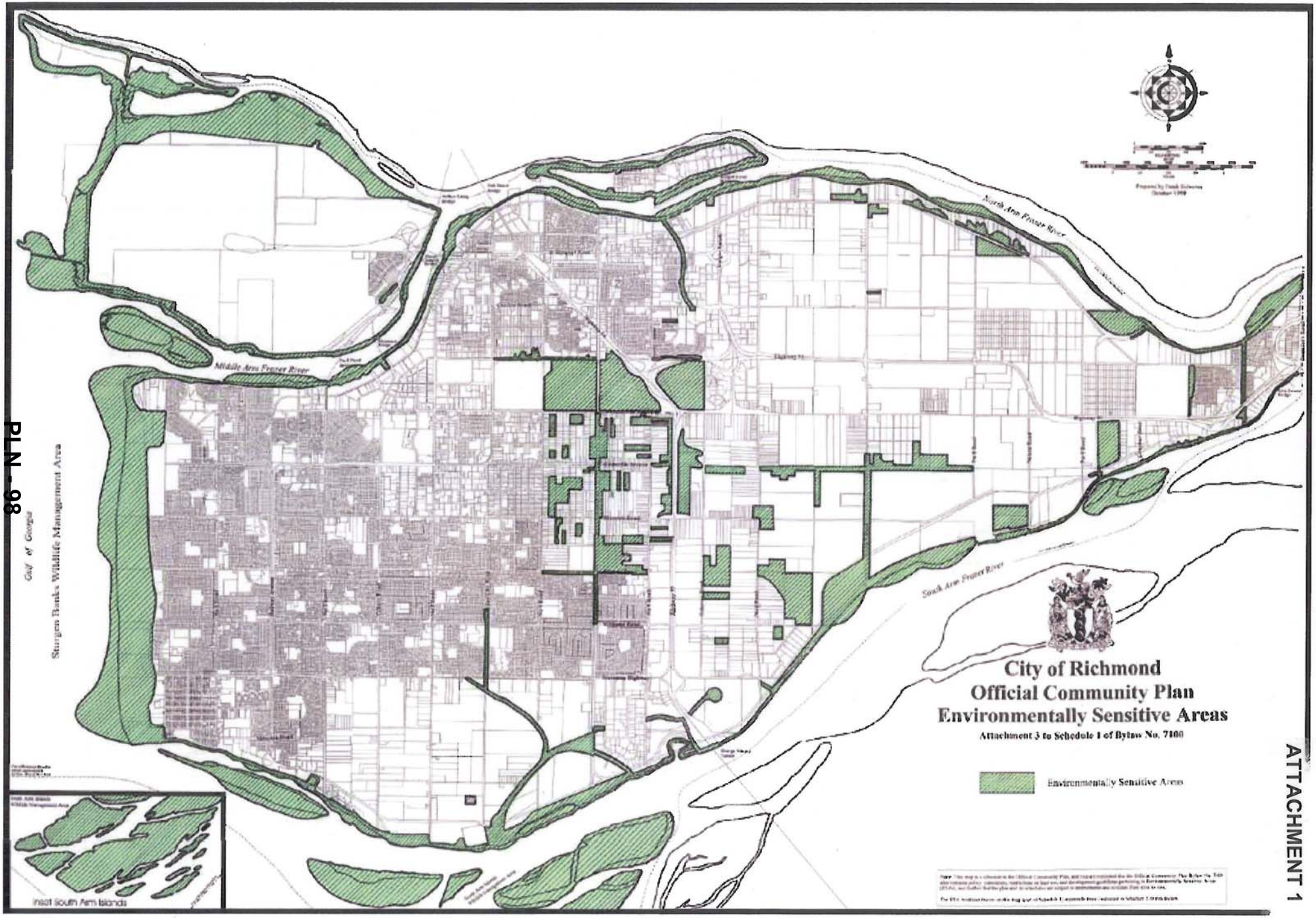
Terry Crowe,
Manager, Policy Planning - 4139

