TECHNICAL MEMORANDUM

SUBJECT: **Green River Basin Plan II**
Watershed Planning

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Introduction

Watersheds, from the perspective of land scale, are subsets of river basins. To evaluate a watershed to gain an understanding of ecological and socio-economical function, it is necessary to comprehensively and scientifically expand on a river basin description. To accomplish this, information available about the physical nature of a watershed is incorporated into the biological, social and economical systems within the watershed.

As a river basin study is descriptive so are watershed studies although on a much more intense and land area specific basis. In addition, watershed studies incorporate into the description a rehabilitation and management plan. The plan within the study provides the local watershed community with support information that will enable them to initiate implementation of activities intended to address issues and opportunities identified in the description and planning process.

The rehabilitation and management plan provides stakeholders with fundamental information and data needed to pursue future project planning. Developed in a watershed study are plans that document and outline the interrelationship between water production and water use within the watershed. Integrated into a watershed approach, managers can enhance water, land and vegetation resources in a sustainable production system that can improve the functionality of the watershed.

As watershed improvement activities are implemented, new information and data feeds forward into subsequent generations of river basin plans, watershed studies and on-farm plans. This provides an opportunity for repetitive advancement of levels of sophistication of the knowledge and understanding of river basins, watersheds and watershed function.

Study Area

Watersheds typically are populated with both urban and rural contingents and often do not have a formalized community entity. Local landowners, agencies, industries, municipalities and organizations with an interest in or dependency on the natural resources within their community are stakeholders and most often the consumer clientele to be served by a watershed study. As such, it is critical to involve all the varied stakeholders and understand their unique and diverse backgrounds.

Local, State and Federal agencies maintain extensive amounts of information. Such information is useful in providing general descriptions and also in documenting site, pasture, allotment specific documentation of resource condition and activities that will contribute to the identification of issues and/or opportunities. As such, agencies can be a significant contributor to the base of knowledge, information and planning for a watershed. Often agencies are also a significant beneficiary of the collection of data and information as they plan, prepare and implement management practices that advance their mission, goals and objectives.

Descriptions should provide a broad overview of a watershed. Included should be general information about the extent of the drainage system, the land area including land ownership and land use, and the natural environment found on the watershed. General discussion of resident population including related infrastructure, such as transportation, power, and industrial development necessary to support that population should be included.

Key Issues Identification

There are three prominent issues that are important considerations in a watershed information review and study. The first is surface water storage. Surface water storage is often of significant interest to a watershed community in order to address seasonal and/or annual shortages of water supply, augment late season stream flow to benefit riparian habitat and wildlife, address flood impacts, enhance recreation opportunities, improve water quality and steam channel stability.

Second is the evaluation of irrigation infrastructure and the information necessary to guide its rehabilitation. Of interest to local water users is ways to improve water deliver and on-farm irrigation application efficiencies often times to address annual or seasonal shortages of water supply or irrigation water delivery issues.

Third is the enhancement of upland water resources and distribution for livestock and wildlife that allows for grazing management adjustments for range resource improvements. Benefits to the watershed, through plant community invigoration, reduction of erosion and stream channel stabilization, are achieved from these types of projects being implemented over a broad scale of the watershed. Other issues and opportunities such as making beneficial use of produced water, removal of high water demand invasive species, and ground water development can also important to a watershed study.

WWDO Watershed Study Objectives

As discussed above, it is critical to consider the stakeholders and understand the issues that they identify as important to the watershed. This gives a foundation from which the watershed study can proceed, using those identified issues as guidance for gathering, processing and presentation of information. This information can be useful in helping guide a watershed study toward addressing locally important issues. There are numerous planning methods and formulas, some informal and some formal, for locally led issues identification as detailed following.

Description/Inventory

Land Use and Management

Land ownership

Land ownership information provides essential initial details about a watershed. The composition of Federal, State and private and the orientation and locations of those ownership parcels are critical for developing future management strategies and project implementation planning. Having land ownership presented in a GIS coverage provides a convenient early stage planning tool when applied with other layers of information.

Infrastructure

Infrastructure type and location is valuable watershed information. It provides a simple and quick reference opportunity for getting oriented within a drainage basin. Roads, railroads, pipelines and power system grid rights-of-way provide information about means of transportation, utility service availability, and transmission corridors. Location of this infrastructure can also provide insight into potential areas of disturbance which might have influence into the present day functionality of a watershed.

