Yakima Basin
Managed Aquifer Recharge Assessment
Final Report

Prepared for

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1 INTRODUCTION

The Yakima Basin Integrated Plan (YBIP) is designed to increase water supply for agriculture by increasing water supply for the proratables in a drought year, domestic use, instream flow and habitat improvements for aquatic life in the basin. Storing groundwater benefits these goals by increasing water supply and partially moderating unnaturally low and high mainstem flows due to operation of the Yakima Project.

This document provides a summary of an assessment of Managed Aquifer Recharge (MAR) in the Yakima River Basin. This work was funded by a grant from the Department of Ecology (Ecology) through the YBIP Groundwater Storage Subcommittee (Subcommittee). It is intended to present a summary of work completed to date, methods used, and ranking of potential MAR projects within the basin.

1.1 Background

The Kittitas Reclamation District (KRD) is actively working to integrate multiple elements of the YBIP, including Enhanced Water Conservation, Habitat/Watershed Protection and Enhancement, Surface Water Storage and Groundwater Storage. KRD's current conservation projects will conserve approximately 123,000 acre-feet of water annually when complete over the next 10 years. KRD's irrigation system is also used to supplement flow in critical periods to improve salmonids and other aquatic life in tributary streams. KRD's irrigation system is used to deliver this conserved water to supplement tributary flows in the critical summer/fall low flow periods to improve salmonids and other aquatic life. The Tributary Supplementation Program, established in 2015, provides a more normative summer flow regime that has been established in these tributaries. This success results from the integration of three of the Yakima Basin Integrated Plan (YBIP) elements- 1) Structural and Operational Changes, 2) Enhanced Water Conservation and 3) Habitat/Watershed Protection and Enhancement.

In 2017 KRD completed an Initial Water Storage Assessment (Jacobs Engineering Group, 2017) that evaluated more than 50 potential reservoir locations in and around the district. This MAR assessment evaluated those sites and 38 others for potential MAR opportunities. This assessment further supports KRD's interest in integrating their conservation, storage, and habitat improvement efforts to identify the best portfolio of projects that support the primary objectives of the YBIP.

KRD originally proposed conducting the MAR assessment in the upper Yakima Basin, in and around the KRD service area. In response to input from the Subcommittee, the scope of the project was expanded to include the entire Yakima Basin (Figure 1).

1.2 Objective

The purpose of the MAR Assessment is to advance the Groundwater Storage element from general basin assessment to specific MAR project locations and projects. The overall objective

is to integrate groundwater recharge, storage, and conjunctive use with other YBIP actions in order to save water in basin reservoirs, increase efficiency after storage control, increase carry-over storage, and mitigate stream temperature issues.

The intent of this assessment is to identify, evaluate and rank potential MAR opportunities so that the highest-ranking projects can be prioritized for further study and proceed toward implementation. There are immediate needs to develop additional storage in the basin. The results of this project can be used to identify groundwater storage projects to help fill those needs.

