DRAFT TECHNICAL MEMORANDUM

Catherine Creek Managed Underground Storage Site Assessment

To: Commissioner Donna Beverage, Union Count

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Attachments: Figure 1 – Catherine Creek MUS Conceptual Model
Figure 2 – Study Sub-Areas

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1. Introduction

This Technical Memorandum (TM), prepared by GSI Water Solutions, Inc. (GSI), summarizes prior investigations related evaluating the feasibility of siting a Managed Underground Storage (MUS) system to augment flows in upper Catherine Creek. The overall goal of the project is to develop a cost-effective underground storage project that provides cool water to Catherine Creek to supplement stream flows by up to 10 cubic feet per second (cfs) during warm, low-flow periods to improve ecological conditions (flow and water temperature) in the creek for sensitive, threatened, or endangered fish. The project aims to accomplish this by diverting water from Catherine Creek in the winter and spring when surface water flows are relatively high, treating diverted water to improve water quality, then storing the treated water underground. Water will be recovered from the aquifer during the summer months and used to supplement streamflow when surface water flows are low (Figure 1).

An initial feasibility study and fatal flaws analysis was completed that concluded that MUS may be a feasible alternative to augment streamflows in Catherine Creek (Anderson Perry, 2010). The study explored:

- The feasibility of locations for a MUS system within the Catherine Creek drainage upstream of Union, OR. Sub-areas considered included the alluvial basins upstream of Union, Badger Flat, and Milk Creek (Figure 2).
- Potential regulatory and permitting frameworks for a MUS system, including the Artificial Recharge (AR) and/or Aquifer Storage and Recovery (ASR) permitting regulations.
- Two MUS techniques: (1) enhancing natural groundwater discharge to the creek by recharging the surficial alluvial aquifer on the valley flanks and allowing the infiltrated water to flow back to the creek, and (2) storing water in the deeper confined volcanic aquifer system (Columbia River Basalt Group [CRBG] and/or Powder River Volcanics [PRV]) aquifer system and pumping it into the stream to augment streamflow. The latter method was found to be best suited to fulfilling project goals for water storage and return to Catherine Creek.

- Source water and groundwater quality suitability.

The 2010 feasibility study concluded that (1) the Milk Creek sub-area is the preferred location to construct an MUS system, (2) the AR permitting pathway is the best to pursue for the project based on maximizing the availability of water that can be diverted for storage, (3) storage in the volcanic aquifer system best meets the project goals, and (4) water quality in the shallow alluvial aquifer is likely permissible for use as recharge source water, although this conclusion was made based on a single sampling event; additional alluvial groundwater sampling is necessary. The MUS concept developed during the study is as follows: source water would be diverted from Catherine Creek via shallow wells installed in alluvium adjacent to the creek, providing some degree of filtration treatment (source water will be further treated if necessary). Water would then be pumped from the alluvial wells, injected into the underlying volcanic aquifer system, recovered during the summer months, and delivered directly into Catherine Creek to enhance streamflow (both volume and temperature).

Since the initial 2010 feasibility study was completed, the potential benefit of a lower streamflow enhancement goal of between 1 and 10 cfs has been discussed. The second and third findings from the 2010 feasibility study (pursuing the AR permitting pathway because of water availability and using the volcanic aquifer system for storage) continue to further the goals of the project. This TM will briefly reconsider the original three sub-areas considering the lower streamflow enhancement goal and focus on the opportunities and risks associated with each sub-area.

2. Milk Creek Sub-Area

The Milk Creek sub-area is the portion of Catherine Creek located within a broader stretch of valley between the confluences of Catherine Creek with Little Catherine Creek and Milk Creek (Figure 2). The current project plan as outlined in a limited license application submitted to the Oregon Water Resources Department (OWRD) in 2012 identified this sub-area as the most likely location to site an MUS system (GSI, 2012). The pros and cons or uncertainties for some key selection criteria in this sub-area include:

- **Hydrogeology**

  1. **Pros**:

     - Riverbank Filtration Diversion Potential: A reconnaissance geophysical survey and geological mapping indicates the likely presence of buried gravel channels adjacent to Catherine Creek. This initial assessment indicates the presence of potentially productive alluvial aquifer materials in connection with Catherine Creek, which suggests river-bank filtration may be a feasible method for diverting water. However, additional mapping and testing is necessary to confirm the feasibility of a riverbank filtration system.

     - Existing Wells and Subsurface Information: Two existing wells completed by the Bonneville Power Administration (BPA) in the volcanics in the early 1990s are located in the sub-area, providing some information regarding the aquifer characteristics and possible use as observation wells for a MUS system (JMM, 1992).

