RECOMMENDATIONS FOR A COMPREHENSIVE AND COOPERATIVE COLUMBIA RIVER INFORMATION MANAGEMENT SYSTEM

Executive Summary
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Submitted to the Northwest Power Planning Council (NPPC)
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I. INTRODUCTION

Managing the Columbia Basin's extensive, diverse, and diffuse information resources is a challenging task. Each year, dozens of entities generate and use enormous quantities of information to accomplish a wide range of goals. At present, several planning and management efforts, including the Northwest Power Planning Council (NPPC) Subbasin Planning Initiative and the ongoing need to support restoration of listed salmonids, including mandated requirements for data management under the 2000 Federal Columbia River Power System (FCRPS) Biological Opinion, are spurring a need to improve the management and organization of information efforts in the Basin.

The successful implementation of these initiatives requires a collaborative approach among the agencies involved to share data among themselves. A collaborative approach allows agencies to build upon - not duplicate - each other's efforts. Though some information repositories exist within the Basin, there is no centralized source for the wide range of information needed by stakeholders within the Basin to achieve the goals.

To support these efforts, the NPPC and the National Marine Fisheries Service (NMFS) signed a Memorandum of Agreement (MOA) in April 2002, for cooperative information system development for the Columbia Basin. This MOA states that:

"The Northwest Power Planning Council (Council) and the National Marine Fisheries Service (NMFS) agree to a cooperative approach to Information System Planning and Development for the Columbia basin. The Council and NMFS believe that the region is best served by a unified approach to meeting all data and information needs".

In addition to signing the MOA, the NPPC and the National Marine Fisheries Service (NMFS) teamed with key partners "*to improve the quality, quantity, and availability of Columbia River Basin data and related information on fish, oceans, wildlife, and their*

habitats using a publicly supported approach to information systems development." (Project Vision Statement, April 2002).

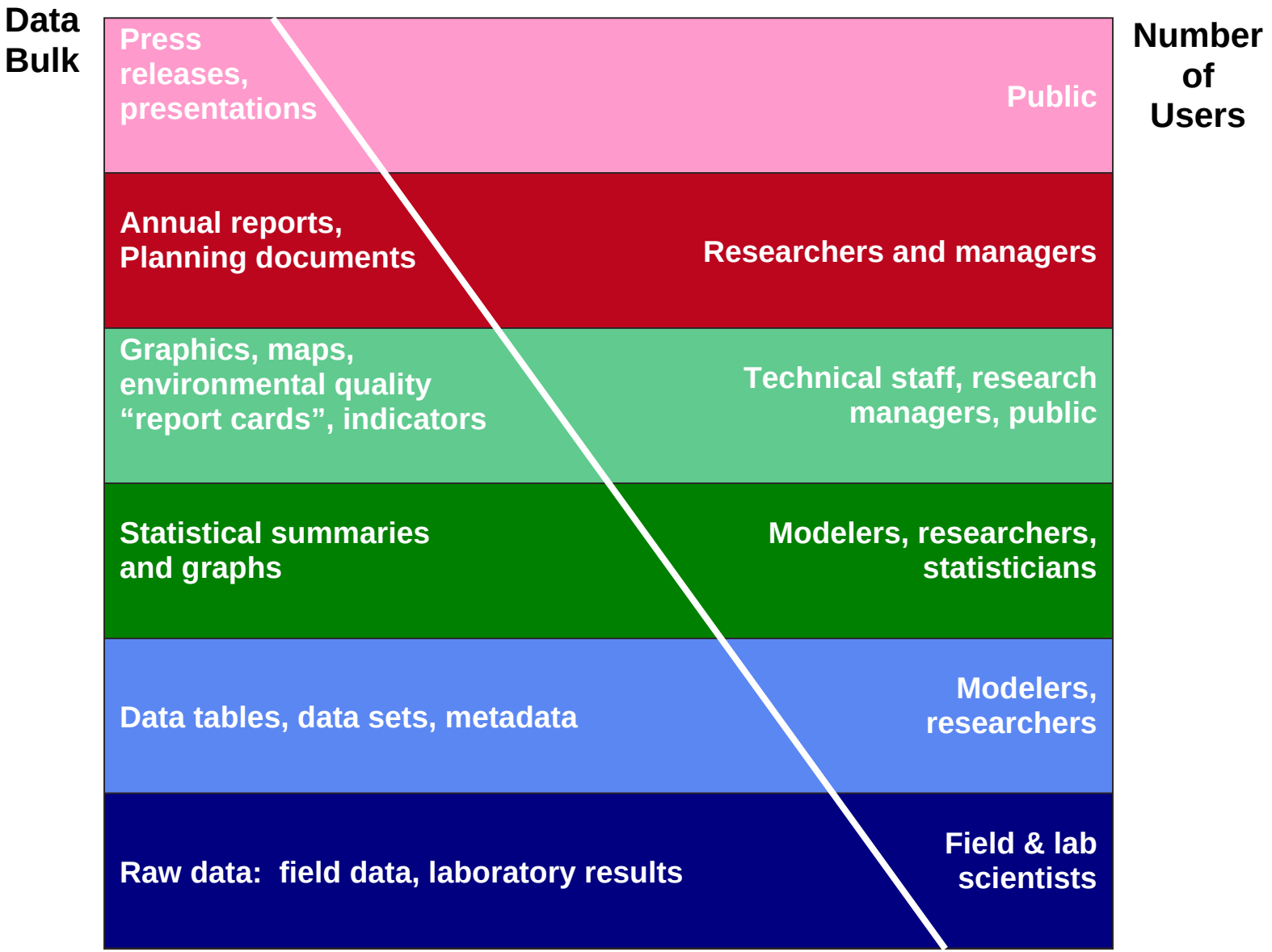
'Information', as described by the Vision Statement, encompasses the entire spectrum of information ranging from data collected in the field or lab to all information products generated from that data. An 'information system' embodies all components of information management that are required to enable collaborative information sharing between people and institutions.

The envisioned product of this effort, referred to as the Columbia Basin Cooperative Information System (CBCIS), would be a multi-state, bi-country, multi-agency information management system to house and disseminate information on the Columbia Basin. CBCIS will provide an online gateway to information resources and supporting tools using the latest Internet technologies to enable a wide range of users to contribute, identify, share and access valuable information about the Columbia Basin.

CBCIS would provide a means of accessing, exchanging, and analyzing data and information across a spectrum of information types reflected as an information spectrum. CBCIS also would provide managers with a tool to support adaptive management and decision-making regarding all of the key planning efforts and other emerging agency issues. CBCIS would address the institutional arrangements, policy requirements, agency communication and coordination needs, and standards and protocols that are needed to share and integrate information resources from disparate information sources. Finally, CBCIS would be an information system accessible to a broad range of users – program managers, researchers, scientists, and the general public, and would encompass all levels of the information spectrum (see Exhibit ES-1).

If CBCIS participants do not agree on common approaches to some fundamental topics affecting raw and processed information, and other approaches that cut across all levels of the information spectrum, the integration and sharing goals of CBCIS cannot be realized and "business as usual" will remain the norm.

Exhibit ES-1. The CBCIS Information Spectrum



II. PROJECT METHODOLOGY

Researchers, managers and staff, decision-makers, and general users, in their day-to-day efforts to understand Columbia Basin issues and implement and track effective restoration programs, clearly identified the need for a careful evaluation of information management capabilities and approaches in the Basin. This evaluation, coupled with a needs assessment, defined the broad framework for the Columbia Basin Cooperative Information System (CBCIS) project. The combined current evaluation and needs assessment comprised the requirements analysis.