Location of irrigated lands and the irrigation system that services those land parcels can have a significant influence on the present condition of a watershed. Points of diversion are sites where stream function can be greatly changed. Components of an irrigation conveyance system and the current condition are critical to evaluate to develop the current and future status. Points of produced water discharge can have a huge influence on a landscape and must be considered to fully understand watershed function.

Land use

Land use, such as cropping systems employed, rotations used and the potential for development of different systems are necessary, as is an evaluation of the irrigation methods used both for conveyance and also on-farm application. Basic water demand data can be developed which allows for understanding irrigation shortages, present and future water needs, and non-consumptive considerations such as fishery habitat issues and opportunities.

Another land use practice that reflects the custom and culture of a watershed community is rangeland and pasture land grazing practices. How public land predominated, where private/public grazing uses are located in a basin, and what upland water development opportunities are available are essential considerations.

A valuable tool in addressing resource condition, both upland, riparian and wetland sites is ecological site descriptions (ESD). An ESD provides a status and transition model that describes a plant community and provides a diagram of a plant community

that would commonly occur on a particular site. A plant community has the potential to reach a biodiversity that has value to grazing, hydrology and resource stability. An ESD will also provide a description of natural events and also strategies for management changes that, if implemented, can influence that plant community. With current condition assessment an ESD can provide land managers with information about the potential of their resource and what management strategies can be implemented to reach that potential.
(USDA Natural Resources Conservation Service. 1997. National Range and Pasture Handbook.)

Industrial activities
Industrial activities, such as oil, gas, mining, and sand/gravel extraction activities are also important land uses to recognize in a watershed description. These activities, and their tending infrastructure footprint, are valuable to consider when evaluating functioning condition of a watershed. Municipalities are also an important consideration. All of these use activities dominant a land area and demand other resources, such as water, for existence, sustainability and expansion.

Natural environment

Climate
Climate is a description of the average of variations of weather in a region over time. Climate can be location specific as affected by latitude, terrain, water bodies, precipitation events, air temperature and snow cover.

Climate is classified into types by parameters such as temperature, precipitation and evapotranspiration. Climate models are mathematical representations using past measurements to predict present and future climate changes or patterns.

Wyoming's climate is semiarid predominated by high mountain ranges and grassland steppes. With an average elevation of 6,700 feet above sea level, annual temperature ranges from 104 °F in the summer to−40 °F in the winter. The climate of a region determines what plants grow there and what animals will inhabit it.
(http://en.wikipedia.org/wiki/Climate)

Vegetation, plant communities, land cover/coverage's
Vegetation is a general term describing the collective plant life of a region. Vegetation, or plant community, along with soil and animal life, form a natural community. Regional climate determines what types of plants can survive in a plant community.

Plants are the only organisms that can make their own food. As such, they are the primary producers that sustain all other life forms. Also, plants provide groundcover which protects soils from erosion and drought.

Vegetation affects soil characteristics, including volume, chemistry and texture, which affect productivity and structure. Vegetation provides food, shelter, medicine,

wood, fuel and other materials and serves as an energy source and habitat for wildlife. Vegetation is the primary source of oxygen in the atmosphere. (http://en.wikipedia.org/wiki/Vegetation)

Soils/soils survey data

Soils determine what plants can grow in an environment. Soil structure is how soil particles are arranged into aggregates. They have various size, shape and degree of development. Physical weathering processes contribute sands and silts and chemical weathering processes contribute to clay particles. Soil texture is the amount of sand, silt and clay particles that contributes to the composition of a soil.

Texture, chemistry and soil color reflect the geologic parent material of a soil. Surveys classify soils in conjunction with climate factors to describe what vegetation can grow in a given location. Soil descriptions can then be used to depict what plant community composition is expected in a given precipitation zone which can then be compared to what is present to evaluate impact over time.

Alluvium is fine particles of silt and clay and larger particles of sands or gravels deposited by a stream, river or other running water. This soil is made up of a variety of sedimentary materials. Areas where water drops these materials are called alluvial fans or flood plains, and the dropped particles are called alluvium. (http://en.wikipedia.org/wiki/Soil; http://soils.usda.gov/)

Geology

Geology is the study of the materials of which the Earth is made and how those materials are structured. It is also the study of the processes that are instrumental in the development of those materials and their structure. A salient part of geology is the study of how those materials, structures, and processes have changed over time.