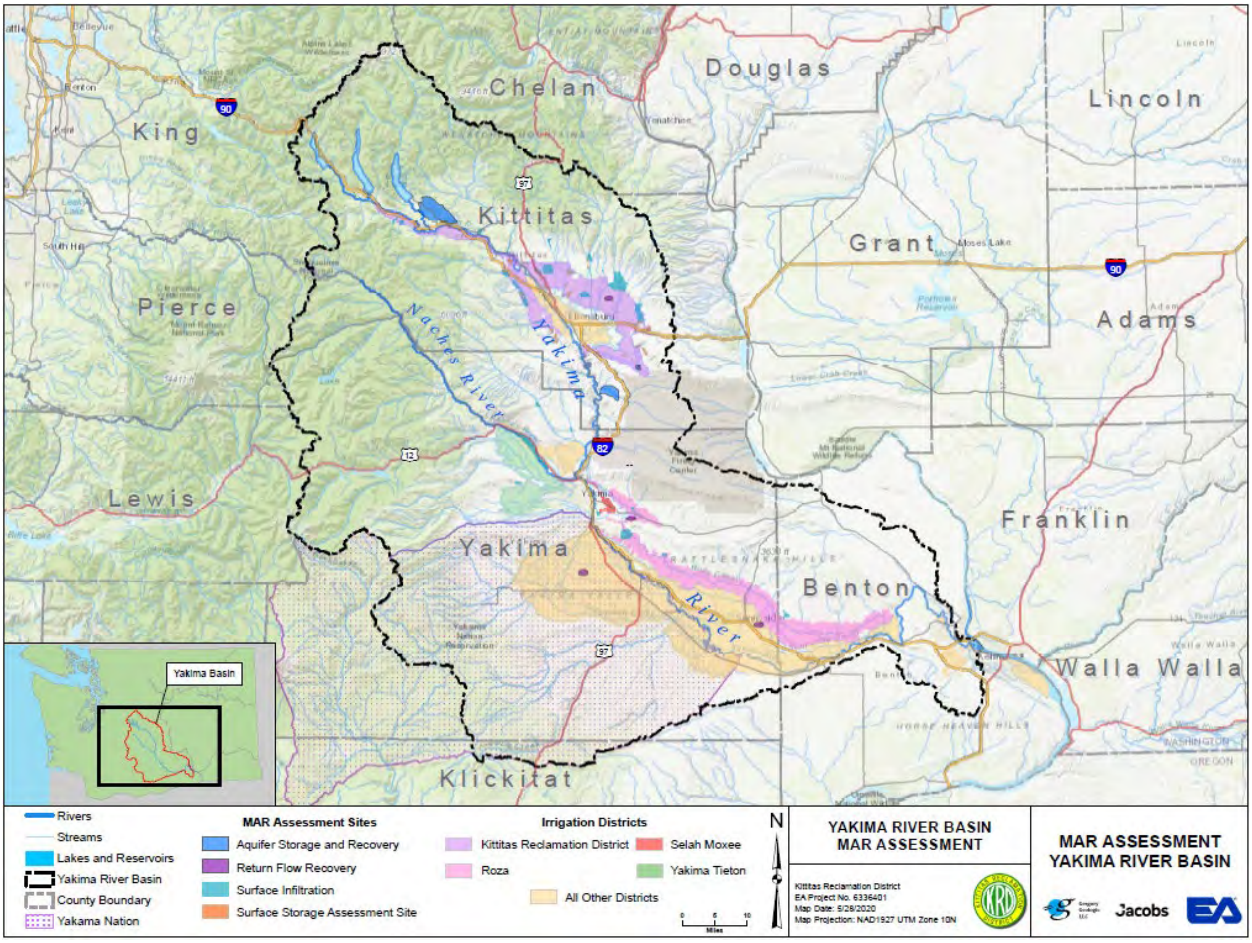

Figure 1 – Yakima Basin MAR Assessment Study Area

Additional objectives include estimating potential annual water volume that could be stored in the aquifer system, as well as evaluating the effects of that additional storage on Total Water Supply Available (TWSA) and instream flow. The YBIP contains quantitative goals for new storage and instream flows. An additional 214,000 acre-feet of storage needs to be advanced by 2025 in order to maintain the Community Forest status of recently acquired land in the Teanaway River Basin. Whereas surface storage potential has been assessed in various forms,

this study provides a quantitative assessment and evaluation of potential aquifer storage opportunities in the basin in comparison with surface storage alternatives.

1.3 Project Description

This project includes the six primary tasks described below. All the tasks were intended to assist in the identification and evaluation of potential MAR projects in the basin and to rank them from highest to lowest for MAR suitability. This equivalent ranking will determine project hierarchy essential to move toward implementation. An additional task of evaluating the suitability of an incentivized MAR water management strategy as is operating elsewhere in the West, for use in the Yakima Basin was included.

The six primary tasks are:

- **Assemble and Review Existing Data**
  Obtain, organize, and analyze relevant data within the Yakima Basin for the purpose of identifying specific MAR locations and projects.

- **Identify and Rank MAR Projects**
  Use the information from Task 2 to build and screen a project list, evaluate, and rank the higher priority projects for costs, benefits, and readiness to proceed. Provide a list of groundwater modeling scenarios. Describe the uncertainties, limitations, and data gaps of the MAR analysis to identify potential risks and benefits, and recommendations for reducing limitations and decreasing uncertainty.

- **Permitting Strategy**
  Develop a roadmap for permitting the various types of MAR projects in the Yakima Basin. Identify regulatory requirements, permitting process steps, and initial data needs for permitting each type of MAR project proposed.

- **Quantify Water Available and Streamflow Benefits**
  Quantify the volume, location, timing, and source of water available for recharge or conjunctive management within the basin. Sources include the Yakima River, tributary streams, conserved water, native groundwater, and water recently infiltrated due to irrigation practices within major irrigation districts served with Bureau of Reclamation (Reclamation) water. Use YBIP RiverWare to quantify and characterize how implementation of higher priority MAR projects would impact surface water management within the Yakima River Basin.