The requirements analysis was performed to develop the background knowledge necessary for developing recommendations and designing an effective information system strategy to achieve Columbia River Basin restoration goals. The evaluation included obtaining knowledge of key initiatives that drive information management, defining priority information needs, developing an inventory of available information, and assessing the types of computing resources available to the users and developers of CBCIS. A variety of research techniques (e.g., interviews, focus groups, questionnaires) were used to obtain this information from participants in the Basin. Participant results were supplemented with a literature review. Findings from all these research modalities supported development of concrete recommendations and this *Evaluation and Recommendations Report* for the initial development of CBCIS.

Project Organization

Two core groups, the Project Team (PT) and the Coordinating Committee (CC), played a vital role in the development of CBCIS.

The PT is a group of approximately 15 individuals comprised of those most intimately involved in the development and implementation of CBCIS. The PT included key people from the NPPC, NMFS and other organizations that are central to the successful development of CBCIS. The PT had oversight responsibility for day-to-day

implementation of the CBCIS project and provided technical reviews, technical expertise, actual “hands-on” support for certain project tasks, and decision-making.

The CC is an advisory group and is comprised of approximately 50 individuals from the major organizations and interest groups associated with CBCIS. The CC is not involved in day-to-day implementation activities, but rather provides high-level review and approval of the CBCIS project implementation.

The key agency/organization leads/decision-makers within the Basin have the ultimate say in the future success of CBCIS. High-level endorsement is necessary to ensure the successful implementation of CBCIS.

Research Techniques

Data Gathering Methods

The CBCIS research project relied heavily on understanding the experiences and opinions of stakeholders working on Columbia Basin resource management efforts. To gather this information, the research team (SAIC) used several data gathering methodologies including: focus groups, questionnaire analysis, literature review, review of existing information on the World Wide Web, and a review of existing data centers.

Working from the comprehensive stakeholder list, the PT helped the research team prioritize the stakeholders into three tiers: (1) those individuals most directly capable of influencing information management outcomes; (2) key agencies and organizations involved in developing, analyzing, distributing, explaining, and making decisions about Columbia Basin information (e.g., the groups most heavily involved in the resource management efforts), and (3) the larger community of users (e.g., citizens). A different methodology was applied to each tier:

- Tier I: Individual interviews;
- Tier II: Focus groups and detailed survey; and
- Tier III: Survey and workshop

At this phase in the study, due to budgetary and time constraints, the Tier III approach was partially deferred until completion of the comprehensive requirements analysis. The NPPC and the NMFS posted information on their web sites including a short questionnaire. Public interest groups were also identified and invited to the focus groups and meetings. However, the PT felt it would be better to address the Tier III stakeholders by making the report and publications public through the Council public planning process.

By far, the majority of study participants were consulted during focus groups. In-person research was conducted during two research trips to the Columbia Basin in July and November 2002. The research team performed extensive email and telephone contact preceding the meetings and following them.

The focus groups used individual and small group work on worksheets, followed by open discussions, structured discussions (e.g., list writing, round robins), and dot voting techniques to accomplish the following agenda goals:

- Identifying frustrations with the current approach to information management;
- Brainstorming “solutions” to “solving” the frustrations;
- Listing currently available information resources;
- Identifying information needs; and
- Turning “solutions” into discrete recommendations.

The desired outcome for each focus group was to have completed worksheets from each participant and an understanding of group priorities for information needs and information management recommendations derived from the dot voting process.

A more open approach was used for the individual interviews. Interviewees were asked to describe their role using and/or generating information and observations about information management in the Columbia Basin. They were asked to describe their frustrations and identify options for improving the system. Based on their experience in the Basin, they were asked to identify keys for success, as well as pitfalls to avoid.

At the end of each focus group and/or interview, the participant(s) were asked to identify additional people and/or organizations for the contractor to consult. In addition, each participant was given a detailed questionnaire to take back to his or her respective organization and asked to work collaboratively with their colleagues to complete.

Completed questionnaires were received from 34 individuals. The results were analyzed using simple statistical methods as well as a qualitative review of any comments provided on the questionnaire form.

A literature review was also performed to gain an understanding of the various initiatives, frustrations and recommendations for data management in the Columbia River Basin. This review was used to inform the formulation of targeted recommendations for the implementation of CBCIS.

In addition, a search of the WWW was done to ascertain the level of Columbia Basin information available and how easy or difficult it is to access this information. This analysis included keyword searches using common Columbia River Basin themes, attempting to find answers to research questions, and an evaluation of existing data resource centers (e.g., Data Access in Real Time (DART), Fish Passage Center (FPC)).

Rounding out the data gathering process was the compilation of a list of existing information resources gleaned from the focus groups, worksheets and questionnaires. This list was used to create a preliminary data inventory.

Study Limitations

This study relied on voluntary participation from many people and groups, and faced several problems, and therefore limitations. These include:

- Voluntary participation: Despite extensive efforts to solicit participation, attendance was uneven and some groups were better represented than others.

- Partial data of varying quality: This study relied heavily on questionnaires and worksheets, as well as validated meeting notes. Follow-up from the participants was high, but uneven – some questionnaires/worksheets were missing information or some organizations did not complete the forms

III. COLUMBIA BASIN PROGRAMS - KEY INITIATIVES DRIVING INFORMATION MANAGEMENT

Information management is driven by the information needs of environmental initiatives to meet their stated goals and objectives. Within the Columbia River Basin, there are several key initiatives that are driving data collection and information management strategies and include: The Endangered Species Act (ESA), Subbasin Planning, and the Clean Water Act (CWA). In addition, many agencies (state, tribal and federal) collect and manage information in furtherance of their mandated responsibilities.

Endangered Species Act

The ESA provides for the protection of threatened or endangered species. The NMFS is responsible for identifying and listing endangered species, and preparing plans for their recovery. Within the Columbia River Basin, twelve populations of anadromous fish are listed as endangered. Accordingly, the NMFS FCRPS Biological Opinion (BiOp) was issued in 2000 to identify and carry out recovery efforts. A Research, Monitoring and Evaluation (RME) plan is under development to comply with the BiOp. The ultimate goal of the BiOp efforts is the survival and restoration of the listed endangered species.

Basinwide Salmon Recovery Strategy

Developed by the Federal Caucus, a collaborative group of the nine federal agencies having natural resource responsibilities under the ESA, the *Final Basinwide Salmon Recovery Strategy* initiated the "All-H" strategy for salmon recovery. This "All-H" strategy focuses the actions of federal agencies in four areas:

- Habitat
- Hydropower
- Hatcheries
- Harvest.

Within each of these H-categories, the Strategy defines discrete actions, lead agencies, and broad timeframes for completion. Also, the Strategy moves forward in defining Basinwide recovery goals and objectives performance measures.

Subbasin Planning

NWPPC is leading the Subbasin planning efforts underway in the Columbia River Basin. Each Subbasin plan outlines steps for fish and wildlife habitat and endangered species recovery and associated project funding in their individual subbasins. Each subbasin plan will: "identify the goals for fish, wildlife and habitat; define the objectives that measure progress toward those goals; establish the strategies to meet those objectives; and incorporate much of the existing information related to fish and wildlife activities in a subbasin in a single document." Subbasin plans that cover areas inhabited by listed endangered species will be used as a basis for recovery efforts. The plans will adopt and implement interim targets for these species to comply with the ESA for several years.