Surficial geology, or surficial deposits, is the geological unit from which soils form. These deposits, as subjected to and responding to climate and time, influence soil type, topography and vegetation. They are also significant in their influence on water yield and as a foundation and building material for surface water storage projects.

Bedrock geology, or the materials underlying the surface of the earth's crust, contributes to the nature and distribution of the surface geology. They are the parent materials from which soils form. Water quality, both surface and ground water, can be reflected by the bedrock mineral composition in the area. Bedrock geology can be exposed at or near the surface of a watershed.

Structure, as geologic description of a watershed, is valuable in providing some insight into the presence of extractable minerals. Slope, particularly slope stability, provides valuable information relative to surface movement and its potential effect on dams and reservoir structures. (http://en.wikipedia.org/wiki/Geology)

Groundwater

Groundwater is liquid water located in and flowing through shallow aquifers. It is water that is located beneath the ground surface. It occupies pore spaces in the soil profile and also in the fractures of rock formations. Groundwater is often withdrawn for agricultural, municipal and industrial use by completing and operating wells.

Springs are where groundwater flows to the surface naturally. Spring flows are recharged from precipitation such as rainfall and snow melt that infiltrate through the soil surface and percolate into an aquifer.

An aquifer is a layer of porous materials that contains and permits transmission of groundwater. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. (http://en.wikipedia.org/wiki/Groundwater)

Surface water

Water that falls to and collects on the ground, in a stream, river, lake, wetland, or ocean is surface water. It is replenished by precipitation and lost through evaporation and sub-surface seepage into groundwater. Surface water found on land is the largest source of fresh water on the earth. Surface and ground water are two separate entities but are also part of an interrelated system and are often conjunctive to each other.

A stream is a body of water confined by stream banks within a bed and has a current. Streams are natural water conduits, serve in migration of fish and wildlife, and are important water sources for groundwater recharge. The ecological site or habitat influenced by and in the vicinity of a stream is a riparian zone. Streams are also called creeks or brooks.

A river is a larger stream of freshwater that flows toward another steam, lake or an ocean. In some cases a river flows into the ground or dries up completely before reaching another body of water. A river is a collection of water from precipitation through surface runoff, groundwater recharge or is water released from a storage reservoir, lake, aquifer or glacier.

Creeks, streams and rivers can be perennial, intermittent, or ephemeral. A perennial stream or river has continuous flow in parts of its bed all year round during years of normal rainfall. Intermittent streams normally only flow for weeks or months each year. Ephemeral channels flow only for hours or days following rainfall. Depending on precipitation, a perennial stream may cease flowing to become intermittent depending on severity of drought conditions.

Lakes are bodies of primarily fresh water contained within a basin. Lake water comes in the form of precipitation onto the lake, stream flow from the watershed catchment area, or groundwater channels or aquifers. Lake water is lost through evaporation from the surface, groundwater flows, or extraction for consumptive or

non-consumptive uses. Lakes can be either naturally formed or artificial as a result of dam construction. (http://en.wikipedia.org/wiki/Surface_water)

Hydrology

Hydrology is the study of the Earth's quantity, movement, distribution, and quality of water resources and also the hydrologic cycle influencing that resource. The hydrologic cycle is described as evaporation of water from the Earth that forms clouds which produce precipitation over land. Resulting liquid water flows into lakes, rivers, aquifers and eventually the oceans. The water then again evaporates back to the atmosphere completing the cycle.

Assessing water resources and evaluating the processes involved in the hydrologic cycle involves many disciplines such as soils, atmospheric science, geology, and geophysics. Information from observations of hydrologic processes is used to make predictions that are presented through hydrologic models which are simplified, conceptual representations of the hydrologic cycle. The models are used for understanding hydrologic processes and to make hydrologic predictions.

Measurement of surface water flow by gauging streams is valuable in developing an understanding of the hydrology of a watershed. Stream gauges measure the volumetric discharge, or flow, of the system. Stream gauging is preferably done at a site on a stream where there is stable stream channel geometry and at a location suitable to make measurements of streamflow.
(http://ga.water.usgs.gov/edu/earthrivers.html)

Stream flow characteristics

Stream flow characteristics are influenced by channel geometry, or the shape of the channel, and stream flow source, velocity, turbulence, and discharge. Long, narrow drainage basins have straight stream channels and short tributaries resulting in storm waters reaching the main channel rapidly. This can result in greater channel erosion potential.
(http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/fluvial_systems/channel_geometry_and_flow.html)

Topography, or relief, and slope, or gradient, can also affect water velocity, infiltration rate, and overland flow rate. Velocity, infiltration rate and overland flow rate can affect the rate of surface and subsurface runoff.