- **Infrastructure Analysis**
  Evaluate irrigation district infrastructure to quantify capacity and limitations of each district's infrastructure for transporting water for implementing MAR projects.

- **Incentivized MAR Project Evaluation**
  Evaluate the applicability of Incentivized MAR (IMAR) water management strategy in the Yakima Basin, like that currently used within the Eastern Snake River Plain, and elsewhere in the West.

Additional details regarding each task are summarized below.

1.4 Limitations

This report was prepared for Kittitas Reclamation District under Washington Department of Ecology Grant WRYBIP-2019-KittRD-00004. It is governed by a scope of work, and only addresses the elements of that scope. That scope is fairly general, and thus the assessments produced are fairly general and subject to the following limitations.

This document is based on review and compilation of existing datasets and reports. None of those datasets, or elements of those reports, have been empirically confirmed or rejected. No field work or confirmation was conducted during this study.

Property access assessment is based largely on the assumption that public land is more accessible for project purposes than is private land. Similarly, we assume private land held by many landholders is generally less available for access than that held by few. No specific assessment of property availability is made beyond those criteria.

Water availability assessments are made using modeled values obtained from either the YBIP Riverware model for Yakima River values, or from the USGS Streamstats calculations for ungauged tributaries. The assumptions underlying the models, and the output values, are different. While efforts have been made to empirically evaluate output values against gage data, those data may not be complete. Each assessment is subject to the limitations of its underlying model and the precision and accuracy of any empirical measurements (if any) available.

Both availability assessments apply the same "skim criteria". The "skim criteria" used, while in many cases applicable through the basin for many years, have not specifically been approved by responsible agents within the Basin. For Tributary flood flows in particular, specific "skim criteria" are presented for comparative purposes only.

Individual recommended sites were initially assembled by examination of existing reports, and evaluation of generally favorable MAR site conditions as shown by nearby surface and subsurface geologic and hydrogeologic information. This report is subject to the limitations of existing sources of information.

Particularly, subsurface information is largely sourced from Washington Department of Ecology well logs within the existing database. Ecology well logs are imprecisely located. In addition, logs are reported by various well drillers, who, while experienced, may not be trained to collect

precise geologic or hydrogeologic information. Additionally, information may be incomplete. No new surface or subsurface information was gathered by this project.

None of the preparers are attorneys, thus permitting and IMAR suitability analysis discussions and recommendations are based upon the administrative experience of the authors. None should be construed as being a legal opinion.

All information evaluated and models used were current as of the date of this report. The preparers believe, allowing for limitations, it allows MAR site suitability comparison between sites selected on an equal footing, for purposes of follow-on empirical site-specific assessment.

2 ASSEMBLE & REVIEW EXISTING DATA

A significant amount of geology and groundwater information exists in the Yakima Basin, including well logs, groundwater level data, hydrogeology publications, and preliminary groundwater storage and suitability assessments, land use and spatial data. Available information was organized to focus on areas within or adjacent to the irrigation district service areas that are most suitable for more detailed evaluation, as well as eliminating areas from further consideration. The purpose of this task was to review hydrogeologic data within the basin with the purpose of identifying specific areas and MAR project sites that would align with the goals of the YBIP. Data was evaluated to identify locations where groundwater storage is available, as well as identifying other locations where existing conditions provide MAR opportunities, including conjunctive use of groundwater and surface water.

3 IDENTIFY AND RANK MAR PROJECTS

The data, publications, and other information assembled were used to identify areas and specific locations in the Yakima Basin that are most suitable for implementation of MAR projects. Thirty-eight project locations were identified, evaluated, scored, and equivalently ranked in terms of suitability, availability of water, relative costs, and benefits describing how the subject water will be used to support overall YBIP objectives and compliment on-going conservation and habitat improvement efforts. Fifty-three additional sites previously identified as potential surface storage locations were also evaluated for their potential for MAR opportunities. Highest ranking projects that could begin in the short term were identified with recommendations for next steps and actions. Project site characteristics were evaluated using the criteria summarized below and described on site summary sheets.

Specific site characteristics are required for successful MAR and conjunctive management projects. These include favorable geology, land availability, hydrologic characteristics, topography, depth to groundwater, seasonal variability, water availability, water quality, cost, benefits, and available necessary infrastructure. Available geospatial, Geographic Information System (GIS), and data sources, identified in Section 2, were used to develop a list of potential

MAR sites that exhibit more favorable conditions and characteristics for further analysis and ranking.