Clean Water Act

Under the CWA, the Environmental Protection Agency (EPA) is charged with establishing water quality standards (WQS). These standards are enforced through discharge permits issued under the National Pollutant Discharge Elimination System

(NPDES). Under the CWA, states are required to establish total maximum daily load (TMDL) limits, which must be approved by the EPA. EPA, in conjunction with the states of Idaho, Oregon, and Washington, and the Columbia Basin Tribes, are working to develop temperature and total dissolved gas (TDG) TMDLs for the Columbia and Snake Rivers. Under Section 303(d) of the CWA, water bodies that fail to meet State and Tribal WQS are listed as impaired waters. In such cases, a TMDL must be developed, which identifies the amount of a pollutant that can be released to a water body and still meet the WQS. Four separate TMDLs are being developed for the Columbia and Snake Rivers: Columbia River and Snake River Mainstem (temperature), Lower Columbia River Total Dissolved Gas (TDG), Mid Columbia River and Lake Roosevelt (TDG), and Lower Snake River (TDG).

Additional Programs

Additional recovery and/or management programs within the Columbia River Basin include: Salmon mitigation programs:

- Harvest management programs;
- Federal, State and Tribal land and water management programs;
- Federal, State and tribal fish and wildlife management programs;
- U.S. Army Corps of Engineers (USACE) activities including hydropower operations, dredging, wetlands and protection;
- Satellite monitoring of environmental conditions; and
- County land use and permitting decisions.

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IV. EVALUATION OF CURRENT COLUMBIA BASIN INFORMATION MANAGEMENT APPROACHES

Frustrations Summary

During the requirements analysis phase of the project, focus group participants were asked to identify their frustrations with the current approach to information management

within and between agencies and organizations. These were supplemented by critiques offered in the literature. The key frustrations identified included:

- It is difficult to find or access relevant information resources.
- Once found, resources may be incomplete, inaccurate, or of an incompatible format for efficient use.
- Documentation is absent so it is difficult to ascertain information quality.
- The desired types of information are not available or they are out of date.
- There is a lack of understanding of what "desired information" is – a lack of unified goals and/or other guidance on what key information types are.
- There are no clear-cut information pathways to facilitate easy evaluation of recurring topics.
- Geographic scales, units, and other topics are incompatible.
- Efforts are duplicated because of a lack of communication and coordination

Questionnaire Summary

To supplement the focus groups and other information gathering practices employed during the requirements analysis, an extensive evaluation and user needs assessment (questionnaire) was distributed electronically to participants. Participants were asked to complete the questionnaire and return it to the research team. Participants were encouraged to collaborate with other members of their organizations in completing the long questionnaire, and to forward the long questionnaire to anyone else whose input might be useful to the requirements analysis.

The following is a summary of the key questionnaire results:

- **Limited response rate; missing some key entities.** Of a approximately 120 long questionnaires distributed to focus group participants and their contacts, 34 responses were received. Some of these responses covered whole agencies, so multiple potential respondents were covered under a single agency response. Nine federal agencies, four state agencies (one from each Basin state), three data centers, two regional groups, and two additional groups (Northwest Habitat

Institute and Lower Columbia River Estuary Project) were represented in the long questionnaires.

- **Predominance of federal agency respondents.** An overwhelming percentage of respondents (62%) represent Federal agencies. Additionally, 18% represent state agencies, and 15% represent each of fish and wildlife agencies and data interest groups.
- **Information organization and management policies exist at most respondent organizations (77%).**
- **Information management standards are not unified toward a Basinwide perspective. More than half of respondents lack data management policies or have incomplete ones**
  - Only half (52%) have an internal metadata policy, with most complying with FGDC standards.
  - 48% have information standards.
  - 23% have a data dictionary.
  - 16% and 36% of those answering report having information collection and reporting standards respectively.
- **Information groups and contacts exist at most respondent organizations.** Of those answering, 72% have a specific information management point of contact, and 80% have a specific group for information management within their organization.
- **Only "medium" investment in information management.** Most respondents (58% to 68%) rate their organization's investments as "medium".
- **Varying missions with emphasis on habitat.** 74% were classified as pertaining to habitat, 50% to hatcheries, 47% to harvest, and 24% to hydropower.
- **Information collection efforts weighted heavily toward fish.** The majority of respondents who answered this question collect information regarding fish (90%). 67% and 63% collect information on water quality and water quantity respectively. The rest break down as follows: habitat, 60%; physical characteristics, 57%; hydrological characteristics, 57%; land use and ownership, 53%; wildlife, 37%; and other, 43%.

- **Public information scores lowest use for information use.** Only 54% stated their information was used for public information and outreach.
- **Electronic information collection already popular; hard copy still used.** Of those responding, 83% collect information in some form of hard copy format: 93% acquire information through electronic means.
- **State and federal information dominates.** Respondents describe as the source of their information (both hard copy and electronic): state and federal agencies (83% each), self generated (69%).
- **Data conversion occurs, primarily into database and spatial formats.** Preferred formats in which to acquire information were database (67%) and spatial data (59%).
- **Quality assurance important to most.** Most respondents (86%) perform some sort of quality assurance (QA) analysis on the data they acquire. 92% perform some sort of QA analysis on the information that they generate.
- **Information gaps exist.** Almost all respondents (96%) report having gaps in the data they generate. 83% of respondents said they were not able to find the kinds of information they use, including: vegetation data, tributary harvest data, water use information, hydrosystem data, redd counts, and hatchery returns. Many respondents expressed a frustration at knowing that the information they need is "out there", but being unable to access it.
- **Varying geographic coordinates in use.** Of those answering, 48% use latitude/longitude, 30% use state plane, 22% use UTM, 22% use LLID (georeferencing system), 15% use township/range/section, and 48% use some other coordinate system.
- **Electronic information distribution under utilized.** Of the 92% that make their information available, 58% make their information available via download 50% via CD, 46% via mail, 46% via hard copy, 23% via floppy disk, and 42% via some other means.
- **Windows operating systems and software prevail.** By far, most respondents use Windows 2000 (74%). Most (79%) report using MS Access as their database software. 47% use ESRI and/or some other form of GIS software, with

a strong preference for ESRI products. 76% report using Microsoft Excel as their spreadsheet application.

- **Capacity to support middleware applications has room to grow.** 50% of respondents have some type of middleware capacity, including ASP (29%), Cold Fusion (21%), and other middleware (29%).
- **Most respondents use Commercial-off-the-Shelf products**, although a few programmers are developing their own applications.
- **All respondents have Internet connection, most high speed.** 21% use dialup.
- **All respondents have email capabilities; 90% host their own www sites.**

Existing Columbia Basin WWW Resources

WWW-Search Evaluation Summary

To get an objective perspective of how readily information concerning the Columbia River Basin can be found and accessed via the World Wide Web, a series of searches were conducted.