Precipitation, specifically type, duration, and intensity is a climatic factor that can also influence stream flow characteristics. Infiltration rate is affected by the intensity of the precipitation event as seen with the erosion induced from downpours.

Plant communities, specifically the vegetation and its condition comprising the plant community, can also influence stream flow characteristics through slope stability. Vegetation can aid change to the velocity, infiltration rate and overland flow rate which can also affect the rate of surface and subsurface runoff.

Produced water

Produced water from underground formations is brought to the surface with oil or gas. It is the largest byproduct of oil and gas production. The volume of produced water from oil and gas wells tends to decline over time and the water-to-oil ratio increases over the life of a conventional oil or gas well. Chemical and physical properties of produced water from oil wells, gas wells, and CBM wells can be widely variable. (*Produced Water White Paper, January 2004)*

Water quality

The relationship of physical, chemical and biological characteristics of water in comparison to empirical and subjective standards determines the quality of water in a water body. Physical characteristics are temperature, total dissolved solids, and turbidity. Chemical characteristics include pH, conductivity, dissolved oxygen, nitrates, orthophosphates and other pesticides. Biological characteristics involve the presence and abundance of aquatic organisms.
(http://en.wikipedia.org/wiki/Water_quality)

Wyoming's water quality program objectives are to provide, wherever attainable, the highest possible water quality for agriculture, fisheries, industry, drinking water, recreation and scenic value, aquatic life other than fish, wildlife, and fish consumption. Water bodies are classed according to existing and designated uses and except for Class 1 waters, each classification is protected for its specified uses plus all the uses contained in each lower classification. There are four major classes of surface water in Wyoming with subcategories within each class.
(http://deq.state.wy.us/wqd/)

Water quality information and data of the water resources within a watershed needs to be evaluated to assess suitability for use whether for irrigation, upland livestock and wildlife, industrial or municipal. Information or data for both surface and groundwater needs to be considered to determine the developmental potential for both consumptive and non-consumptive uses.

Geomorphology

Geomorphology is the study of landform and the processes that contribute to the existing and future condition of that landform. Fluvial geomorphology connects stream and river flow and its sediment transport capacity to the channel networks found across a watershed. The channel form that a river exhibits is a culmination of the adjustments over time from steamflow and its eroded contents that have been produced within a watershed.

Channel and valley morphology therefore represent erosion, transport and deposition of materials found within that ecological system. Influences, such as disturbances, storm events and climate variability will eventuate themselves in the geomorphologic conditions found within channels and valleys. (Applied River Morphology, Rosgen, 1996)

Stream channel classification provides an effective communication tool useful in describing channel form. Classification of a channel potentially provides a reflection of ecological conditions within a watershed. Stream channel adjustments, as depicted by classification, may provide a glimpse into the stability of resources with a watershed, as expressed by the morphology of channel segments.

Through understanding the effects of hydrologic process on stream and valley form, it is possible to evaluate the changes taking place within a watershed by evaluating the changes taking place within a stream channel. Identifying erosional, transitional and depositional zones within a segment and a watershed can provide insight into fluvial functions important to decision processes for water storage, management and rehabilitation interests.

Stream order is a measure and classification of the stream size. First -order streams, the smallest tributaries in a watershed, together with second and third order streams comprise headwaters. Fourth, fifth, and sixth order streams are considered medium streams. Seventh order or larger are considered a river. The Amazon, the largest river in the world, is a twelfth order waterway.

First-order streams have perennial flows that have no permanently flowing tributaries. Two first-order streams combine to form a second-order stream. Two second-order streams combine to form a third-order stream. However, if a first-order stream joins a second-order stream, the latter remains a second-order stream. A stream increases in order of magnitude when two streams of the same order combine.

As headwaters, streams, and rivers combine to become a higher order, they increase in width, depth and velocity and the discharge volume also increases. This can affect the physical, chemical and biological characteristics of the watershed's water system. (http://www.cotf.edu/ete/modules/waterq3/WQassess4b.html)

A stream system has zones of erosion, transition and deposition or rifles, runs and pools. Stream channels also have transition zones between segments of different geomorphologic classifications. Recognizing these transition zones could allow broader understanding of the current and future conditions of a river system. Why a stream or river channel exhibits spatial changes could be revealed in the characteristics found in the transitions.