     - Shallower Storage Aquifer: The depth to top of the volcanic aquifer system (PRV and CRBG) is relatively shallow (estimated at 50 to 125 feet below ground surface [bgs]), reducing drilling costs for recharge and recovery wells.

  2. **Uncertainties/Cons**:

     - Storage Aquifer Limitations: The volcanic aquifer system is heavily faulted and compartmentalized in this sub-area. Results from aquifer tests on existing wells in the sub-area confirm the presence of a highly-compartmentalized system. This may limit the

available storage space and limit the storage volume and recovery rates, as each fault may act as a local boundary to groundwater flow.

- Flowing Artesian Conditions: The volcanic aquifer system is under flowing artesian conditions, requiring additional specialized equipment and potentially limiting injection rates.
- Potential Yield Limitations: Artesian flows from existing wells in the area are 200 to 400 gallons per minute (gpm) (0.45 to 0.90 cfs), less than the minimum project target of 1 cfs. The yield of the explored section of the volcanic aquifer system would need to be tested under pumping conditions, and the aquifer yield may need to be investigated at greater depths, at added cost.
- Riverbank Filtration Feasibility Unproven: While preliminary reconnaissance indicates the presence of coarser channel sediments near the creek, the yield and filtration efficacy of the sediments needs to be verified.

- **Existing Infrastructure**

1. Pros:

    - Potential Site Access: Oregon State University (OSU) owns the experimental station in the sub-area, has provided access for feasibility investigations in the past and is a potential project partner.

2. Uncertainties/Cons:

    - Recharge/Recovery Infrastructure: Preliminary information suggests that the two BPA wells are crooked and may be in poor condition, limiting their usefulness to the project (apart from monitoring and potentially testing). Recharge and recovery wells likely still need to be constructed.
    - Diversion/Treatment Facilities: As with all locations, shallow alluvial wells and conveyance piping will need to be constructed to capture source water, convey it to the recharge and recovery wells, and discharge recovered water to Catherine Creek.

- **Ecological Benefit.** The Milk Creek sub-area is the furthest upstream and flow augmentation would benefit the longest reach of the three sub-areas. The absolute temperature benefit would depend on the temperature of recovered water and the flow rate added to the stream. At minimum augmentation rates, a project would locally provide a thermal refuge near the discharge point.
- **Water Availability.** Water from Catherine Creek may be available for use in an AR-based MUS system under a multi-purpose Storage Reservation from October through June above Ames Creek (OAR 690-508-0120). This longer season maximizes storage volumes and potential stream augmentation flows while allowing the system to shutoff during high flow events in Catherine Creek to protect water quality in the volcanic aquifer system and still maximize storage without missing storage volume targets. Use of a Storage Reservation for subsurface storage is a relatively new concept that has not yet been done on a permanent basis. Discussions with OWRD and the Department of Agriculture have received generally positive indications that the Storage Reservations may be used for this type of application. However, a permit has not yet been issued for this type of application other than on a temporary basis and some uncertainty about whether the Storage Reservation can be accessed still exists.

Overall, the Milk Creek sub-area provides the potential for the most available source water for the longest duration, would provide a flow benefit to the longest reach of the creek, and has a landowner (OSU) that may be a willing partner. However, the compartmentalized nature of the volcanic aquifer system likely will limit storage volumes and injection/recovery rates, and the rate and/or duration of flow augmentation of the system.

3. Union Sub-Area

The Union sub-area is the portion of Catherine Creek from downstream of the confluence with Brinker Creek to the City of Union (Figure 2). Frontal faults demarcate the hills to the east and south of Union, and the downstream end of this part of the Catherine Creek basin. Considerations are included below regarding siting an injection/storage well on the valley bottom north/west of the frontal faults versus to the south/east (either on the hills above Union or in the subarea proper). The pros and cons for some key selection criteria include:

- **Hydrogeology**

  1. Pros:

     - More Favorable Storage Aquifer Capacity Potential: The volcanic aquifer system is better understood (less uncertainty) in Union based on information derived from published mapping and several City of Union and irrigation water supply wells. The volcanics are substantially thicker and less compartmentalized by faulting in the downstream portion of this sub-area (near Union). The volcanic aquifer system has high well yields in this area of up to 2,000 gpm (4.5 cfs). The combination of high yields and greater extent suggests a higher potential for greater storage volumes and higher recovery rates than the other sub-areas.

  2. Uncertainties/Cons:

     - Aquifer Compartmentalization: Upstream of Union (east and south of frontal faults), the Catherine Creek valley is fault bounded, although less so than upstream locations. The storage capacity of the fault-bounded areas would need to be assessed through a pilot well testing program.