In summary, the results from these searches showed that if an average citizen searched the web, they would quickly realize that there are numerous agencies within the Basin that are, in some capacity, doing work within the Basin. Arguably, from the viewpoint of citizens seeking information, the amount of information on the Internet about the Columbia River Basin could seem overwhelming. That is, it would seem difficult to find a good starting point. Many of the web sites seemed to be singularly focused in their purpose. That is, the agency (be it a government entity or nonprofit) had a specific role in restoration efforts and this was the focus of their web page. Though all agencies – government and nonprofit – are focused on restoration efforts, there is a difference between their approaches and the type of information they portray. No single entity or site stood out as being 'the site' for information about the Columbia River Basin. Though many of the agency's websites are well maintained, they are specific to the

needs and mission of the agency. The data centers all contain high quality and relevant data, but frequently these data centers were not found during the searches. And, many of the data centers are not 'public-friendly' (details of a preliminary review of the data centers is discussed later in this section). That is, they provide high quality data that is relevant to a technical audience, not necessarily the public.

The data centers all contain high quality and relevant data, but frequently these data centers were not found during the searches. And, many of the data centers are not 'public-friendly' (details of a preliminary review of the data centers is discussed later in this section). That is, they provide high quality data that is relevant to a resources manager, not necessarily the public, which is what many were set up to do.

Data Center Evaluation

To determine at what level current data centers and databases that make their information available online were meeting the goals of an information spectrum approach, a review of eight data centers and databases within the Basin was conducted. From the online review, the following general conclusions were drawn:

- The current data systems, though well-managed, do not meet the PT's desire to have an information spectrum approach to data management;
- The systems tend to be agency or mission specific;
- The systems do not provide information on how their effort fits into the larger Columbia River Basin restoration efforts;
- Most of the systems are not 'public-friendly';
- Generally, the systems contain information on why the information was collected, but not how the information could be used; and
- Most of the systems contain data and not information summaries.

Preliminary Data Inventory

During the requirements analysis focus groups, and in the detailed questionnaires, participants were asked to complete a brief worksheet to identify available information that may be relevant for dissemination through CBCIS. Information resources were defined as any dataset, report, project, tool or initiative that would potentially contain information of interest to a Columbia Basin stakeholder or CBCIS user. Information from the worksheets and questionnaires was compiled to create a preliminary information inventory. The current information inventory is still a draft as the quality of the information the respondents provided on the worksheets varied greatly. Recommendations on how to complete the inventory are discussed

All-H Categories

To assist in their planning and restoration efforts and to help them ascertain the effectiveness of these efforts, the Council is tasked with trying to determine:

- How much money is being spent on research efforts within the Basin?
- What is the fish abundance?
- What are the habitat conditions?
- How much is it going to cost to restore the habitats?

A matrix to identify the sources of these questions was developed by the Council. To complete the matrix, the key words, data set name and content descriptions of data sets contained in the information inventory were reviewed to determine to which category the data set could apply. Because the key words in the database differed from the 'key word' categories in the table, the agencies and sources listed are probable sources and not definitive sources.

The ability to accurately complete the table was limited by the quality of the data contained in the inventory, and therefore, the table should be considered a starting

point. Additionally, very little, if any, information concerning research efforts as well as financial resources expended was identified in the inventory.

V. FINDINGS FROM THE REQUIREMENTS ANALYSIS

CBCIS Information Priorities Identified to Date

Information needs gleaned from the research investigations tracked with needs identified as important for achieving the Columbia River Basin key drivers. Information needs as expressed by focus group participants were prioritized into a hierarchy of information categories based on the number of groups in which they were discussed. Exhibit ES-2 summarizes the information needs categories in priority order.

By far, the majority of information needs fall into the environmental data and fish categories. The environmental data category encompasses a wide range of subcategories. However, participants expressed a greater need for hydrological, water quality, and habitat data than for other types of environmental data. Within the fish category, abundance information was expressed as the highest priority. Hatchery and passage information was also expressed as a priority. Through these priorities, participants expressed their desire to fully understand the physical characteristics of the river system, as well as the condition of the water and fish within it.

Other information priorities include regulatory information, land classification, project management data, information about other flora and fauna, information management data, and socioeconomic information.

Exhibit ES – 2. Information Needs Categories

Categories in Priority Order
Hydrological
Abundance
Regulatory: General
Water Quality
Hatcheries
Habitat
Land Use
Passage
Biodiversity
Fish: General
Mapping and GIS
Land Cover
Energy
Harvest
Project Performance
Meteorology
Survival
Project Tracking
Project: General
Geological
Transportation
Project Location
Project Scope
Socioeconomic: General
Project Description
Threatened and Endangered Species

CBCIS Priority Functions

CBCIS must perform a broad range of functions to achieve the broad range of Columbia Basin restoration goals and needs expressed by key initiatives and Basin restoration participants. Functions are those actions the users desire the information system to perform, whether the user initiates the action, or the system automatically performs it. The results of the contents analysis were reviewed to determine the highest priority CBCIS functions. The raw data on functions from the requirements analysis were

grouped into first and second level categories and counted, ranked and graphed. Exhibit ES-3 presents a summary of the CBCIS features and functions in priority order.

Exhibit ES-3. CBCIS Features and Functions

Categories in Priority Order
Build a CBCIS institutional and administrative infrastructure.
Develop CBCIS funding support and grant guidance hub.
Provide access to tools and guidelines supporting CBCIS data collection and reporting (data dictionary)
Develop and implement metadata entry tool and data repository.
Provide repository and data/information entry procedures (e.g., forms for manual entry and automated upload) for actual data and information products (beyond metadata records).
Provide access to tools and guidelines supporting CBCIS data quality and data/research documentation.
Develop and implement robust search engine for all levels of information pyramid.
Browse and download CBCIS-related outreach and education materials.
Provide access to tools and guidelines supporting CBCIS system security.
Provide links to relevant sites and existing information resources.
Develop CBCIS information repositories and inventories.
Perform project tracking.
Enable interactive mapping.
Provide access to tools and guidelines supporting CBCIS data analysis.
Establish query capability so user can define limits/conditions to subset database for download.
Perform simple statistics including trend analyses.
Incorporate a variety of public functions.
Review and feedback
Provide access to real-time data.
Enable download of entire data/information resource
Incorporate GIS functionality.
Provide a reporting function.
Access and search interactive CBCIS Who's Who.
Provide access to models and modeling results.

VI. A MODEL BASINWIDE INFORMATION MANAGEMENT SYSTEM

Model Basinwide Information Management System

Basinwide information management must occur in the context of overall Basin planning and adaptive management. To pursue any of these approaches without consideration of the others will lead to ineffectual results where goals are unclear and remain untracked, key questions cannot be answered, context for actions is misunderstood, program efficacy is questioned, agency communication and integration is ineffective, and stakeholders are frustrated. Information management is an integral component of basin planning and adaptive management – none of these approaches can occur effectively without an overall information management approach, nor can information management be considered in a vacuum absent the larger planning effort.

Basin Planning

Many Federal and state agencies are moving toward a basin approach to environmental management, addressing the interrelationships between air, land, and water, and associate living resources (fish, wildlife and vegetation). Local basin groups also are adopting this overall view.

As one Federal lead in basin management, the EPA promoted a watershed (basin) approach, outlining the principles of partnerships, geographic focus, and sound management techniques based on strong science and data. This broad guidance has been used and modified by basins around the country as they implement their unique approaches. For example, many of these elements are identified in the Columbia River Basin's subbasin planning approach currently underway.

Some of the critical areas where the process can falter include:

- Inadequate inclusion of stakeholders in planning and decision-making, especially at the highest level of decision-makers

- Excessive emphasis on assessment at the expense of implementation and evaluation;
- Inadequate goal setting;
- Lack of relating data to goals;
- Lack of a basinwide research, monitoring and information management plan; and
- Not developing a basinwide information strategy at the outset or at all.