Wetlands

Wetlands are low lying areas that are connected to groundwater and occur where water availability to the area exceeds loss, such as from seepage or evapotranspiration. Although wetlands are usually only a minor component to a watershed, their hydrologic and biologic functions are significant to the functionality of a watershed.

Wetlands have a major role in enhancing water quality, reducing flood impact and mitigating erosion activity and sediment transport. They are important groundwater

recharge zones, sustain streamflow, and for cleansing water that flows into the wetland prior to its release.

Physical, biological and chemical functions of a wetland are important considerations for understanding watershed function. Physical function is largely from a wetland acting as a reservoir, detaining water through the storage basin and releasing it over time therefore acting to modify run-off peaks.

Chemical function of a wetland is largely through purification of water inflows. Sediment deposition and the constituents that accompany sediment, such as minerals, metals, nutrients and particulates, can settle in a wetland. Some of those deposits can be used by the plant community that inhabits wetland resources.

Biological function of a wetland is largely through the habitat provided for aquatic species, waterfowl, and migratory song birds. Additionally, wetlands in a naturally functioning condition, can act as a nutrient sink reducing nutrient export to streams, ponds and other water bodies.

The loss and/or gain of wetlands need to be assessed in a watershed study to understand cumulative effects. Assessment should be concerned with hydrologic function, soil erosion capture, sediment delivery, and maintenance flows to downstream reaches. Properly functioning wetlands, together with upland conditions that limit sediment transport, can have far reaching influence with overall watershed function. (Hydrology and the Management of Watersheds, Third Edition, Kenneth N. Brooks, et.al.)

There are several wetland assessment methods. The Wetland Evaluation Technique (WET) is a comprehensive approach developed by the U. S. ACOE. The Environmental Monitoring Assessment Program-Wetlands (EMAP-Wetlands) is an approach developed by the EPA.

The Hydrogeomorphic Approach (HGM) is a method also developed by the U. S. ACOE. HGM assesses the biological, physical and chemical functions of wetlands, is a revision of the WET approach and is more applicable to specific regions. (National Water Summary on Wetland Resources, USGS Water Supply Paper 2525, Richard P. Novitzki, et. al.)

Watershed Management and Rehabilitation Plan

Water Storage and Retention

Surface water availability

Surface water flows available for municipal, recreational, environmental, agricultural and industrial uses was evaluated as part of the WWDC river basin planning process. Models for each of the seven river basins in the state were developed and are presented in Volume I of

the Wyoming Framework Water Plan. Models were populated using data from existing reports and modified for the basin planning purpose.

Shortages

Using surface water availability information and consumptive use demands for agriculture, municipal and industrial components of the river basins, shortages are developed for dry, normal and wet year scenarios. Identified are annual and seasonal shortages and the sub-basins experiencing consumptive use shortage demands. Biological evaluations of stream segments can provide information related to calculated non-consumptive use shortages.

Models

Models are water yield based accounting spreadsheet models that incorporate the system diversions, gaging stations and other water resource data that is available. Again, models represent dry, normal and wet year water supply scenarios. Data inputted into the model is streamflow, consumptive use for the cropping systems with a basin, diversions from the system, and return flows. It is important to understand the limitations of such models and attempt to gather necessary localized hydrological yield data for storage project evaluations.

Existing facilities

A description and mapping of existing surface water storage facilities is an important consideration. Descriptions should include any and all physical inventories of structures, water right permits, existing condition assessments, dam safety information, and where the stored water is used.

Previous site investigations

A description and mapping of any previous surface water storage facility site investigations is also an important consideration for a watershed inventory and description. Descriptions should include any and all physical inventories of structures, water right permits, existing condition assessments, and where the stored water is originally intended and/or used.

Alternative site investigations

Surface water storage sites are considered to be a primary focus of a watershed study. This should include the identification and initial evaluation of opportunities to develop additional water storage sites within the watershed being studied. Benefits to be addressed would be irrigation water supply, increased late season flows, reduced flooding, improved stream channels, fish habitat enhancement, improved water quality, and development of recreational opportunities.