June Christy
Senior Planner, Policy Planning -4188

TTC:jc

Att. 3

Attachment 1	Existing 1999 OCP ESA Map
Attachment 2	ESA Management Strategy Terms of Reference
Attachment 3	A Memorandum from HB Lanarc Re The Methodology for Identifying and Mapping City ESAs



PLN - 98

ATTACHMENT 1

November 25, 2009

City of Richmond
Terms of Reference
Environmentally Sensitive Areas Management Strategy Update

1. Purpose

The purpose of the Environmentally Sensitive Areas (ESA) Management Strategy Update is to update Richmond's existing 1999 Official Community Plan (OCP) ESA inventory, policies and mapping, and to develop a more comprehensive strategy and implementation program for better managing the ESA's over time. The Strategy will establish policies, regulations and guidelines for a more effective identification and management approach to ESA's (e.g., best practises, incentives, partnerships, regulatory tools) and establish clear policies for development and retention.

2. Background

Importance of ESA's

Richmond believes in the importance of protecting ESA's as, in addition to containing valuable habitat for birds, fish and other wildlife, ESA's contribute to healthy ecosystems, and are recognized as contributing to the quality of life (through cleaner air and water), providing opportunities for active living through recreational pursuits and creating a diverse vibrant urban community.

ESA Protection in Richmond

Richmond has been protecting its natural areas since the 1960's when the 300 acres of bog and bog forest (the Richmond Nature Park) were acquired by the City. Throughout the 1980's and 1990's, various City-wide inventories of Richmond's natural areas were developed. The current OCP ESA map and Development Permit guidelines were adopted in 1999 and are the legal tools currently used in Richmond to manage the potential impacts of development on ESA's. In the last few years, the City and a consultant modified and adapted an inventory system developed by the Fraser River Estuary Management Program (FREMP) for classifying and inventorying shoreline habitats. The system is based on an Ecological Features and Functions Approach (EFFA) and Richmond adopted EFFA for assessing its Environmentally Sensitive Areas in the upland areas behind its dykes. The ESA update will not duplicate FREMP, Provincial and Federal environmental policies but will build on them.

Need for An Update of the ESA

Richmond's current ESA inventory needs to be updated to assess the current situation and its OCP policies improved to better meet the full range of needs related to the management of

ESA's. More information on the ecological features and functions within the ESA's is needed and several original OCP ESA areas have undergone changes and their environmental characteristics and values may have changed. As well, there is new environmental legislation, tools and best practices that could be utilized in the protection of ESA's in Richmond. As well, more clarity is needed regarding whether or not identified ESA's should be retained as is and/or the degree to which they may be modified.

ESA's within Agricultural Areas

Many of Richmond's ESA's lie within or adjacent to the ALR. Current OCP policies on ESA's do not directly limit agricultural cultivation and farmers may clear areas of ESA for farming purposes, and in the past, large forest clearings have taken place within the ALR without any prior notice. Farmers have also expressed concern that the existence of an ESA may have an impact on the economic viability of farm operations and have identified several issues (as cited in the Agricultural Viability Strategy). These issues will be addressed in the scope of work.

ESA's Within Non-Agricultural Areas

A significant amount of Richmond's ESA are within its industrial areas. Many industrial operations require large cleared areas of land for operations such as truck parking, storage, warehousing and manufacturing processes. In the past, there has been illegal activity such as clearing land containing ESA's for industrial use without prior notification to the City. Issues such as limited staff resources for enforcement and inspections also hinder the preservation of Richmond's ESA's.

Over the years, there has been a slow decline in the significant habitat in Richmond and more resistance by developers to protect ESA's.

What is Needed?

ESA's need a better classification criteria and a clearer strategy to manage them on private and public lands (e.g., development versus conservation). The current ESA approach identifies the ESA but does not specify to what degree it should be protected during site-specific development. More clarity and a better approach to the management of ESA's are needed.

3. Scope

The Study Area will be the entire City of Richmond, including its watercourses, wetlands, riparian areas, forests, and potential sensitive wildlife locations and habitat features (e.g. nest, roosts, burrows, travel corridors). The study is not to duplicate existing provincial (e.g., riparian) and federal environmental areas and policies.