While Columbia Basin programs have been in existence for many years, the Basin also is in a period of significant evaluation and change as a result of the 2000 Biological Opinion. The time is right to implement more effective Basin and information management strategies.

The ISAB provided a review of salmon recovery strategies for the Columbia River Basin (2001). Their findings support the need for greater program integration, context setting, and goals development. All of these issues are related to information management, as well. When asked if the four major salmon recovery strategies in the Basin would lead "collectively to salmon recovery actions that have a high chance of succeeding," the ISAB responded simply with "no." The reasons for this pessimistic view included data gaps, conceptual gaps, lack of integration, and lack of implementation. (ISAB, 2000).

An information management strategy should be informed by larger basin goals and performance measures. A clearly articulated set of indicators provides context for research, monitoring and information management. These efforts should be considered together in an integrated, iterative process. This point is further articulated when considering the operating principles behind an adaptive management approach.

Adaptive Management

Simply put, adaptive management is an approach that enables resource managers to move forward in the face of uncertainty. Many consider it an approach that values experimentation, evaluation, and modification (i.e., you select an approach, establish a measurable objective, try the approach, monitor outcomes for some time, use the data to evaluate the efficacy, and make changes as needed). Kai Lee, former member of the

Northwest Power Planning Council sums up the approach by saying that “solutions to problems cannot be commanded, they must be discovered” (Lee, 1993).

Holling’s adaptive management model comprises six major steps, each step includes many subsets, but Holling definitely felt that a collaborative approach among many disciplines (e.g., natural resource management, economics, sociology) and skill sets (e.g., policy development and science) was essential to overall success. He also emphasized the importance of goal setting to provide focus and context.

Chesapeake Bay Case Study

One of the Nation’s premier models for basin and information management is the Chesapeake Bay. The Chesapeake Bay watershed-based fish and wildlife program was getting started about the same time as efforts in the Columbia Basin. Although “small” in comparison to the Columbia Basin, at 64,000 square miles, the Chesapeake Bay watershed covers multiple states and countless political and organizational jurisdictions. Further, it is one of the nation’s most productive commercial fisheries – it’s blue crabs, oysters, clams, and rockfish are renown. Like the Columbia salmon, these key living resources began a precipitous decline in the 1970s that led to action in the 1980s with the signing of the Chesapeake Bay Agreement. This agreement established the Chesapeake Bay Program, a collaborative management structure comprised of participants from the major states, academic institutions, communities, government agencies, and other stakeholders in the Basin. This structure is central to the overall success of the Program. The structure has a significant amount of clout behind it, as the governors of the major states, the mayor of the District of Columbia, and representatives from the federal and local governments are signatories to the Agreement and all subsequent actions. This kind of high-level management support has been one of the primary keys to success.

Further, the Chesapeake Bay Program is built around a series of clearly defined and articulated goals, starting with a top-level goal of a 40% reduction in nutrients entering

the Bay and moving toward numeric tributary-specific goals for nutrient reduction and specific goals for living resources and other natural resource management components. These goals are encapsulated in a comprehensive environmental indicators program that provides the framework for funding decisions, program approaches, research and monitoring efforts, reevaluation, and information management. Participants in the program attribute their success to having an effective collaborative management structure consisting of subject-based subcommittees (including an information management subcommittee) that serve to breakdown agency and organizational walls towards greater collaboration at meeting consensus-based goals. Further attributes supporting program implementation include (Boesch, Undated):

- **Commitments**: A strong system of consensus-based agreements, Memoranda of Understanding, and similar formal and informal policies bring together stakeholders at all levels in a collaborative approach. This collaborative approach starts at the highest level, through the Executive Committee – a body comprised of participating state governors, federal government, and local representatives.
- **Goals**: "The Chesapeake Bay Program has set goals, even when it was not crystal clear what those goals should be (Boesch, Undated)." These goals provide necessary program focus for bureaucratic attention, program activities, public understanding, and information management. These goals are intentionally numeric so that tracking and reporting are facilitated.
- **Science**: Science provided the assessment foundation for initial program directions and goals and continues to inform the program.
- **Modeling**: The Bay Program uses a suite of linked computer models to support program tracking and effectiveness studies. Computer modeling has been very important as a decision-making tool.
- **Monitoring**: The Bay Program operates one of the largest monitoring programs in the world, and is constantly reevaluating its efficacy to ensure it stays on track with program priorities.

For the first decade and a half of the Chesapeake Bay Program, the strong program goals and approaches were not backed up by an effective information management system. When preparing for the 1997 Reevaluation of the Nutrient Reduction Strategy, Bay Program staff expressed concern about the state of information management in the watershed. An effort to organize these approaches, the *Chesapeake Information Management System*, was initiated. It provides an example of how information management can be restructured to support development, tracking, and achievement of Basinwide goals and measures. CIMS was a vision of building an integrated information management system and process to support Chesapeake Bay restoration goals. While some participants were enthusiastic but skeptical of the process, CIMS has proven a success in the basin and has supported a more organized information management approach that is closely tied to program goals.

A Model Information Management Approach for the Columbia Basin

A model information management approach must link information strategies with Basinwide goals. Various components are essential to incorporate in order for the approach to succeed. These are listed below, but discussed in more detail in the Recommendations chapter.

A basinwide information management approach must be developed as part of the overall basin planning and adaptive management approach.

The information management approach must relate to program goals and objectives showing clearly how information content and system functionality relate to priorities.

The information management approach must be recorded in a comprehensive basinwide information strategy document that clearly defines goals, activities, roles and responsibilities, timeframes and milestones, and measures of success. The information strategy must be developed in consultation with and integration with research, monitoring and evaluation strategy development.

The information management approach must incorporate an institutional and administrative infrastructure and communication strategies to support collaborative information management.

The information management approach must be developed collaboratively with all participants and have agreements to participate.

The information management approach must adhere to Basinwide information management standards for:

- Security
- Funding
- QA/QC and Documentation
- Metadata
- Monitoring
- Data Standard and Data Dictionary.

The information management approach must consider the spectrum of users and information.

The information management approach must build in reevaluation.

These are presented in the CBCIS information framework (see Exhibit ES-4a,b). They are elaborated on in the Recommendations section