Surface water storage

Identification and characterization of sites for initial reconnaissance can involve local landowners and stakeholders, the Wyoming State Engineer's Office dam's database, topographic maps, digital aerial photography and identification of stream reaches with available flow to support a surface water storage project.

Conceptual design and sizing of appropriate storage capacity provides a visual means to present special locations of a storage site, approximate structure size and shape, the

approximate potential reservoir size and footprint, and the approximation of the facility to potential points of use.

The potential and likely environmental processes, permits and related requirements and conditions including identification of environmental documentation, agency clearances and approvals, permit requirements, and agency coordination responsibilities should be analyzed. Compliance with and documentation of the National Environmental Policy Act and other Federal, State or local environmental permits and regulations need to be identified and included in a watershed study.

Irrigation

Water conveyance systems for irrigation range from small, privately owned and maintained systems to large, complex entity owned and operated. In Wyoming, the agronomic practice of irrigation developed prior to statehood. As such, much of the irrigation delivery infrastructure is aged. This contributes to the significant demand across Wyoming for rehabilitation and/or replacement of conveyance systems.

To address this issue, it is important and necessary to evaluate, assess and prioritize this infrastructure in order to address the rehabilitation needs of these important and valued conveyance systems. Infrastructure important to evaluate are diversions, conveyance canals and ditches, head gates and checks. Determine seepage losses and outline mitigation measures to consider as well as means by which water delivery might be enhanced is vital. Many systems have aquatic vegetation issues as well as operation and management opportunities to improve delivery efficiencies. These considerations should be reviewed given the economic capacity of the system operation and be feasible to install, operate and maintain.

Upland wildlife/livestock water development

Rangelands and pasturelands comprise a major component of a watershed. In addition, condition of those resources can have a significant impact to the functionality of a watershed. Health of range and pasture resources can and will influence riparian areas, wetlands, stream channels, quantity and quality of water, and subsequently the overall health and condition of the watershed.

Healthy range and pasturelands can slow water runoff, retard soil erosion, increase infiltration and percolation of precipitation, improve spring and stream flows, and enhance groundwater recharge. They also provide for diversity of plant communities which, when available for grazing, can provide many benefits to both local wildlife and livestock. These factors when managed in a sustainable manner can provide direct and indirect socioeconomic benefits to a watershed community.

An evaluation of existing upland water availability provides a baseline of water distribution information. Location identification and type of source provide valuable data for the description inventory. A given water source location is then associated with a grazing radius

of influence which allows for the determination of the areas within a watershed that could benefit from implementation of an upland water development.

Locating existing streams, springs, ponds, wells, and pipelines/tank systems allows for watershed planning and management to identify, plan and prioritize the development of alternative sites. In upland water development, it is also valuable to have knowledge of available power sources in the event it is necessary to lift or pump water to areas within the watershed deficient of a water supply.

It is important to understand that upland water development, as with evaluation of irrigation infrastructure, will largely engage the private landowner or public land permittee. Therefore, approach these evaluations from a voluntary consideration. Also, for upland range and pasture condition information, using NRCS Ecological Site Descriptions can provide a resource manager with a guidance tool from which to do planning and make critical management decisions.

In addition to grazing management and upland water developments, invasive species infestations are an important consideration when developing watershed plans. Also, the use of pesticide and pyric treatments can and will have an impact on soil, plant and water resources within a watershed. Ultimately, stream and channel conditions will be a window into the condition of a watershed and can be utilized in the development of strategies to maintain or restore healthy watershed function.

Economics

Upon describing the varied resources found within a watershed and providing some evaluation and analysis of their condition, it is eventual that an economic review be developed to compliment a plan to address watershed improvement activities. Conducting a benefits analysis of existing conditions provides a baseline of current condition value. A benefits analysis of alternative projects can provide a review of the potential of project implementations to return the investment and provide additional future contributions to the watershed and its entire community of residents.

An ability to pay analysis should be conducted to determine the extent to which those responsible to pay for project implementation can and will be able to cover project costs. This analysis can consider multiple benefits from a storage project, from additional crop production resulting from the rehabilitation of irrigation infrastructure, or the installation of upland water developments.

It is quite possible that ability to pay will revolve around available financing. Obviously, project funding is a critical factor in the implementation of the projects outlined and prioritized in the watershed rehabilitation and management plans. As there are a number of private, local, State and Federal programs and funding sources, a resource to consider is: http://wwdc.state.wy.us/wconsprog/WtrMgntConsDirectory.html.

