WATER DEVELOPMENTS AT SPRINGS ON NATIONAL FOREST SYSTEM LANDS

CONSIDERATIONS FOR DESIGN, CONSTRUCTION, MAINTENANCE, and RESTORATION

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Introduction

Flow regulation structures at springs and wetlands are designed to capture and divert water for uses such as livestock watering, or irrigation. Historically, the goal for a successful spring development was to maximize the amount of spring flow captured. Today, the water needs of the spring habitat and the overall ecological health of the local aquatic and terrestrial system are of equal or more importance. This list of considerations for water developments at springs has been developed by ecologists, hydrologists, range conservationists and other specialists with experience in spring evaluation, monitoring and development. Many of these considerations come from the publication *National Best Management Practices for Water Quality Management on National Forest System Lands (USDA Forest Service 2012)* and from the Nevada Springs Restoration Committee. These considerations are focused on spring developments for livestock watering. Water developments for domestic or public water supply have specific construction and testing requirements in State public health codes. In most cases, the ecological health of the spring system is secondary to water quality protection measures.

Design

- Are there alternative methods and solutions available that will 1) eliminate the need to modify the spring and associated habitat or 2) allow the development of the spring while protecting native species and habitat?

- Is there a project design that will ensure an environmental flow for native species and habitat?

- When determining the amount of flow to divert consider that recent studies on spring channel water diversion indicate that substantial decreases in spring channel physical and aquatic habitat occur with relatively small (10 to 20%) discharge reductions (Morrison et al. 2013).

- Determine if there are native and/or sensitive species present at or adjacent to the site that will need to be accommodated in the design. Are there steps that can be taken to increase the level of protection for native and sensitive species and adjacent habitat?

- Conduct a Level 2 inventory (USDA Forest Service 2012b) on the spring to determine what functions and values to protect or enhance during development.

- Locate the water trough, tank, or pond at a suitable distance from the spring to avoid or minimize adverse effects to the spring and wetland vegetation from livestock trampling or vehicle access.

- Locate the spring box to allow water to flow by gravity from the spring to the spring box to eliminate disturbance from pumps and auxiliary equipment.

- Design wetlands to create hydrologic conditions (including the timing of inflow and outflow, duration, and frequency of water level fluctuations) that provide the desired wetland functions and values.

- Collect no more water than is sufficient to meet the intended purpose of the spring development.
- Ensure that enough water remains in the spring to support the source groundwater dependent ecosystem and downstream aquatic ecosystems.
- Design the collection system to avoid, minimize, or mitigate adverse effects to the spring ecology and downstream waters from excessive water withdrawal, freezing, flooding, sedimentation, contamination, vehicular traffic, and livestock.
- Size the spring box sufficient to store expected volume of sediment generated between maintenance intervals and enough water for efficient operation of the system, and to provide access for maintenance and cleaning.
- Avoid or minimize backing up of spring flow by providing overflow relief sized to carry the maximum flow expected from the spring during periods of wet weather.
- Use suitable measures to avoid or minimize erosion at the overflow outlet.
- Maintain fish and wildlife access to water released below the spring development to the maximum extent practicable.
- Use suitable species and establishment techniques for wet conditions to cover or revegetate disturbed areas near springs in compliance with local direction and requirements for vegetation ecology and prevention and control of invasive species.
- Identify the aquatic and aquatic-dependent species that live in the habitat and their life histories to determine protection strategies, such as timing of construction, sediment management, species relocation, and monitoring during construction and operation.
- Use a flow splitting devise to leave as much flow in the existing outflow and associated habitat as possible.
- Use float valves or other flow control devices to provide flow only when a demand is present.
- Avoid methods that utilize trenching or installation of grout walls or perforated pipe systems near spring sources.
- Consider short- and long-term maintenance needs and unit capabilities when designing the project and develop a strategy for providing emergency maintenance when needed.
- Divert water or locate spring box or water collection tray downstream from the spring source area to protect the critical groundwater emergence zone habitat. Dewatering of sites can shrink the GDEs making them more prone to upland and invasive plant species.
- Bury pipelines to and from troughs to limit temperature increase if water is returned to the aquatic system.