Criteria were divided into four categories based on relative importance for successful MAR implementation. For example, all MAR projects require suitable geology and available land whereas, costs and benefits can vary from one project to another. As such, critical criteria were weighted higher than less important criteria when ranking projects. Criteria for evaluating and ranking projects, as well as relative importance and weighting factors are described below and shown in Table 1.

3.1 Required Criteria for MAR Projects

Required criteria for successful MAR projects includes property access and suitable hydrogeology. These criteria were scored between 0 and 10. The total score for required criterion was weighted by multiplying the score by 4. Factors affecting assignment of each score are described below.

*3.1.1 **Property Access***

Access to property to investigate, build, operate, and maintain MAR facilities is a required element of any MAR project. Ideally, land is currently available and will be for the foreseeable future. Additionally, purchasing or leasing land, when it may become available, and how long it could be used are other important considerations for project viability and overall cost. In some cases, access to multiple properties may be required for diversion, conveyance, recharge, and recovery facilities. This criterion is intended to score how available a project might be, ranging from property that is currently available to unknown availability.

Relative Importance	Criteria	Range in Score for each Criteria	Weighting Factor	Possible Score
Required	Property Access Suitable Hydrogeology	0 - 10	Score x 4	0 - 80
High	Ditch flows Flood Flows Water Quality Out-of-Stream Benefits Instream Benefits	0 - 3	Score x 3	0 - 45
Medium	Infrastructure Operational Risk Relative Cost	0 - 3	Score x 2	0 - 18
Low	Permitting Conceptual Facility Type	0 - 3	Score	0 - 6

Table 1 – MAR Site Evaluation and Scoring Criteria

Land demands for MAR facilities can vary widely, from small parcels utilizing wells, to large areas for infiltration basins. Many projects require access to property for conveyance of water to recharge facilities and from recovery facilities. Thus, the type of MAR project being considered needs to be compatible with the land potentially available.

Publicly owned property, especially property owned by Yakima River Basin Integrated Plan partners, is likely to be more readily available for MAR facilities than privately owned property. Conceptual MAR projects on land currently available will likely be higher priority projects than those without a known location or plan for acquiring the necessary property. An assessment of any individual private landowner's willingness to make land available for MAR facilities is beyond the scope of this study. However, general areas were identified where MAR projects are likely to be successful where specific parcels for projects were not identified.

*3.1.2 **Suitable Hydrogeology***

Suitable hydrogeology, namely surface and subsurface conditions that allow for the recharge, storage, and flow of groundwater, must be compatible with the intended design and purpose of a proposed MAR facility. This includes matching 1) rates of recharge with infrastructure, 2) water availability and seasonality, and 3) recharge volumes with storage capacity. Groundwater must be stored when and where it can be recovered without causing unacceptable risks or impairment to existing water rights while meeting the intended timing and recovery rates, whether it be pumped from a well or providing baseflow to a stream.

Important factors considered in this category include topography, surface water features, soil type, surface geology and structure, depth to the water table or potentiometric surface in a well, hydrologic characteristics of the target geologic unit, potential storage potential and recovery efficiency, travel time and characteristics of baseflow discharge (if that is the objective), potential for impairment to existing water rights. Many of these elements are not well known at this stage of the investigation. Site conditions were assessed with development of a site conceptual model to estimate the suitability and likelihood of success. Conceptual projects with the most suitable hydrogeologic conditions will score higher while sites lacking the best hydrogeologic characteristics will score lower.

3.2 Highest Criteria for MAR Project Scoring

Highly important criteria used for the ranking of potential MAR projects include water availability from the Yakima River and tributary streams, water quality, and instream and out-of-stream benefits. Each of these 4 criteria were scored between 0 and 3. These scores were then weighted by multiplying the sum by 3.

*3.2.1 **Water Availability Scores***

Scores for water availability were determined based on assessment of water available from the Yakima River and tributary streams, each of which were evaluated and scored separately.

Methods for estimating the volume of water available from each of these sources is described in Section 5 below.

Water available from the Yakima River includes natural flows and existing water rights using conserved water. It was assumed that all water available from the Yakima River, referred to as *Ditch Flows*, would be diverted at existing diversion facilities used by the major irrigation districts. Water from tributary streams was assumed to be available only during high flow events and is referred to here as *Flood Flows*.