The strategy will:

1. Contain a vision, principles, policies, objectives, guidelines, maps, models and facts;

2. Identify best practices most suitable for Richmond and use a modified Ecological Features and Functions approach (EFFA), and other best practises developed by the Fraser River Estuary Management Program (FREMP) or others;
3. Update a Geographic Information System (GIS) based, OCP Environmentally Sensitive Areas (ESA) Map;
4. Recommend a more effective management approach to ESA's (e.g., a clear philosophy, best practises, degree of conservation versus degree of development allowed, any incentives, partnerships and other regulatory tools);
5. Propose a program for ongoing monitoring, protecting and enforcing ESA's over time; and
6. Establish clear guidelines and possible incentives for the management of ESA's within agricultural areas, industrial areas and urban areas.

4. Major Study Components

Phase 1 (January 2009 to March 2010) – Getting the ESA Strategy Right

1. Preliminary Consultation with Agricultural Advisory Committee (AAC), Advisory Committee on the Environment (ACE), FREMP, etc.;
2. Hire Consultant;
3. Review existing ESA data, ESA inventories and ESA mapping for their accuracy;
4. Review Watercourse Classification and Sensitive Habitat Inventory Mapping and various Provincial, Regional and City environmental studies;
5. Analyze and confirm existing information and identify gaps in data or information.
6. Review and select "best ESA management practices";
7. Develop and confirm a criteria, Environmental features and functions (EFFA) and methods for ESA inventory and assessment;
8. Propose a spring (2010) work program for field work inventorying and mapping;
9. Stage 1 Progress Report summarizing:
   a. ESA purpose, philosophy, policy needs and framework, and flexibility;
   b. Existing data gaps and needs;
   c. A modified Ecological Features and Functions approach; and
   d. The Spring 2010 work program.
10. Presentation to Staff Steering Committee (include interim progress report);
11. Presentation to Advisory Committee on the Environment and the Agricultural Advisory Committee; and
12. Present to Planning Committee and then Council for the approach of the ESA Strategy.

Phase 2 (March 2010 to June 2010) – Spring Field Work, Inventorying and Mapping Fieldwork

1. Utilize geographic information systems database software, 2009 aerial photographs, and published data;
2. Selective field inventory and "ground-truthing" (use remote sensing information, if possible) in the field;

3. Use the EFFA approach and identify each ESA feature and/or function and justify why each ESA feature and/or function is important;
4. Summarize findings and meet with City staff for confirmation;
5. Through mapping and inventory, specifically identify what part of each ESA feature and/or function is important to manage (all? some? little?);
6. Identify how important and why, it is to manage each ES feature and/or function (high? medium? or low?);
7. After establishing the importance (high, medium or low) and the amount (all, some, little) of each ES feature and/or function, identify the extent and location if any, that new development (e.g. buildings, site clearing, industrial storage, cultivation) can take place on designated ESA portions of a property;
8. Adjust ESA designations as necessary;
10. Progress Meeting/Workshop with Staff ESA Steering Committee to review the maps and supporting data;
11. Second round presentations on findings to ACE and AAC (and other stewardship and community groups); and
12. Update to Planning Committee and Council.

Inventorying and Mapping

1. City-wide inventory and mapping, including Federal, Provincial and FREMP areas:
   a. Watercourse, wetland and riparian areas, rated for significance and integrity;
   b. Vegetation communities, forests, fields rated for significance and integrity;
   c. Slopes, soils, surficial geology, aquifers rated for sensitivity to disturbance; and
   d. Identify potential sensitive wildlife locations and habitat features (nests, roosts, burrows, travel corridors, etc); and
2. Deliver a set of City-wide ESA Inventory maps in electronic (GIS) and hard copy in a shape file format, INAD 83 (specifications to be confirmed by City of Richmond).

Phase 3 (July 2010 to August 2010) – Draft ESA Strategy

General

1. Goals, and Options;
2. For each identified ES feature and/or function:
   a. What OCP ESA policy is needed?
   b. The degree of ESA development versus its conservation;
   c. What OCP ESA designation is needed?
   d. What OCP ESA development permit guidelines are needed? and
   e. What ESA regulations are needed? (e.g., zoning, covenant, caveats, performance requirements).