- Use suitable measures to maintain desired downstream temperatures, dissolved oxygen levels, and aquatic habitats when water is released from a pond or impoundment.

- Create microtopography and macrotopography to mimic natural conditions and achieve hydrologic and vegetative diversity.

- Design the project to create a biologically and hydrologically functional system.
    - Design for function, not form.
    - Keep the design simple and avoid over engineering.
    - Design the project for minimal maintenance needs.
    - Use natural energies, such as gravity flow, in the design.
    - Avoid use of hard engineering structures or the use of supplemental watering to support system hydrology.
    - Plan to allow the system time to develop after construction activities are complete.

- Include implementation and effectiveness monitoring to evaluate success of the project in meeting design objectives and avoiding or minimizing unacceptable impacts to the spring ecology.

Construction

- Use suitable measures to protect the aquatic system when preparing the site for construction or maintenance activities.
    - Clearly delineate the work zone.
    - Locate access and staging areas near the project site but outside of Aquatic Management Zones, wetlands, and sensitive soil areas.
    - Consider using small, low ground pressure equipment, and hand labor where practicable.
    - Ensure all equipment operated in or adjacent to the aquatic system is clean of aquatic invasive species, as well as oil and grease, and is well maintained.
    - Use vegetable oil or other biodegradable hydraulic oil for heavy equipment hydraulics wherever practicable when operating in or near water.

- Schedule construction or maintenance operations in aquatic systems to occur in the least critical periods to avoid or minimize adverse effects to sensitive aquatic and aquatic-dependent species.
    - Avoid scheduling work during the spawning or migration seasons of resident or migratory fish and other important life history phases of sensitive species that could be affected by the project.
    - Avoid scheduling work during periods that could be interrupted by high flows.

- Use suitable measures to avoid or minimize impacts to the aquatic system when implementing construction and maintenance activities.
    - Minimize heavy equipment entry into or crossing water as is practicable.
    - Conduct operations during dry periods.
    - Stage construction operations as needed to limit the extent of disturbed areas without installed stabilization measures.

- Promptly install and appropriately maintain erosion control measures.
- Promptly install and appropriately maintain spill prevention and containment measures.
- Promptly rehabilitate or stabilize disturbed areas as needed following construction or maintenance activities.
- Minimize wetland and riparian area excavation during construction to the extent practicable.
- Keep excavated materials out of the aquatic system.
- Use only clean, suitable materials that are free of toxins and invasive species for fill.
- Use suitable species and establishment techniques to revegetate the site in compliance with local direction and requirements for vegetation ecology and prevention and control of invasive species.
- Avoid or minimize unacceptable damage to existing vegetation, especially plants that are stabilizing the aquatic system.
- Remove aquatic organisms from the construction area before dewatering.
- Return clean flows to channel or aquatic system downstream of the activity.
- Restore flows to their natural stream course as soon as practicable after construction or before seasonal closures.
- Minimize disturbance in the spring source area.

Operation and Maintenance

- Periodically monitor the spring development and promptly take corrective action for sediment buildup in the spring box, clogging of outlet and overflow pipes, diversion of surface water from the collection area and spring box, erosion from overflow pipes, and resource damage from animals or people.

- Conduct a Level 2 inventory (USDA Forest Service 2012b) on the spring to determine what functions and values to protect or enhance.

- Construct/Repair exclosure fences around spring sources and associated wetlands/riparian areas. Springs/wetlands that have more surface water expression, wetland vegetation, and hydric soils are more prone to damage through hoof shear in organic soils and soil compaction in mineral soils.

- Manage uplands and surrounding areas to avoid or minimize unacceptable impacts to water quality/quantity in the spring.

- Use suitable measures to manage uses such as livestock grazing and vehicle traffic around the spring development to avoid or minimize erosion, sedimentation and compaction affecting the spring.

- Trail livestock away rather than through the spring/wetland.

- Reduce impacts due to recreation by building trails and boardwalks, eliminating on-site camping and vehicular access, or complete site closure.

- Relocate water troughs away from springs and wetlands/riparian areas to limit trampling. Troughs placed within the aquatic habitat result in continuous livestock disturbance to soils and vegetation.