The Ditch Flows criterium has a scoring range of 1 – 3 (Low, Medium, and High) based on the annual median volume of water available as presented in Table 2.

Criterion Score	Annual Median Water Available (KAF)
1 (Low)	20 – 30
2 (Medium)	31 – 60
3 (High)	>60

Table 2 – Criteria for Water Availability Score from Ditch Flows

The Flood Flows criteria has a scoring range of 1 – 3 based on the estimated range in peak annual runoff events. Because most of the tributary streams are not gauged, flood flows in tributary streams were estimated using StreamStats, developed by the USGS. Table 3 presents the association of the range in estimated annual peak flow events and the flood flow criteria score. Methods for estimating available Flood Flows are described in Section 5.

Criterion Score	Estimated Annual Peak Runoff Events (cfs)
1 (Low)	10 – 100
2 (Medium)	101 – 1000
3 (High)	>1000

Table 3 – Criteria for Water Availability Score from Flood Flows

3.2.2 Water Quality Score

Water Quality was included as an important scoring criterion, as water treatment requirements could require significant costs that could make certain MAR projects infeasible. A value between 0 and 3 was used for scoring this criterion. Water quality issues are particularly important for Aquifer Storage and Recovery (ASR) projects where water must be treated prior to recharge in order to comply with State Groundwater Quality Standards. As this project evolved, it became apparent that water quality may not be a major factor in distinguishing between the scoring and ranking of MAR projects, as most of the projects entail recharge of water into the unsaturated zone. Because this type of recharge is already occurring on a broad scale through natural exchange between surface and groundwater, as well as through irrigation practices, it was assumed that treatment would likely not be required for most projects. Thus, most projects were given a score of 3 for the water quality criterion.

3.2.3 Instream Benefits Score

The Instream Benefits criterion was scored Low, Medium or High on the seven following attributes:

- Increase tributary flow: river miles affected and site proximity to the tributary.
  - Consider percent and/or linear distance of stream affected.
  - Consider length of time and duration of groundwater return to the stream. Assumptions include qualitative evaluations of drainage speed and distance based on subsurface thickness and overall sediment texture. For example, silty material will take more time to drain to the stream than clean gravel material.
- Increase mainstem flow.
  - Consider if biologically significant.
  - Consider percent and/or linear distance of stream affected.
- Water is Exchangeable with TWSA.
  - Consider if existing infrastructure allows an exchange with one of the 5 reservoirs.
  - Consider if feasible with additional infrastructure.
  - Consider the quantity of exchangeable water.
- Seasonal flow improvement.
  - 1st priority = summer base flow period, which could include early fall.
  - 2nd priority = spring smolt outmigration period.
  - 3rd priority = winter overwintering (likely not a big issue).
- Improves cold water refugia.
  - Considered important for sites with the potential to improve water temperatures in the summer period primarily downstream of Union Gap.
  - Applies mainly to the lower Yakima River.
- Improves riparian and/or floodplain habitat.
  - Consider potential quantity of storable groundwater.
  - Consider seasonality of water availability: growing season 1st priority.
- Helps ESA species- steelhead and/or bull trout.
  - Consider 1st priority to streams with steelhead and/or bull trout.
  - Consider the temporal and spatial overlap with their life history.

Weighting factors of 1, 2, and 3 were applied to the Low, Medium or High attributes, respectively. For example:

If site A scored 2 “Lows”; 3 “Mediums”; and 2 “Highs”; the total site score would be:

(2 * 1) + (3 * 2) + (2 * 3) = 2 + 6 + 6 = 14

The attribute Instream Benefits score was then reduced for each site as 1 (Low), 2 (Medium) or 3 (High) using the following scale:

- Site Score 1 (Low): 7 - 10
- Site Score 2 (Medium): 11 - 14
- Site Score 3 (High): 15 - 18

3.2.4 Out-of-Stream Benefits Score

The Out-of-Stream Benefits criterium was scored Low, Medium or High on the four following attributes:

- Mitigate curtailment of junior permitted water use,
- Mitigate effect of domestic withdrawals,
- Mitigate impact of drought well production on Yakima River or tributaries, and
- Recover conveyance leakage for beneficial use.

The Matrix Out-of-Stream Benefits score for each site was 1 (Low), 2 (Medium) or 3 (High). The total site score was binned as follows:

- Site Score 1 (Low): 4 and 5,
- Site Score 2 (Medium): 6 and 7, and
- Site Score 3 (High): 8—10.