Exhibit ES-4a. CBCIS Information Framework

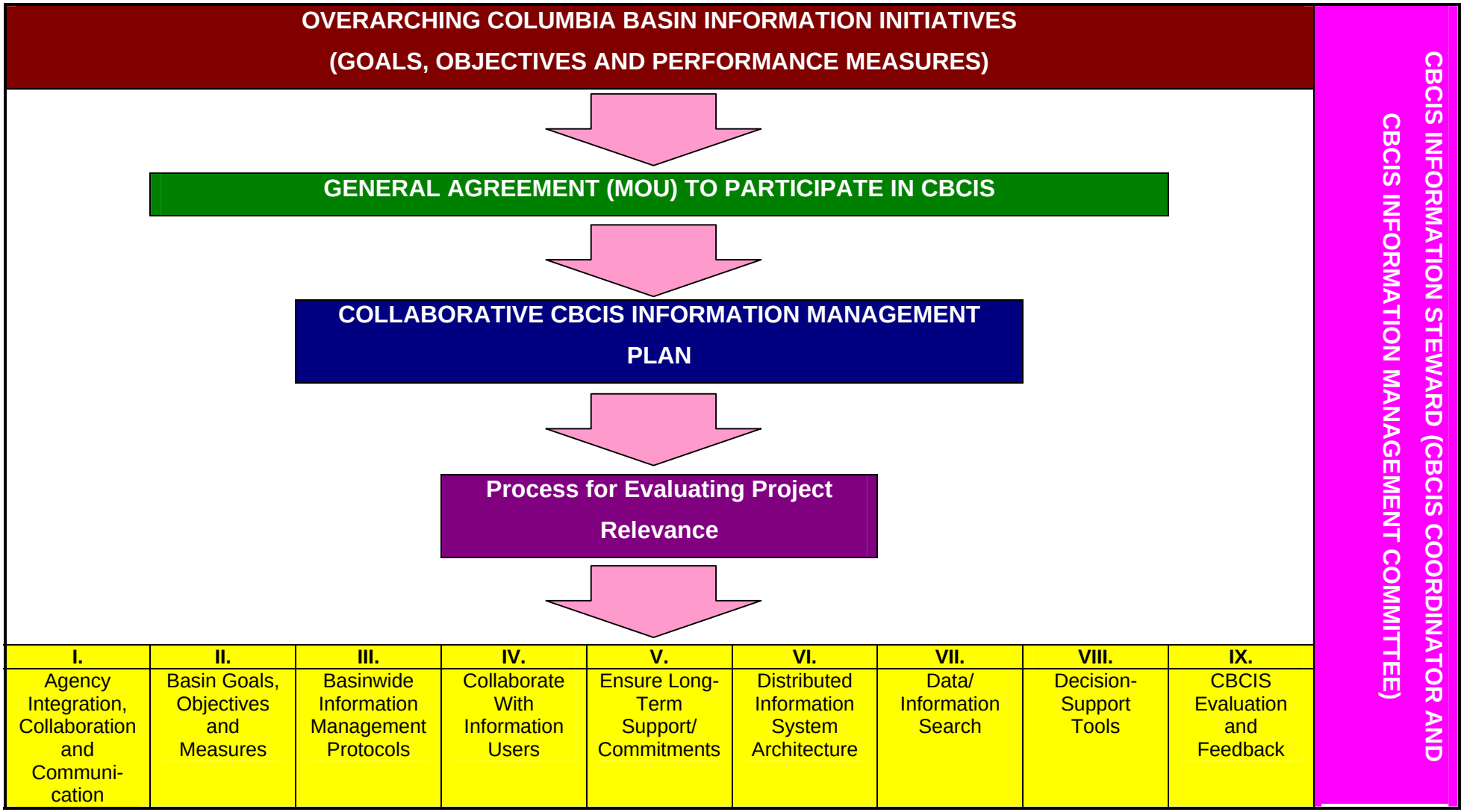


Exhibit ES-4b. CBCIS Information Framework

I. Agency Integration, Collaboration and Communi-cation	II. Basin Goals, Objectives and Measures	III. Basinwide Information Management Protocols	IV. Collaborate With Information Users	V. Ensure Long-Term Support/ Commitments	VI. Distributed Information System Architecture	VII. Data/ Information Search	VIII. Decision-Support Tools	IX. CBCIS Evaluation and Feedback
Formalize an accountable CBCIS administrative framework.	Develop Basin information management goals, objectives and measures.	Research and post inventory(ies) of existing standards and protocols.	Develop information management and public information/ communications work groups.	Develop a long-term resource plan (staff and dollars) for CBCIS	Develop CBCIS using a distributed system architecture based on an enterprise approach.	Develop tools that will enable searching, accessing, acquiring, sharing, and contributing info. resources.	Provide access to modeling information and basic analytical tools.	Conduct periodic evaluations of CBCIS implementation.
Expand efforts to seek buy-in from other key decision-makers and stakeholders.	Develop an overall Basin management strategy.	Develop and implement CBCIS-specific metadata tools.	Expand CBCIS outreach and investigation to other segments of the CBCIS community.	Develop a funding and resource support workgroup.	Establish guidelines for becoming a CBCIS node.	Develop a means to compile historic metadata.	Develop WWW-enabled interactive mapping tool.	Periodically evaluate of the relationship between goals and information management.
Develop CBCIS conceptual design and demonstration package.	Evaluate project relevance to goals as part of the grant and contract process.	Develop and post standards for reporting geographic data.	Conduct Basinwide public workshops to advertise and seek feedback.	Support CBCIS using financial arrangements and participation incentives.	Redirect resources to support development of CBCIS nodes at originating data sources.			
Establish high-level agreement endorsing and pledging signatory support.	Complete the preliminary inventory of information resources.	Develop Basinwide monitoring protocols and data standards.	Develop a CBCIS public outreach strategy.	Develop CBCIS as a base-funding category, not to be recompeted on an annual basis.	Develop CBCIS technical assistance.			

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Agency Integration, Collaboration and Communi-cation	**Basin Goals, Objectives and Measures**	**Basinwide Information Management Protocols**	**Collaborate With Information Users**	**Ensure Long-Term Support/ Commitments**	**Distributed Information System Architecture**	**Data/ Information Search**	**Decision-Support Tools**	**CBCIS Evaluation and Feedback**
Develop a CBCIS working prototype.	Further evaluate info. needs against resources.	Develop and post QA/QC procedures and protocols.		Develop strong operations and maintenance plan.	Develop CBCIS data repositories.			
Identify a CBCIS Coordinator and Project Manager.	Write a long-term regional information system development plan.	Develop documentation standards for data processing and analysis.		Conduct an annual Basinwide CBCIS workshop.				
Develop communication and coordination hub of CBCIS.	Establish a Basinwide research and monitoring strategy.	Develop system security protocols.						
	Develop online, interactive research and monitoring inventory.	Incorporate requirements into future grants and contracts						
		Develop common db designs for similar info. types.						
		Develop and post guidance manual that documents everything needed to become a participant.						

VII. CBCIS RECOMMENDATIONS

This chapter presents a series of recommendations needed for the successful implementation of CBCIS. Short-term recommendations are highlighted so that the Basin has a clear idea what steps need to be taken right away in order for momentum to remain and successful implementation to occur. Remembering that CBCIS is an information system, these recommendations address institutional, administrative, policy, financial, technical, and education/outreach elements that comprise an effective information system. Each type of recommendation is needed to support the others – without an integrated package of recommendations, CBCIS could lose Basin support, falter in maintaining implementation momentum, or stray from achieving its highest priority goals. CBCIS could fail if one or more recommendations are ignored. For example, inadequate high-level support from key agencies could derail the collaboration and/or resource allocation needed for CBCIS. Therefore, recommendations related to education and creating buy-in are crucial. Similarly, ill-conceived technical solutions that do not match Basin capabilities could reduce the ultimate effectiveness of CBCIS. Inadequate attention to and agreement on minimum standards would make it very difficult to support data sharing and integration. The list of examples could go on and on. In short, all pieces comprising CBCIS must be addressed in the recommendations, from communication and coordination to data.

These recommendations were developed as part of the CBCIS requirements analysis, supplemented with careful review of the literature and consultant expertise. During each focus group and interview, participants were asked to identify their frustrations with the current information management approach in the Basin and brainstorm solutions. Many of these solutions pointed the way to clear recommendations. Using the project research methodology (described in Chapter II of the Final Report), the results from the requirements analysis were considered along with recommendations presented in the written literature and the consultant's experience in other watersheds to present the following list of CBCIS recommendations (see Exhibit ES-5).