     - Groundwater Levels: Wells located on the valley floor and completed in the volcanic aquifer system near Union are flowing artesian and locating a well in that area would require equipment to inject under pressure. The static water level in the volcanic aquifer system in the valley floor upstream of Union is unknown, but anticipated to be near ground surface, which also would require injecting under pressure. Injection under pressure is commonly done; however, it may increase costs and be a limiting factor for injection rates.

       A well sited on the hillside above the City of Union well would have a water level below ground surface, as evidenced by a City well located above town. However, water would need to be pumped up to the well for injection with increased costs for associated pumping and piping. Also, consideration of interference between an injection/recovery well and existing supply wells may dictate where an MUS well is sited.

     - Potentially Higher Well Costs (depending on location): The top of the volcanic storage aquifer is as much as 300 or more feet below the valley floor north and west of the frontal faults adjacent to Union, potentially substantially increasing the cost of an injection/recovery well. A well situated in the valley upstream of Union or on the adjacent

hills would likely be shallower because the sediments overlying the volcanic aquifer system are less than 100 feet thick. A well sited on the hills adjacent to the valley could potentially be even shallower but pumping costs to bring water up to the well from the valley floor would be greater.

- Recovered Water Temperatures: The geothermal gradient in this area is relatively high and native groundwater temperatures are relatively warm. Consequently, the aquifer would need to be thermally conditioned with cold water requiring lower recovery percentages (recovered volume/stored volume). In other words, more water would need to be stored (and left in storage) over successive injection/recovery cycles to thermally condition the aquifer.
- Alluvial Aquifer/Creek Connection Uncertain: The productivity and connection of the alluvial aquifer to Catherine Creek has not been explored in this sub-area. Individual domestic alluvial well yields are generally relatively low, suggesting that that coarser and more productive alluvial sediments may be localized and further exploration would be needed to evaluate the feasibility of installing a riverbank filtration diversion facility (e.g., shallow wells).
- Site Availability: The availability of a site with suitable alluvial aquifer characteristics for installation of a riverbank filtration diversion system is not known.

- **Infrastructure**

  1. **Pros.** The proximity to the Union means there may be some infrastructure suitable for use. The City has an inactive infiltration gallery and disinfection facility and a few supply wells that may at least be available and suitable for acquisition of data.
  2. **Uncertainties/Cons:** The potential feasibility and location(s) for a riverbank filtration facility for diversion/treatment are unknown and may require significant effort to determine.

- **Ecological Benefit.** The Union sub-area is the furthest downstream, and flow augmentation would benefit a shorter reach than the other sub-areas. However, the flow augmentation would provide a temperature benefit starting in a relatively warm downstream reach, and at minimum augmentation rates, a project would locally provide a thermal refuge The ultimate temperature benefit would depend on the temperature and rate of flow added to the stream.
- **Water Availability.** In addition to remaining uncertainty about whether OWRD will allow the Storage Reservation to be used for subsurface storage, it also is currently unclear whether the Storage Reservation could be accessed for a storage project on this downstream reach of Catherine Creek. Without access to the Storage Reservation, water is only available for storage under AR rules in May and June, which may significantly limit the amount of water that can be stored (and the resulting flow augmentation rate).

The Union sub-area, especially near the City of Union, has the least uncertainty regarding the presence of favorable storage aquifer characteristics because the volcanic aquifer system is relatively thick, and existing wells have identified productive water-bearing zones. Furthermore, the aquifer system does not appear to be as tightly compartmentalized as upstream areas.

Siting a facility in the valley north and west of Union in the valley may entail higher drilling costs because the volcanic storage aquifer is relatively deep. The depth to the volcanic aquifer becomes less south of Union in the Catherine Creek valley, which would reduce costs. Alternatively, volcanics are exposed at the surface on the adjacent ridge and a well located there (such as the City of Union well) would likely be shallower although siting the well on the hill would require pumping the water from the diversion point up the hill to the well. Two

key uncertainties with regard to the Union Sub-area include: (1) whether the Storage Reservation can be accessed in this area, and (2) whether and where the alluvial aquifer has suitable characteristics for diverting/treating source water.