The sum of the 5 highly important scores were then weighted by multiplying the sum of these scores by 3.

3.3 Medium Criteria for MAR Project Scoring

Medium criteria used for the ranking of potential MAR projects include infrastructure, operational risk, and relative cost. Each of these 3 criteria were scored between 0 and 3. These scores were then weighted by multiplying the sum by 2.

3.3.1 Infrastructure Score

Projects were scored based on what infrastructure is currently available and what is needed to implement the conceptual MAR project. Other factors include matching infrastructure delivery and recovery capacity with the conceptual MAR project and how the project might impact land-use and property.

There is a wide range of infrastructure needs, complexity, and cost between MAR projects. Although a thorough analysis for each potential project is beyond the scope of this study, a

general description of what infrastructure is available and what is needed was described for each project. Projects requiring a relatively small amount of infrastructure improvements will score higher than those projects that require significant and costly improvements.

3.3.2 Operational Risk Score

An initial assessment of operational risk factors was evaluated for each potential MAR facility. Increased frequency of flooding is a potential risk in areas that already have a shallow water table. Raising the water table could impact farming, septic drainage, and cause corrosion or rust. Increasing contaminants in surface or groundwater is a potential risk that would be higher if there is potential for impairing nearby domestic or municipal wells. Other risks include the inability to operate in freezing conditions, maintenance needs and associated limitations, and nearby pipelines or other large infrastructure. MAR projects with potentially more significant risks will score lower than those site with minimal identified potential risks.

3.3.3 Relative Cost Score

A qualitative assessment of major cost elements was made for each project for scoring and for comparison to other MAR alternatives. The cost estimates include investigative, permitting and capital costs. Unit costs for primary elements of MAR projects were determined for preliminary cost estimates. These estimates can be used to calculate rough project cost and cost per acre-foot of recovered water which was factored into scoring. Because of the large number of uncertainties, detailed cost estimates were not determined.

3.4 Lowest Criteria for MAR Project Scoring

The lowest criteria used for the ranking of potential MAR projects include permitting and the conceptual facility type. Each of these 2 criteria were scored between 0 and 3. These criteria were considered the least important, relative to the other scoring criteria and were not adjusted by using a weighting factor.

3.4.1 Permitting Score

Scores for permitting considered readiness to proceed, and the estimated relative difficulty of permitting. It was assumed that all projects can acquire water rights or contracts and other required permits to construct the facility. Permitting for some projects are relatively straight forward whereas others may require adoption of rules, face opposition and appeals, and face uncertain outcomes. Although not all factors and outcomes could be known, factors relating to the relative difficulty of permitting were used to score potential projects between 0 and 3.

3.4.2 Conceptual Facility Type Score

The score for the conceptual facility category was based on the relative complexity among the potential MAR projects. Simple projects, such as building a diversion structure that routes high

flows onto the floodplain for infiltration will rank the highest. These projects will have minimal operation and maintenance costs. Projects such as constructed infiltration ponds, galleries, or horizontal distribution wells with minimal to moderate operational and maintenance and monitoring complexity would score in the middle of this category.
Complex conceptual facility types needing significant operational management, maintenance, and monitoring such as deep well aquifer storage and recovery facilities score the lowest in this category. Each project was scored between 0 and 3.

4 PERMITTING STRATEGY

Applicable laws, regulations, policies, procedures, and requirements for MAR projects were analyzed and a permitting strategy for each type of project was developed. All projects will require water rights permitting and compliance with applicable State, Reclamation, Tribal, and county rules and regulations.

The permitting process for all MAR projects should begin with the Groundwater Storage Subcommittee and must include consultation and agreement with YBIP partners, particularly the Yakama Nation, Reclamation, irrigation districts and Ecology. MAR projects must be agreed upon by the various agencies' habitat and fish biologists and considered in conjunction with other storage and conservation projects being considered and implemented by the YBIP. One of the primary objectives of the Plan's groundwater storage element is to develop MAR projects that capture and store water when it is available for beneficial uses, including instream flows, during times when water is typically not available. Although most MAR projects are primarily non-consumptive, agreement and concurrence among YBIP partners to develop MAR projects is a critical first step that must occur before the permitting process begins.