Land Use and Density:

For each identified ES feature and/or function, what urban or agricultural land uses, if any, should the City allow the owner to develop on the site?

1. To what Degree?
2. How?
3. Conditions?
4. What possible incentives?

Project Deliverables

1. ESA Management Strategy and Implementation Program;
2. A modified EFFA model and EFFA inventory methodology; and
3. A detailed inventory and database and a model for updating Richmond's upland ESA inventory.

A Data Base:

1. Maps, inventory data, digital site photographs where possible, and detailed site use guidelines and procedures for each of the ESA sites analyzed and of the existing and potential ecological characteristics associated with each ESA site; and
2. A description of the criteria, uses and the justification for the significance ratings associated with the ESA Maps.

5. Roles

Consultant

The consultant will:

1. Assemble a team with the skills including:
   a. Environmental assessment;
   b. GIS mapping;
   c. Urban lands economics, planning and regulation;
   d. Other, to be determined by the consultant and City;
2. Perform services necessary to achieve the work set out in the proposed work program;
3. Perform the work within the budget and work program timeframe; and
4. Attend meetings with the City Team, the Agricultural Advisory Committee (AAG) and the Advisory Committee on the Environment (ACE).

City Team

The study will be led by Policy Planning with staff from:

1. Policy Planning;
2. Development Applications;
3. Environmental Programs;
4. Parks, Recreation and Culture;
5. Engineering; and
6. Sustainability.

Policy Planning Staff will:

1. Manage the consultant contract, work program and the City Team;
2. Consult with Advisory Committee on the Environment (ACE) and the Agricultural Advisory Committee (AAC);
3. Provide available City data, reports, and maps;

4. Make final decisions regarding consultant selection, work program, and report revisions; and
5. At City expense:
   a. Provide central copying/printing service;
   b. Make available meeting space; and
   c. Provide mail service.

The Advisory Committee on the Environment (ACE) and the Agricultural Advisory Committee (AAC)

1. Review and provide input into the study at selected stages of the process (at least 2 structured meetings/workshops with each committee) through review and evaluation of the study at key points;
2. Speak from their own expertise and interest;
3. Reflect diverse perspectives;
4. Maintain awareness of the study, and be informed; and
5. Review draft and final report.

6. Other Consultation

1. Federal, provincial, and non-government organizations (e.g., Department of Fisheries and Oceans, Canadian Wildlife Service, FREMP, Agricultural Land Commission, and YVR Airport Authority);
2. Community and stewardship groups; and
3. Open Houses as per the OCP process.

7. Time Frame

It is anticipated that the study will commence in January 2010 and will be completed by August 2010.

8. Mapping Scales

A variety of City mapping scales will be used (e.g., City-wide OCP Scale, site details will try to show ESA details clearly).

HB LANARC

MEMORANDUM

CITY OF RICHMOND: Environmentally Sensitive Area Management Strategy

Prepared by HB Lanarc Consultants Ltd., Raincoast Applied Ecology

May 17th, 2010

ATTENTION: JUNE CHRISTY

RE: Methodology for Identifying and Mapping City ESA's

This memo summarizes the approach for identifying and mapping environmentally sensitive areas (ESAs) in the City of Richmond.

ESAs include areas (polygons) or point features that are important for maintaining the environmental features and values. Examples of potential ESAs in Richmond include:

1) Natural foreshore areas (outside dykes, including saltmarsh and sandflats);
2) Remnant bogs and bog forest (unique ecosystem type on Fraser River delta);
3) Watercourses (sloughs, ditches), wetlands, and their adjacent riparian areas;
4) Forest patches and other treed areas;
5) Old field and meadow areas; and
6) Hedgerows and scattered trees in agricultural areas.

The City of Richmond requires a rigorous, science-based approach to identifying existing environmental areas and features, prioritizing their relative value, and recommending strategies for protecting and restoring environmental values as the city continues to develop.