A. GUIDING PRINCIPLES

These recommendations are framed within a series of guiding principles developed by consensus in the Project Team and agreed to by the Coordinating Committee. In the course of the CBCIS requirements analysis investigations, several recommendations were mentioned so frequently that they were common to almost all participants. These highly identified recommendations were elevated through discussions with the Project Team and Coordinating Committee to be considered as Guiding Principles for CBCIS. These set the essential framework and operating principles for CBCIS. The following guiding principles are the basic tenets under which CBCIS will operate:

- CBCIS encompasses the information spectrum (data and related information products) by performing outreach and education at all user levels and incorporating information and technology tools in a phased approach.
- CBCIS is committed to a publicly supported process and will include efforts for public participation.
- CBCIS tools must enable users to search and navigate through the information spectrum.
- Information accessible through CBCIS must be geo-referenced using standard georeferencing approaches
- Basinwide information management standards (e.g., data standards) supporting CBCIS must be developed and agreed upon by CBCIS participants.
- Efforts will be made to provide access to high priority legacy data and information from CBCIS.
- CBCIS will be developed using the WWW, ensuring easy to understand and navigate graphical user interfaces. Additional data distribution modes will also be incorporated to address the spectrum of potential users.
- Ensure that every group affiliated with CBCIS development and implementation has balanced membership representing all levels of the spectrum (i.e., information users and providers must communicate). If a group is highly technical (e.g., a workgroup on developing networking solutions), ensure that

representatives of the higher levels of the information pyramid are informed of approaches and progress and given the opportunity to comment.

Exhibit ES-5. CBCIS Recommendations

FOSTER INTEGRATION, COLLABORATION, AND COMMUNICATION
1. Formalize an accountable CBCIS administrative framework.
2. Expand CBCIS outreach efforts to seek buy-in from other key decision-makers and stakeholders in the Basin. Develop targeted outreach and education materials for key CBCIS participants and supporters that clearly outline the need for CBCIS and describe the benefits and costs for such an endeavor. Ensure this outreach approach addresses the need for long-term support for CBCIS to succeed.
3. Develop CBCIS conceptual design and demonstration package (interactive presentation).
4. Establish a high-level agreement (MOU or stronger document) endorsing CBCIS and pledging signatory support.
5. Develop a CBCIS working prototype.
6. Identify a CBCIS Coordinator and Project Manager and a funding source.
7. Develop communication and coordination hub of CBCIS.
INTEGRATE INFORMATION MANAGEMENT WITH BASIN GOALS AND PERFORMANCE MEASURES
Basinwide Goals, Objectives, Measures:
8. Develop basinwide data management goals, objectives and measures (e.g., performance measures, indicators) that cut across and integrate individual agency missions and mandates.
9. Develop an overall basin data management strategy.
10. Develop a process for evaluating proposed data management project relevance to goals as part of the grant and contract process.
Information Needs:
11. Complete the preliminary inventory of information resources in the Columbia River Basin.
12. Further evaluate CBCIS information needs against available information resources to identify gaps and develop acquisition strategy.
13. Write a long-term regional information system development plan and develop a Basinwide collaborative RM&E program.
Research and Monitoring:
14. Collaboratively establish a Basinwide research and monitoring strategy.
15. Develop an online, interactive research and monitoring inventory.
DEVELOP BASINWIDE INFORMATION MANAGEMENT PROTOCOLS
16. Research and post inventory(ies) of existing standards and protocols in the Columbia River Basin.
17. Develop and implement CBCIS-specific metadata tools.
18. Develop and post on CBCIS standards for reporting geographic data: latitude and longitude; map coordinate datum; and map coordinate projection.

19. Develop Basinwide monitoring protocols and data standards addressing data collection, storage and analysis.
20. Develop and post on CBCIS Quality Assurance and Quality Control procedures and protocols.
21. Develop documentation standards for data processing and analysis.
22. Develop system security protocols.
23. Incorporate CBCIS requirements into future grants and contracts.
24. Develop and post common database designs for similar information types.
25. Develop and post a CBCIS guidance manual that documents everything needed to become a CBCIS participant.
COLLABORATE WITH THE FULL SPECTRUM OF INFORMATION USERS
26. Develop management and public information/communications work groups as part of the CBCIS administrative structure.
27. Expand CBCIS outreach and investigation to other segments of the CBCIS community not included in the original requirements analysis.
28. Conduct Basinwide public workshops to advertise and seek feedback on CBCIS recommendations.
29. Develop a CBCIS public outreach strategy.
ENSURE LONG-TERM SUPPORT AND COMMITMENTS
30. Develop a long-term resource plan (staff and dollars) for CBCIS.
31. Develop a funding and resource support workgroup.
32. Support CBCIS using financial arrangements and participation incentives.
33. Develop CBCIS as a base funding category, not to be recompeted on an annual basis.
34. Develop a strong operations and maintenance plan.
35. Conduct an annual Basinwide CBCIS workshop.
MOVE TOWARD A DISTRIBUTED SYSTEM ARCHITECTURE, USING AN ENTERPRISE APPROACH
36. Develop CBCIS using a distributed system architecture based on an enterprise approach.
37. Establish guidelines for becoming a CBCIS node.
38. Redirect resources to support development of CBCIS nodes at originating data sources.
39. Develop CBCIS technical assistance.
40. Develop CBCIS data repositories.
DESIGN AND DEVELOP INFORMATION SEARCHING (DATA INDEXING) TOOLS
41. Develop tools that will enable searching, accessing, acquiring, sharing, and contributing information resources about the Columbia River Basin resource management efforts.
42. Develop a means to compile historic metadata.
DESIGN AND DEVELOP DECISION-SUPPORT TOOLS LINKED TO BASIN GOALS, OBJECTIVES AND MEASURES
43. CBCIS should provide access to modeling information and basic analytical tools to perform user-defined queries, simple statistics, and trend analyses against databases available through CBCIS.

VIII. IMPLEMENTATION APPROACH

The implementation of CBCIS should occur in four phases: (1) planning and requirements phase, (2) pilot phase, generating a functional prototype; (3) production phase, generating an operational system; and (4) operation and maintenance phase.

Building support for CBCIS was expressed as a key need. To maintain the momentum gained during the requirements analysis and to keep moving forward, it is important to develop a CBCIS outreach approach. As soon as possible, CBCIS implementation should move to the Pilot Phase, pursuing parallel tracks of implementation in administrative infrastructure development, agency collaboration agreements and communications support, outreach and education, and prototype development. Technical aspects of prototype development are covered in this chapter.

Based on specifications developed during the requirements phase, a prototype system is built. It often helps education and outreach efforts to precede the prototype with a conceptual design document and interactive demonstration presentation that shows CBCIS potential through a series of mocked up WWW pages. The end product is a system prototype that provides initial system functionality and a mechanism to obtain user feedback for refining the prototype into a fully operational system. The production phase consists of developing a fully operational system based on the prototype and user feedback obtained during prototype evaluation. System operation and maintenance is the final phase of development. This phase consists of developing a system operation and maintenance plan to describe procedures that can be followed to keep the system current.

The technical approach to achieving the CBCIS vision is to search, discover, and access distributed and disparate databases throughout the Columbia Basin through one WWW gateway. This is referred to as a federated search capability. If distributed and disparate (geospatial, bibliographic) databases are to be searched, then business logic

software (i.e., the rules governing search and access functions) is required to perform a search through a common gateway that employs standard protocols.