- Change the duration, season, or intensity of grazing if the current grazing strategy inhibits natural recovery at a given site. In certain instances, it may also be necessary to provide off-site watering.

- Reduce impacts of spring developments through management strategies such as changing the location of the diversion, reducing the quantity of water diverted, or allowing an increased amount of flow to discharge to the spring outflow habitat.

- Install/Repair float valves on water troughs, tanks, or ponds to ensure spring flow is not diverted from the habitat when not needed for livestock.

- Enhance flow and habitat conditions at the springs source by installing a flow splitter, installing a float valve on the trough, shifting the point of diversion downstream from the source, removing a dam, or modifying a spring box and pipes.

- If there is pre-orifice groundwater extraction, avoid or minimize drawdown effects in the spring source by limiting timing and rate of water withdrawal to allow sufficient downstream water flow to maintain desired conditions.

- Consider discontinuing use of a water resource in critical habitats.

Restoration

Many water developments on National Forest System Lands have been poorly designed, not maintained, or have fallen into disrepair over time through neglect or disuse. These situations can be turned into opportunities to reestablish ecological values that have been lost. Lack of ongoing maintenance can threaten surface water and groundwater quality and abandoned structures may pose a safety risk to the public. Water developments should be reclaimed after the need for them ceases or the recurrent impacts to resources indicate the site cannot be properly managed with available resources. Although a large amount of general planning and implementation guidance is available for ecological restoration, recommendations, guidance documents, manuals, or methods specific to springs restoration have not been published (Stacey et al. 2011). The Groundwater Dependent Ecosystems: Level II Inventory Field Guide (USDA, Forest Service 2012b) presents assessment protocols developed specifically for springs and can aid in the restoration planning process.

Methodologies have been developed to help prioritize restoration efforts. Coles-Richie et al. (2013) presents a phased approach for developing a springs and GDE restoration-rehabilitation program and project. The first phase involves determining where to focus stewardship program efforts within an area of interest. The second phase involves focusing on high priority sites to determine what actions to propose at those sites. The third phase involves deciding on what actions to take and the fourth phase involves implementation of actions and monitoring results at specific sites. The fifth phase provides information that can be used to evaluate and adjust the other phases of the process. Smith

(2008) also presents a template for prioritizing lentic (non-riverine) sites and is designed to be used to help organize and prioritize management and restoration efforts in lentic systems. Abele (2011) shows how to summarize the current condition of springs, identify future threats and highlight necessary conservation actions.

- Develop a plan to rehabilitate and restore, to the extent practicable, the natural ecological components, structures, and processes consistent with land management plan desired conditions, goals, and objectives.

- Conduct a Level 2 inventory (USDA Forest Service 2012b) on the spring to determine what functions and values to protect or enhance during restoration.

- The overall approach to spring restoration and the desired condition should match the spring type and characteristics of the pre-disturbance spring condition as closely as possible.

- Restoration efforts frequently achieve stated objectives, but fall short of full restoration. Try not to focus solely or primarily on one goal (e.g. native vegetation restoration or non-native species removal), rather focus on ecosystem-level restoration of flow, geomorphology, flora, and fauna.

- Carefully evaluate the pre-treatment condition through comparison of the restoration site with similar springs in the region. Reference conditions may be difficult to define – in some cases human impacts to springs may have taken place over centuries or millennia. This may restrict the comparative approach and use of control sites to evaluate restoration success.

- Develop a monitoring plan that will define restoration success by carefully selecting appropriate monitoring elements that span the scope of the restoration goals.

- Springs are uniquely individualistic ecosystems, sometimes containing multiple microhabitats, and no two springs are precisely alike. The expectations, strategies, and outcomes of restoration are likely to vary within and among spring types, influencing the costs and scheduling of interventions.

- An environmental flows and levels analysis (an EF/L establishes the limit to water flow or groundwater level change) should be undertaken whenever a spring or spring-fed wetland is to be developed, redeveloped, restored or is to undergo maintenance of diversion or collection facilities (Forest Service and The Nature Conservancy, in prep.).