A New ESA Approach: Green Infrastructure

"Green infrastructure" is a term that is becoming more common in land use planning, engineering, and site design. In general, green infrastructure is an interconnected network of natural or "green" elements that occur at a variety of scales – site/building, neighbourhood, community-wide, regional, and beyond.

A Green Infrastructure assessment uses Geographic Information Systems (GIS) and the principles of landscape ecology and conservation biology to identify a connected network of natural and semi-natural lands most critical to an area's long-term ecological health. Sites can be prioritized for their relative importance within the network. The Green Infrastructure Network approach has been used successfully to identify priorities for environmental management in other jurisdictions at both large (e.g, State of Maryland, State of Florida) and small (e.g., City of Surrey) scales.

In the Richmond context, a Green Infrastructure (GI) approach builds on traditional Environmentally Sensitive Area (ESA) identification and mapping methods. Both approaches address the need to spatially delineate important environmental and natural assets. However, unlike traditional ESA mapping, the GI approach also emphasizes the spatial relationships between natural and semi-natural areas within the landscape and their important functional

role in landscape processes, such as sustaining natural flows of water, nutrients, and energy. Key to this approach is the identification of hubs, the largest intact patches of naturally-functioning ecosystems, and corridors, which provide physical or functional linkages between hubs of similar or different ecosystem types.

Several key principles underlie the GI approach:

1) **Natural ecosystems provide important benefits that help to sustain both a resilient environment and healthy human communities.** Often called "ecosystem services", these benefits include services such as habitat for biodiversity, water and air purification, waste decomposition, and crop pollination.

2) **Natural ecosystems can be important because of their composition (e.g., presence of a rare species), structure (e.g., grassy areas that are used by owls and hawks for hunting), or function (e.g., retaining rainfall during large storms).** Consideration and understanding of all of the ecological features and functions that each ecosystem type and individual parcels provide is an important aspect of assessing their relative value. Ecosystem functions are often not well covered in traditional ESA approaches.

3) **The value of natural ecosystems depends on their context within a system of interconnected natural or other open spaces.** Sites are not viewed independently but within the context of the network. Some sites may be more or less important to the network. Restoration and enhancement priorities can also be identified that would most improve the overall functioning of the network.

Inventory: Mapping Important Ecosystems and Ecosystem Services

Natural ecosystems are increasingly being recognized for providing important ecosystem services in urban landscapes. Four functions or services are often the focus of urban environmental management: 1) biodiversity and wildlife habitat; 2) watersheds, watercourses, and wetlands; 3) human benefit such as recreation and the enjoyment of natural areas; and 4) carbon sequestration and storage. Although natural ecosystems provide other services and benefits as well, many are more difficult to map or are not easily connected to management (e.g., crop pollination). Focusing on this subset provides a broad yet practical approach for understanding the value of natural-functioning ecosystems in Richmond. Therefore, our inventory will focus on mapping the distribution of these four key ecosystem functions within the City of Richmond.

Below, the proposed inventory, analyses, and potential products or deliverables are outlined for each of these four ecosystem services:

1) **Biodiversity and Wildlife Habitat.** A wide range of animal and plant species depend on natural ecosystems for their habitat and biological needs, including economically- and culturally-important species (e.g., salmon, Great Blue Heron) and regionally-rare species and ecological communities. Vegetation is the best indicator of habitat value for biodiversity.

   Existing information sources: Existing ESA mapping updated by Berris and Associates (2003); FREMP habitat inventory (2006); Lulu Island Bog report (2008); historic and recent BC

Conservation Data Centre rare species occurrence records; park biophysical inventories and assessments; naturalist's information; consultant's reports (if available).

New information: Building on previous ESA mapping, natural and semi-natural vegetation will be mapped using a standard classification and mapping method (USNVC) based on interpretation of existing vegetation in recent (2009) orthophotos. The mapping process will use some attributes from the 2003 GIS data but we will update and refine polygon boundaries, as well as add additional areas such as urban parks that were not mapped in 2003. Vegetation within highly developed areas, such as gardens and lawns, will not be mapped. Degree of naturalness will be estimated from orthophoto interpretation. Mapping will be undertaken in ARCGIS using 2009 orthophotos. Vegetation units will be delineated using an onscreen scale of 1:5000. Limited field surveys will be undertaken to review polygon boundaries, assess species composition, and identify the presence of important features such as red- or blue-listed ecological communities. Appendix 1 provides the proposed classification scheme for mapping of natural and semi-natural vegetation.