Water rights in the Yakima Basin have been fully allocated. In 1977, Ecology filed an action in the Yakima County Superior Court to determine the legality of more than 4,000 claims for use of surface water in the Yakima River Basin. Water use must have been established prior to 1917 for a claim to be valid. The court case, Ecology v. James J. Acquavella, et al, included a thorough examination of each claim by Ecology, the court, and other parties. Claims ranged from small individual uses to major claims for irrigation districts and cities, and for federally based water rights such as Indian tribes and the U.S. Forest Service.

Starting in 1989, the court issued a series of Conditional Final Orders as water rights assessment work was completed in one of the 31 Yakima subbasins. Superior Court Judge F. James Gavin entered the Final Decree in the case on May 9, 2019. This Final Decree defines the relative priorities of about 2,300 surface water rights in the Yakima Basin under Washington State's water law. It also integrates all the Conditional Final Orders entered in the case, other orders governing administration of the waters of the Yakima Basin, and the Final Schedule of Rights.

Reclamation has the senior storage rights in the Yakima Basin. In addition, they have withdrawn (under RCW 90.40.030) all unappropriated surface waters in the basin for "purposes of

continuing implementation of the Yakima Basin Water Enhancement Project objectives". This withdrawal began February 13, 1981. It has been subsequently extended by the State of Washington through January 18, 2023. Additional measures, including assessment, design, permitting and operation of MAR facilities, by Reclamation, the Yakama Nation, and Yakima Basin irrigation districts toward implementation of the Yakima River Basin Water Enhancement Project is unlikely to be complete by the current expiration date. Thus, it is reasonable to anticipate the reservation can be expected to be extended again.

Revised Code of Washington (RCW) Chapter 90.03 authorizes the appropriation of public water for beneficial use and describes the process for acquiring water rights. Laws governing the surface water permitting process are contained in RCW 90.03.250 through 90.03.340. Determinations must be made on the following four criteria (4-part test) for a water right permit to be issued:

- Water must be available
- There must be no impairment of existing rights
- The water must be put to beneficial use
- The water use must not be detrimental to the public welfare

Water Rights are required for any diversion and beneficial use of surface water. Beneficial uses, defined by RCW 90.54.020(1), should be consistent with the goal of the YBIP and could include instream flow, habitat protection and restoration, fish passage, irrigation, and mitigation of consumptive water use.

All water right applications are subject to a SEPA threshold determination (SEPA checklist) to evaluate if the project is likely to have significant adverse environmental impacts, if any of the following conditions are met:

- It is a surface water right application for more than 1 cubic foot per second (cfs), unless the project is for agricultural irrigation, in which case the threshold is increased to 50 cfs, as long as that irrigation project will not receive public subsidies.
- It is a groundwater right application for more than 2,250 gallons per minute (gpm).
- It is an application that, in combination with other water right applications for the same project, collectively exceed the amounts above.
- It is part of a larger proposal that is subject to SEPA for other reasons, such as the need to obtain other permits that are not exempt from SEPA.
- It is part of a series of actions, that together, trigger the need to do a threshold determination, as defined by WAC 197-11-305.

Water right applications within a given basin are typically processed in order of the date the completed application was received (Priority Date). However, under Ch. 173-152 WAC Ecology can prioritize applications that meet certain criteria including proposed water uses that are non-consumptive and if approved, would substantially enhance, or protect the quality of the

natural environment. It is likely that most of the conceived MAR projects would satisfy this criterion and be eligible for priority processing.

The formal permitting process begins with a pre-application consultation between project proponents, YBIP interested parties and Ecology staff to identify requirements and expectations, anticipated timelines and information needs, options for application processing, and Ecology contacts. Ecology has provided a pre-application consultation form which identifies the relevant issues that need to be addressed during the permitting process which should completed prior to the meeting. Projects could be permitted with new water rights, changes to existing water rights, and temporary permits. Investigations to characterize MAR sites or to collect any information needed for permitting could occur under a preliminary permit, as authorized by RCW 90.03.290.

All permitting decisions in the basin are subject to review by the Yakama Nation and the Washington Department of Fish and Wildlife, as well as other YBIP partners and the Groundwater Storage Subcommittee. Applications for new water rights would be reviewed by the Water Transfer Workgroup. Any new water right permits would be part of the reservation by Reclamation.

4.1 MAR Project Types

MAR projects considered in this assessment include surface infiltration facilities, aquifer storage and recovery, and recovery of artificially stored Reclamation water for beneficial use. Permitting for each type of MAR project is briefly summarized below.