- Restoration of limnocrenes (springs with pools) may involve recreating natural water quality and desired pool area and pool habitat.

- Analyze groundwater levels in relation to the habitat types desired. Shallow water tables are required to sustain saturated soil conditions and surface discharges including stream baseflow.

- Restoration of helocrene (springs emerging from low-gradient wetlands) habitats may involve filling in ditches, preventing erosional head-cutting with grade control structures, eliminating erosional channels, removing drainage tiles or subgrade water diversion structures, and replanting native wetland plant species.

- The feasibility of restoring a fen requires that suitable conditions exist or are created for the development of a shallow water table (within a few centimeters of the ground surface) and permanently saturated peat layer.
- Remove unneeded structures where ecological function is impacted by them.
- If a historically developed site has naturalized and ecological function is largely intact, consider leaving structures as they are, thereby, eliminating unnecessary disturbance.
- Re-establish original slope contours, surface, and subsurface hydrologic pathways where practicable and as opportunities arise.
- Improve infiltration capacity on compacted areas of sensitive sites which might include where freeze/thaw is not expected to break up the compaction over 6 inches deep over time.
- Use suitable species and establishment techniques to revegetate the site in compliance with local direction and requirements for vegetation ecology and prevention and control of invasive species.
- If native species remain in the system they should be salvaged prior to diversion and desiccation of the spring source and outflow.
- Decommission unneeded roads, trails, staging and recreational areas.
- Use suitable measures to limit human, vehicle, and livestock access to site as needed to allow for recovery of vegetation.
- Reduce the amount of habitat most suitable for the invasive species and maximize the amount of habitat suitable for desired species.
- If invasive species are a major issue, consider mechanical removal of invasive plants, trapping of invasive animal species, or the application of herbicide and pesticide.

Spring Channel Restoration

Many springs and wetlands have runout channels that may support important ecosystem components. Small, low order channels located at springs and in wetlands that receive the bulk of their flow from spring discharge exhibit a morphology that differs markedly from channels that receive the bulk of their flow from runoff. The flow variability of springs is generally much smaller than streams making concepts such as channel geomorphology, bankfull flows, overbank flows, and sediment transport relatively less important in design or restoration.

- For spring channel restoration, select the appropriate channel dimension and morphology (width, depth, slope, sinuosity, substrate, single or multiple thread channel, etc.) by an analysis of spring channel specific geomorphology and hydrology, historic channel form, habitat requirements of target species, and desired conditions. (see Griffiths et al. 2008; Whiting and Moog 2001)

- The dampened hydrograph and limited sediment input characteristics of springs leads to the formation of channels with steep, well-vegetated banks; armored beds; higher sinuosity values; and lower width-to-depth values.
- Spring-dominated channels have a very broad flood hydrograph compared to the flashy hydrograph typical of streams receiving flows directly from snowmelt or rainfall.
- Channel bars are commonly lacking in the spring-dominated streams which may be a result of the relatively low flood flows that do not remove woody debris.
- The range of discharge in spring-dominated channels is narrow, flowing at bankfull or above 20 percent of the time while the typical value for runoff-dominated channels is 2-4 percent.
- Stream banks are typically rich in organic material—over 50% at some sites.
- The resistance to flow (Manning coefficient) is typically large in spring-dominated channels due in part to the greater resistance associated with the large amount of organic debris in the channel.
- The streambed is generally armored in spring dominated channels consistent with sediment supply limitations.

- Develop a plan to rehabilitate and restore, to the extent practicable, the natural ecological components, structures, and processes associated with the spring channel.

  - Stabilize disturbed spring channel bed and banks.
  - Consider returning flows to the historical channel if present.
  - Avoid changing channel alignment unless the change is to reconstruct the channel to a stable geometry consistent with spring-dominated channel characteristics.
  - Avoid relocating natural stream channels and return flow to natural channels, where practicable.
  - Provide habitat complexity where reconstruction of stream channels is necessary.
  - Choose vegetation appropriate to the site to provide streambank stabilization and protection adequate to achieve project objectives.
  - Use vegetation species and establishment methods suitable to the project site and objectives, consistent with local direction and requirements for vegetation ecology and prevention and control of invasive species.

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