Analyses: A Green Infrastructure assessment will be conducted consisting of the following components:

1. Delineation of hubs (largest areas of naturally-functioning ecosystems) using criteria based on vegetation type, naturalness and area
2. Delineation of corridors (linkages between hubs) based on impedance of the landscape between hubs to wildlife movement, seed dispersal, etc.
3. Multi-criteria ranking of hubs and corridors for significance within the network

Products/Deliverables:

1. City-wide vegetation mapping based on physiognomic class and subclass
2. Map of rare and endangered species occurrences based on existing information, and limited fieldwork
3. Map of red- and blue-listed plant communities based on existing information, new vegetation mapping, and limited fieldwork
4. Maps showing delineated hubs and corridors of Green Infrastructure Network
5. Habitat value rankings for each hub and corridor (based on importance to overall network)

2) **Watersheds, Watercourses and Wetlands.** Ecosystems provide important functions and capacity for managing water. Ecosystem services in this category include stormwater retention, infiltration, and purification; flood and drought mitigation; and protection from stream and coastal erosion. (Provision of drinking water or water for irrigation purposes is not included for the purposes of this project.) Importance depends on vegetation, soils, location, and imperviousness in the surrounding landscape.

Existing information sources: Watercourse mapping by type (lines); Riparian Areas Regulation streamside protection areas (5 m and 15 m setback areas (based on buffered centrelines); fish species distribution; pump station catchment boundaries; BC Ministry of Agriculture soils layer; Ministry of Natural Resources Canada surficial geology layer; FREMP shoreline colour coding.

New information: Imperviousness will be mapped using existing Metro Vancouver land cover, riparian vegetation will be mapped as a component of City-wide vegetation mapping, watercourses and wetlands to be mapped as polygons (currently as line features).

Analyses: The following calculations will be completed on a catchment basis as indicators of watercourse health:

1. Calculation of imperviousness by catchment and other units using existing Metro Vancouver land cover (CLUCS code) mapping and estimates of total and effective impervious areas
2. Calculation of riparian vegetation cover, particularly forest cover (by catchment) using buffered watercourses

Products/Deliverables:

1. Map of imperviousness by catchment
2. Map of riparian vegetation cover and assessment ratings by catchment or watercourse network
3. Map of wetland areas (and seasonally flooded areas where existing data exists)
4. Map showing overlap between hydrologically sensitive areas and GIN

3) **Recreation and the Enjoyment of the Natural Areas.** Increasingly, natural ecosystems are being valued for their recreation opportunities, such as bird watching or nature study, and simply as places to experience and connect with nature. Recreational value is influenced by an area's uniqueness, habitat diversity, as well as accessibility and proximity to residents. Greenways also provide an opportunity to protect and use natural corridors to provide cycling and walking corridors between neighbourhoods in the city.

Existing information sources: Park boundaries, park amenities (fields, playgrounds), trails, greenways, population distribution information.

New information: Vegetation and naturalness mapped for all parks (from City-wide vegetation inventory)

Analyses: An assessment of recreational benefits will be conducted using the following components:

1. Proportion of park network that are composed of natural ecosystem types
2. Current representativeness of vegetation and/or ecosystem types within park network (City-wide and by neighbourhood)
3. Proximity of natural parks to population (within walking distance)
4. Proportion of greenways or linear parks within or adjacent to natural ecosystem types

Products/Deliverables:

1. Parks classified by proportion of natural or semi-natural ecosystems (from City-wide vegetation mapping)
2. Map showing overlap of Green Infrastructure Network corridors and potential greenway routes

3. Map showing priority parkland acquisition areas of Richmond for natural parkland based on current distribution

4) **Carbon Storage.** Climate change has increased the importance of carbon storage in all parts of the world, including urban areas. Some natural ecosystem types sequester more carbon than others and some are more suitable for restoration work to increase carbon storage.