Conclusions/Recommendations

Summary conclusions and recommendations need to reflect and follow the progression of resource elements used to describe the watershed. Conclusions based on the gathering and presentation of information should focus on a summary of the information developed for the description/inventory including land use, management and the natural environment.

Also included in conclusion of a watershed study should be the watershed management and rehabilitation plan including water storage, irrigation and upland water development opportunities and considerations. The watershed study conclusion should also review permitting and environmental considerations as well as project financing options, cost estimates and the ability of community stakeholders to pay for project implementation.

Recommendations should be offered as to specific practice activities for irrigation system rehabilitation, upland water development and surface water storage. These project activities should be site located with some conceptual design offered. A prioritization of project practices and an implementation schedule would be helpful for the watershed community, agencies and organizations involved with watershed restoration activities to develop strategies for future implementation. (Cottonwood/Grass Creek Watershed Management Plan, Level I Study, Short Elliott Hendrickson, Inc., WWDC Oct. 10, 2007)

Other Watershed Plans and Studies

River basin planning is conducted through interaction with local Basin Advisory Groups, or BAGs. For initial river basin plans, these groups comprised of local stakeholders and interested citizens identified issues and opportunities that were of significant interest and importance to them and their basin community. (http://waterplan.state.wy.us/)

Coordinated Resource Management Planning is a landowner initiated, consensus driven process that develops goals and objectives for dealing with critical natural resource issues within a watershed. Although a CRM does not necessarily encompass a specific land area, such as a watershed, what is identified by a CRM group within a watershed can be valuable for developing guidance for conducting a watershed study. (http://wyagric.state.wy.us/)

Conservation District long range plan, developed every 5 years with input from interested constituents identifies issues, activities and opportunities for the management and conservation of resources. A District plan outlines goals, objectives and solutions and is a practical guide for annual planning of work by the district, cooperators and other agencies. A long range plan should provide a description of the district, some history of the area, goals and objectives for resource conservation and any and all relevant policies. A long range plan can also be related to a local watershed plan.

Local watershed planning is an outreach of a local Conservation District and is stimulated by listing on the EPA 303(d) list of impaired waters. Local people, with public input, develop their own watershed restoration goals through an inventory of the watershed, identification of issues, and development of a risk assessment. Issues are then prioritized, baseline data gathered, goals/objectives are developed, a course of action to be implemented outlined,

needed resources identified, and a course of action outlined and initiated. (http://www.conservewy.com/WATER.htm)

EPA watershed based plans develop and implement watershed plans for waters that are impaired by nonpoint sources. The intent is to select management measures and practices that will reduce pollutant loads and restore impaired waters to meet water quality standards. Beneficial uses and criteria describing physical, chemical, and biological attributes or conditions that protect those uses are established. This is done by identification of the impairment and source, estimation of expected load reduction, describing management measures, determining needed assistance, and informing the public.

A TMDL (Total Maximum Daily Load) is the amount of a specific pollutant that a water body can assimilate and still meet water quality standards. The load is allocated among the current pollutant sources such as point, nonpoint, and background, includes a margin of safety, and can allow for future growth. A TMDL will identify links between water quality problems and pollutant sources, estimate a pollutant load rate that achieves water quality standards, and allocates load rates for pollutant sources. (http://www.epa.gov/owow/nps/watershed_handbook)

NRCS rapid watershed assessment provide information on where conservation practices could most effectively address concerns of landowners and stakeholders, conservation districts, and community organizations. This assessment can help local communities set priorities and determine an action plan to achieve established goals. A rapid watershed assessment is conducted by watershed planning teams traveling through each watershed, meeting with landowners and conservation groups, inventorying agricultural areas, identifying conservation opportunities and current levels of resource management, and estimating impacts of these opportunities on the local priority resource concerns. (http://www.nrcs.usda.gov/programs/rwa/)

Resource management plan (RMP) is a land use plan that provides broad multiple use direction for managing public lands. The Federal Land Policy and Management Act (FLPMA) directs the development of such land use plans to provide for appropriate uses of public land. Decisions in land use plans guide future land management actions and subsequent site specific implementation decisions. The RMP establishes goals and objectives for resource management and measures needed to achieve them. These measures are expressed as management actions and allowable uses. (http://www.blm.gov/)