4. Badger Flat Sub-Area

The Badger Flat sub-area is a small sub-basin area between Badger Flat Road and Catherine Creek (Figure 2). The pros and cons for some key selection criteria include:

- **Hydrogeology.** Limited information about the hydrogeology of this sub-area is available, as there are no verified wells located within the sub-area. The PRV is exposed in the immediate vicinity of the sub-area suggesting the depth to the top of the volcanic aquifer system (PRV and CRBG) is relatively shallow. However, older crystalline rocks, which are not suitable storage aquifers, are also exposed adjacent to the sub-area, suggesting that a storage aquifer system in the volcanics may be tightly-bounded and thin, if present at all.
- **Infrastructure.** There is no existing infrastructure in this sub-area.
- **Ecological Benefit.** Flow augmentation from a system in the Badger Creek sub-area would benefit a shorter reach than the Milk Creek sub-area, although it would provide a temperature benefit starting in a lower (and warmer) reach. At minimum augmentation rates, a project would provide a thermal refuge locally. The ultimate temperature benefit would depend on the temperature and rate of flow added to the stream.
- **Water Availability.** It is currently unclear whether the Storage Reservation is available for AR use on this reach of Catherine Creek. Without access to the Storage Reservation, water is only available for storage for AR purposes in May and June, which may significantly limit the amount of water that can be stored (and the resulting flow augmentation rate).

The Badger Flat sub-area has the most data gaps of the three sub-areas because of the lack of subsurface data in the area. Existing mapping suggests that the volcanic aquifer system is compartmentalized and that potential storage opportunities would be limited. The presence and nature of the alluvial aquifer, and thus the feasibility of installing a riverbank filtration system to divert water from Catherine Creek is unknown. The reach benefitting from flow augmentation would be shorter than a system in the Milk Creek sub-area; however, a system in the Badger Flat sub-area could provide thermal refuge further downstream than Milk Creek. The lack of existing infrastructure could drive up implementation costs. Notably, this sub-area has the same water availability uncertainties as the Union sub-area.

5. Conclusions

Generally, the Milk Creek sub-area presents some risks and uncertainties from a hydrogeologic perspective, with it being unclear whether the streamflow benefit goal of a minimum of 1 cfs can be met. The sub-area has some clear benefits in terms of drilling costs and ecological benefit, and water availability.

The Union sub-area has the most well understood/favorable hydrogeology for storage, with the highest potential for stream flow augmentation rates greater than 1 cfs from a storage and recovery perspective. However, a location with suitable alluvial aquifer characteristics can likely be found to provide the higher storage volumes. The volcanic system aquifer in this sub-area can likely store and produce a sufficient volume of water to meet the project goal of at least 1 cfs streamflow benefit. However, it would carry the highest drilling costs and least ecological benefit in terms of river miles impacted.

The Badger Flat sub-area is intermediate between the Milk Creek and Union sub-areas in the factors considered in this TM and has the most data gaps in terms of hydrogeologic feasibility.

A significant data gap for Union and Badger Flat sub-areas is whether a MUS can access the Storage Reservation. If not, the period available for aquifer recharge will be severely limited and possibly not allow the project to store sufficient water to meet the project goals. Another data gap is the feasibility of diverting sufficient rates/volumes from the shallow alluvial aquifer near the creek to meet the project goals. The 2010 feasibility study recommended investigations to identify and characterize local sand and gravel channel deposits in connection with Catherine Creek. Identifying and testing the yield of productive zones in connection with the creek will be critical to evaluate the potential feasibility of diverting water from the creek through the alluvial aquifer to treat it using riverbank filtration. A component of this part of the evaluation will be to assess the quality of surface water, alluvial groundwater and of water pumped from the alluvial aquifer in connection with the creek. Surface water and groundwater sampling to fully characterize seasonal variability will be necessary at any of the three sub-areas.

6. References

Anderson Perry & Associates, Inc., and GSI Water Solutions, Inc., 2010. Upper Catherine Creek Storage and Feasibility Study. Prepared for the Grande Ronde Model Watershed. Study funded in part by an Oregon Water Resources Department Conservation, Reuse and Storage Grant. 141 p.