Existing information sources: BC Ministry of Agriculture soils layer; existing vegetation data from ESA mapping updated by Berris and Associates (2003), FREMP habitat inventory (2006), and Lulu Island Bog report (2008).

New information: Existing carbon sequestration and potential carbon storage based on existing and potential vegetation type (based on City-wide vegetation mapping). Relationships will be based on existing data on carbon storage and release for general terrestrial ecosystem types.

Analyses: Carbon storage and sequestration can be estimated using general terrestrial ecosystem components and standard coefficients of biomass production (appendix 2). The following calculations will be completed:

1. Calculation of total carbon stored by general terrestrial ecosystem type
2. Calculation of total yearly carbon sequestered by general terrestrial ecosystem type
3. Estimation of land use changes on carbon release and loss of sequestration potential

Products/Deliverables:

1. Map of ecosystem types with importance to carbon storage
2. Map of areas with potential for restoration to improve carbon storage

Appendix 1: Classification Tables

Table 1. Vegetation classes (5) and subclasses (13) in the City of Richmond

Class	Subclass	Richmond Examples
Forest (FO)	Evergreen Forest (FO-EV)	Western hemlock forest
	Deciduous Forest (FO-DE)	Black cottonwood forest; paper birch forest
	Mixed Evergreen-Deciduous Forest (FO-MX)	Western red cedar forest; Big-leaf maple forest
Shrubland (SH)	Evergreen Shrubland (SH-EV)	Rhododendron gardens
	Deciduous Shrubland (SH-DE)	Hardhack shrubland; Himalayan blackberry shrubland
	Mixed Evergreen-Deciduous Shrubland (SH-MX)	Cultivated gardens
Herbaceous (HB)	Perennial Graminoid Vegetation (HB-GR)	Lawns; old fields; pastures
	Hydromorphic Rooted Vegetation (HB-HY)	Cattail marshes; reed canary grass marshes
	Annual Graminoid or Forb Vegetation (HB-AN)	Gardens; fields with corn
Sparse Vegetation (SV)	Boulder, Cobble, Gravel, or Talus Sparse Vegetation (SV-BO)	Gravel bars; riprap bank protection with sparse vegetation
	Unconsolidated Material Sparse Vegetation (SV-UC)	Exposed soil and gravel with sparse vegetation
Unvegetated (UV)	Unvegetated Unconsolidated Material (UV-UC)	Gravel and soil with no vegetation
	Unvegetated Water (UV-WA)	Water (ponds, river, channels with no emergent vegetation)

Table 2. Vegetation modifiers (3) and submodifiers (19) for City of Richmond

Modifier	Submodifier	Modifies	Richmond Examples
Agricultural (AG)	Pasture (AG-PA)	HB-GR	Hay fields and pastures
	Old field (AG-OF)	HB-GR	Unmaintained fields with previous agricultural activity
	Seasonally flooded (AG-SF)	HB-GR	Agricultural fields with seasonal flooding
	Row Crop (AG-RC)	HB-GR, SH	Vegetable fields, blueberry fields
	Corrals (AG-CO)	SV-UC	Corrals, horse riding rings, feed lots
	Bare Ground (AG-BG)	SV-UC	Recently plowed or cleared fields with no evidence of crop
Developed (DV)	Playing Field (DV-PF)	HB-GR	Turf soccer fields
	Lawn (DV-LA)	HB-GR	Developed lawns in parks
	Old fields (DV-OF)	HB-GR	Unmaintained fields without previous agricultural activity
	Garden (DV-GA)	SH, HB	Large residential gardens, parks
	Golf Course (DV-GC)	HB-GR	Grass areas in golf courses
	Bare Ground (DV-BG)	SV-UC	Gravel road, dirt road, and similar clearings
	Road Margin (DV-RM)	HB-GR	Road medians and edges, may be sporadically maintained
	Urban Trees (DV-UT)	FO	Planted hedges, landscaping trees, forest with no natural understory
Aquatic (AQ)	Wetland (AQ-WN)	HB-HY	Freshwater wetlands: fens, marshes, swamps
	Lake/Pond (AQ-LP)	HB-HY, UV-WA	Farm and golf course ponds, natural lakes
	River/Fluvial (AQ-RF)	HB-HY, UV-WA	Larger river channels including the Fraser River
	Marine/Intertidal (AQ-MI)	NV-AL, SV-UC	Mud flats, beaches, river flats with tidal activity
	Ditches (AQ-DI)	UV-WA	Large ditches