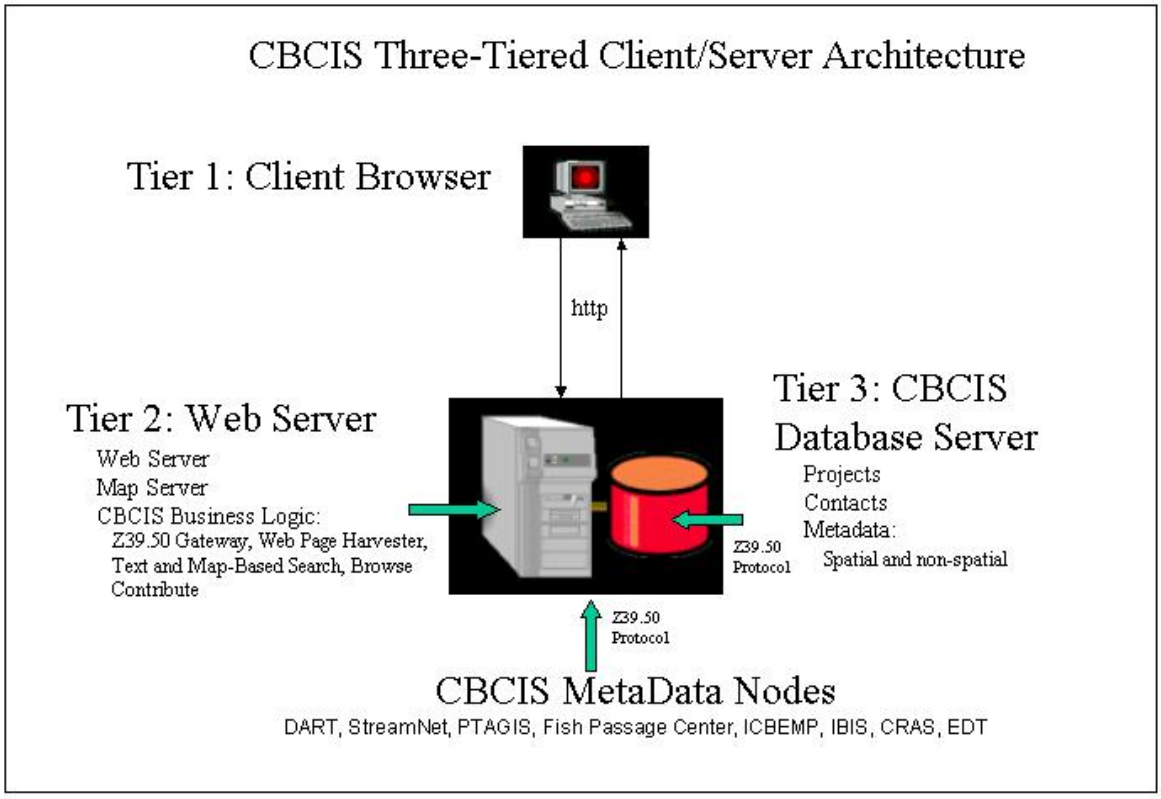
The architecture for this federated search capability is diagrammed in the three-tiered structure shown in Exhibit ES-6. The federated search capability evolves from: (1) the additional business logic software deployed on the Web Server, (2) connection to a CBCIS Metadata Database and (3) connections to multiple database servers (CBCIS Metadata Nodes). The technical approach described below presents an architecture to achieve this federated search capability. This is a proven architecture that has been implemented by the FGDC Clearinghouse and Alaska's Cooperatively Implemented Information Management and Monitoring System (CIIMMS).

In addition to the federated search component of CBCIS, the CBCIS WWW site should incorporate a number of hubs addressing other recommendations including:

- Public information
- Agency communication, coordination, and work space
- Planning and strategy integration and tracking
- System standards and protocols
- CBCIS tools.

Based on previous experience, SAIC recommends that the architecture be based on a Commercial-off-the-Shelf (COTS) solution. The advantage of a COTS solution is that it offers "out-of-the-box" functionality that can be quickly customized for CBCIS. The system components, bundled together, allow for the search, discovery of, and access to geospatial and non-geospatial metadata and information. This is accomplished through access to (1) servers that comply with existing standards (i.e., Z39.50 protocol), (2) servers with Open Database Connectivity (ODBC) compliant databases, (3) the CBCIS database containing metadata, project descriptions, and CBCIS contacts, and (4) selected web pages and hypertext.

Exhibit ES-6. CBCIS three-tier system architecture.



Various COTS solutions exist that integrate database, search engine, and web technologies in a single solution that provides for the search and discovery of metadata and information via the Internet. SAIC also recommends that the architecture include a Web Harvester, which is a software robot that gathers selected information from designated websites. This tool gathers and parses XML and HTML, extracting designated elements such as HTML tags and META tags (e.g., title, body, meta, etc.). The robot will allow CBCIS to include web-page information in its metadata database and search engine.

SAIC also recommends that, a map server component be added to provide a map-based metadata search function. This tool will display local GIS layers, selected boundary files and a digital gazetteer to generate place name keywords and bounding rectangle coordinates. These criteria will be passed to the CBCIS gateway to facilitate the search and discovery of geospatial and non-geospatial metadata.

Exhibit ES-6 shows a high-level schematic of the CBCIS system architecture. The components of the three-tiered structure are described below

- **Tier 1**: End user machine with an Internet browser, such as Netscape or Internet Explorer.

- **Tier 2:** Web Server, which houses the CBCIS business logic software for discovering and accessing metadata and information, and the Map server, which provides the map-based metadata search function. This function displays local GIS layers and a digital gazetteer. The map presentation and GUI allow for bounding coordinates, place names and subject keywords to be passed to the Z39.50 gateway.

- **Tier 3:** CBCIS Metadata Database, which houses the CBCIS metadata, projects, and contacts database; and Z39.50 compliant distributed databases (CBCIS Nodes).

Identifying and accessing metadata and information will be accomplished by using the Z39.50 standard client-server protocol for information retrieval and for focused web crawling of non-Z39.50 sites that contain web pages and hypertext relevant to CBCIS. A map-based query tool will also be provided to facilitate the search and discovery of metadata on a locational basis. The system architecture also will provide for online linkages to the data and information through data downloads (via ftp), document viewing via portable document format (PDF) files, and image viewing through standard formats, such as graphics interchange format (GIF) files.

This architecture enables existing data centers to become CBCIS nodes. Using CBCIS protocols, each data center can provide metadata for and access to their existing resources. Similarly, as CBCIS progresses, these centers can provide technical assistance to their data sources – data origination points (e.g., state agencies) – to enable them to become CBCIS nodes. In addition to technical assistance, the existing

data centers can continue providing metadata support and/or tools development to meet the needs of users and Basinwide goals. SAIC agrees with the ISRP evaluation that the data centers should develop a joint working group to iron out who does what – specific functions and foci of each data center should not be prescribed from outside entities unless the existing data centers are unable to reach a consensus-based strategy amongst themselves.

In the Recommendations chapter, SAIC proposed several potential prototype projects. We recommend selecting one and moving forward as soon as possible. The preliminary deliverables of a conceptual design and demonstration package will provide immediate and useful outreach tools.

The pilot phase should be completed between 1-1.5 years after its initiation. Results from the pilot will provide information to update the implementation plan to describe the production and operation and maintenance phases.

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