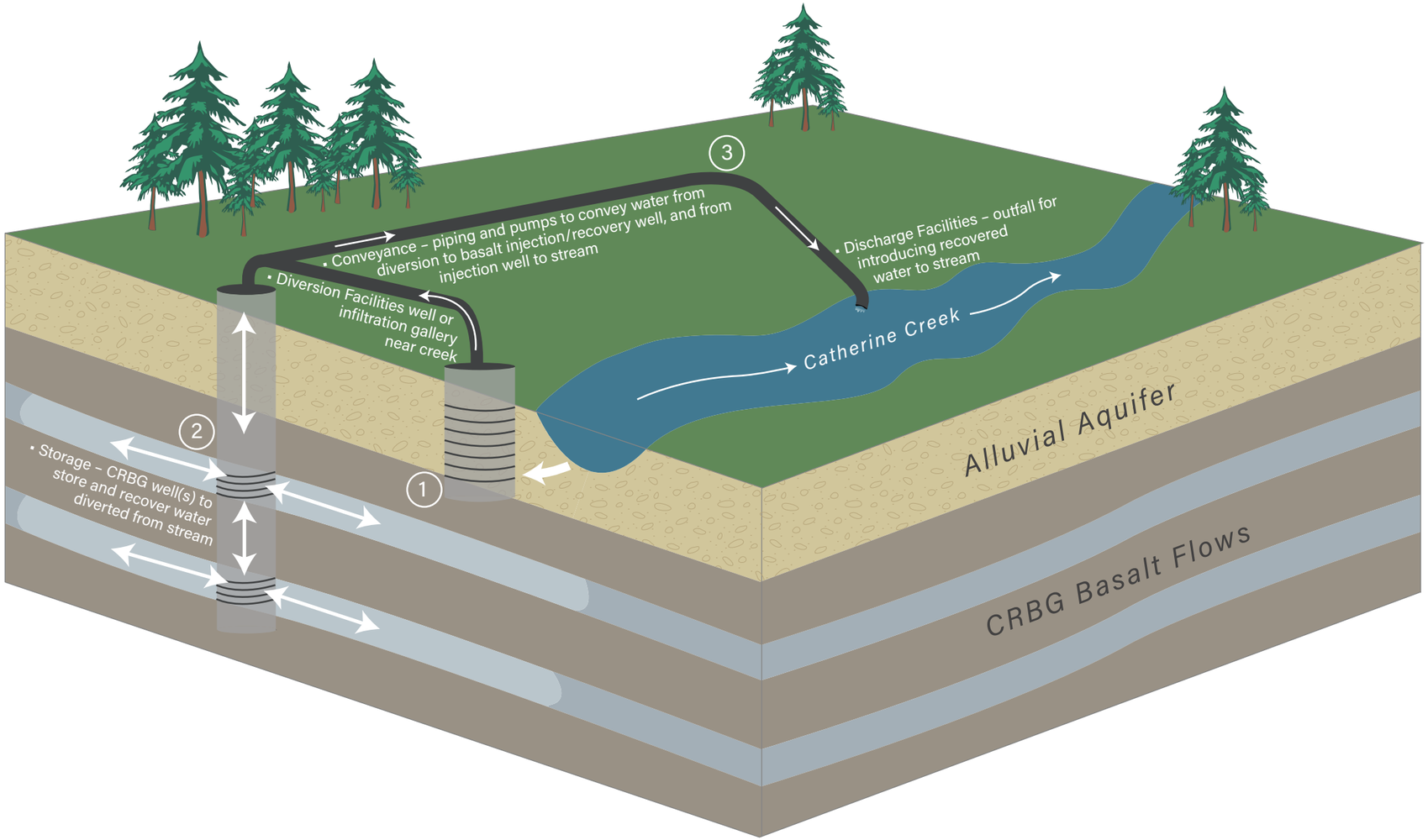
GSI Water Solutions, Inc., and Anderson Perry & Associates, Inc., 2012. Upper Catherine Creek Aquifer Recharge Limited License Application and Hydrogeologic Feasibility Report. 71 p.

JMM, 1992, Preliminary Report of Test Well Drilling Northeast Oregon Hatchery Project: Consultant report to USDOE-BPA prepared by James M. Montgomery Consulting Engineers, Inc., (JMM).

Figures

FIGURE 1

Catherine Creek MUS Conceptual Model



LEGEND

- Alluvial Aquifer
- Basalt Interflow (CRBG aquifer)
- Basalt Flow Interior (CRBG aquifer)

Not to scale
Schematic Diagram

GSI Water Solutions, Inc.

Y:\0339_Anderson_Perry\Source_Figures\019_UCC_Aquifer_Capacity

FIGURE 2

Study Sub-Areas

U N I O N

Little Creek

ABOVE UNION
SUB-AREA

Little Catherine Creek

McDow Creek

Ames Creek

203

Catherine Creek

BADGER FLAT
SUB-AREA

237

Pyles Creek

UNION PACIFIC RAILROAD COMPANY

PYLES CANYON
RESERVOIR
NUMBER TWO

MILK CREEK
SUB-AREA

Milk Creek

LEGEND

- Sub Area Location
- City Boundary
- Major Road
- Railroad
- Watercourse
- Waterbody

N

0 2,000 4,000 6,000

Feet

Date: January 19, 2024
Data Sources: BLM, ESRI, ODOT, USGS, Aerial Photo 2020

GSI Water Solutions, Inc.

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