Table 3. Vegetation naturalness ratings (5) for City of Richmond

Name	Definition	Examples
Natural	Undisturbed by direct human activity	Old-growth Forest
Mainly Natural	Disturbed historically (logged) by sufficient time to restore native species and structure; eg forests greater than 120 years old	Older forest, saltmarshes; some older deciduous forests
Semi-natural	Disturbed vegetation; predominantly native species but lacking some species and structures associated with natural vegetation	Red alder forest;
Altered	Heavily disturbed vegetation that is often a mix of native and non-native species; may be recovering or rapidly changing	Old fields; hedgerows, shrub communities on cleared sites
Cultural	Vegetation that is regularly maintained	Crops, pasture, gardens, lawns

Table 4. Forest age ratings (3) for City of Richmond

Forest Age	Name	Definition	Examples
Y	Young	Typically 5 to 35 years with canopy closure; often very even in appearance	Young red alder or cottonwood stands
M	Mature	35 to 120 years old; multilayered canopy; more structural diversity	Mature second-growth coniferous, deciduous, and mixed forests
O	Old	>120 years old	Old growth forest

Table 5. Forest Density ratings (3) for Richmond

Forest Density	Name	Definition	Examples
D	Dense	Complete Canopy Closure	Significantly forested areas
M	Medium	Partial Canopy Closure, Some gaps between trees	Isolated stands of trees in parks, agricultural parcels
S	Sparse	No Closed Canopy, significant gaps between trees	Street Trees

Table 6. Wetland Classification for Richmond

Wetland Classification	Name	Definition	Examples
FF	Flooded Field	Field that seasonally flooded	Seasonally flooded agricultural areas
SS	Shrub Swamp	Swamp areas with primary vegetation being low shrubs	
MF	Mud Flat	Flooded area with low amounts of vegetation	Foreshore Areas
B	Bog	Flooded areas that contain a diversity of vegetation including trees	Lulu Island Bog

Appendix 2: Carbon Calculation Coefficients & Equations

Table 1: Biomass coefficients and constants for common species in Richmond Terrestrial Ecological zones

Species	Wood constant (a_{wd})	Wood exponent (b_{wd})	Bark Constant (a_{bk})	Bark Exponent (b_{bk})	Branches constant (a_{br})	Branches Exponent (b_{br})	Foliage constant (a_{fl})	Foliage exponent (b_{fl})	DBH Range (cm)
Lodge pole Pine	0.0202	1.7179	0.0099	1.6049	0.044	3.719	0.0785	2.5377	2.5-39
White Birch	0.0593	2.5026	0.0135	2.4053	0.0135	2.5532	0.0546	1.6351	1.5-43.6
Black Cottonwood	0.0117	1.7757	0.018	1.8131	0.0112	3.0861	0.0617	1.8615	2.0-53.2
Red Alder	0.00119	2.17247	0.0112	3.28106	0.0112	3.28106	0.00239	1.32553	3-63
Western Hemlock	0.1132	2.257	0.0125	2.258	0.0053	2.778	0.0146	2.128	15-78

Table 2: Carbon constants for biomass to C02 conversion

Factor	Value
Root adjustment Factor (RA)	1.28
Dry Weight to Carbon Factor (DW)	0.5
Carbon to C02 Factor (C02)	3.67
Density (D)	Varies - Units per area
Area (A)	Varies - Size of ecosystem unit

Generalized Total Stored Carbon Dioxide calculation:

$$(a_{wd}(DBH_{wd})^{b_{wd}} + a_{bk}(DBH_{bk})^{b_{bk}} + a_{br}(DBH_{br})^{b_{br}} + a_{fl}(DBH_{fl})^{b_{fl}}) * RA * DW * C02 * D * A$$