4.1.1 Surface Infiltration

Surface infiltration projects may consist of diversion of surface water for infiltration on a flood plain, infiltration facilities, fields, and/or subsurface pipes and trenches. Sources of water include direct diversion from tributary streams and diversion of the Yakima River at existing irrigation diversion structures. An example of a surface infiltration MAR facility in the Walla Walla Basin is shown in Figure 2.

A water right permit is required although most surface infiltration projects are *not* required to be permitted under Ch. 173-157 WAC, Underground Artificial Storage and Recovery because infiltrated water is not stored and actively recovered. However, compliance with all other permitting requirements, including groundwater quality standards is still required.

The water right permit will specify source of water, points of diversion, place of use, instantaneous and annual quantities for diversion and season of use. The permit would also be conditioned by instream flow requirements, monitoring and reporting. A Quality Assurance Project Plan (QAPP) will be required for all data collection and reporting as conditioned in the permit.

Ecology has used Temporary Water Right Permits in conjunction with Preliminary Permits for surface infiltration facilities in order to expedite implementation and to monitor operation of the facility in order to collect information needed to issue a permanent water right permit. Issuance of Temporary Permits still require Ecology to make 4- part test determination and conduct public notice of the application as required by RCW 90.03.280.

Figure 2 – Hall-Wentland Aquifer Recharge Site (courtesy Bob Bower)

4.1.2 Aquifer Storage and Recovery

A new process to permit Aquifer Storage and Recovery (ASR) began in 2000, when the state legislation expanded the definition of 'reservoir' to include "any naturally occurring underground geological formation where water is collected and stored for the subsequent use as part of an underground artificial storage and recovery project." The state defines ASR as projects that add water to underground geologic formations for subsequent beneficial use. Managed recharge methods under the reservoir permitting structure can include surface spreading and infiltration, the use of injection wells, or any state-approved method. An example of a permitted ASR facility (the City of Yakima) is shown in Figure 3.

The application process for a reservoir permit requires a description of the hydrogeologic system, operational plan, legal framework, environmental assessment, monitoring plan, and when necessary, a descriptive mitigation plan. The hydrogeologic system or model must characterize the hydrogeology, compatibility of injected water with ambient conditions, the proximity to natural hazards, and locations of streams, springs, creeks, or rivers that are affected by a proposed ASR project. An operational plan provides estimates of source water quality and availability, injection and withdrawal rates, storage duration, proposed site locations, water treatment compliance, and other parameters required for discharging or suspended sediments from ASR well. The legal framework requires documentation of water rights used for source water storage, a list of all water rights within the project area, proximity to instream flow diversion points and stream closures, plus ownership of operating facilities used for a planned project. The environmental assessment is a description of historical or existing wetland habitats, flood plains, and proximity to contaminated areas, in addition to descriptions of slope stability, wetland habitat, ground deformation, and surface water bodies. A monitoring plan is implemented during the pilot and operational phase to evaluate and verify assumptions within the hydrogeologic conceptual model. When a mitigation plan is necessary, a licensed engineer must describe actions that will be taken to prevent adverse impacts to the environment, including a description of the methods and evaluations of each measurement.

To permit an ASR project, a reservoir permit, water rights to divert the source water, compliance with groundwater quality standards, and possibly a discharge permit is required. Two water right permits may be required. The first allows for the diversion and recharge of non-native water to the aquifer, and the second grants recovery of stored water. For applicants with an existing water right with no change to the proposed end use of the stored water, a secondary permit is not required. For projects that do not require an applicant to obtain a new water right, the state may grant priority processing, which allows for expedited assistance and permitting during project initiation.

Injection water must meet state groundwater quality standards according to the antidegradation policy of the water quality standards for ground waters of the state of Washington in Ch. 173-200 WAC. Should injection water contain contaminants in excess of groundwater quality standards, the applicant can perform an analysis of All Known, Available and Reasonable methods of prevention, control and Treatment (AKART) in support of a determination of whether a project is in the Overriding Public Interest (OPI). Ecology has published a guidance document for conducting an AKART analysis for ASR projects. All ASR wells must be also be registered as Class V non-hazardous injection wells of the Underground Injection Control Program.

4.1.1 Recovery of Groundwater Artificially Stored within the meaning of RCW 90.44.130

Leakage of currently appropriated conveyance water from a facility such as an irrigation canal may be recaptured. One way to do this would be to declare that volume artificially stored and construct recapture facilities in accordance with RCW 90.44.130.

Several studies and publications have documented the impact of irrigation practices in the Yakima Basin showing large quantities of water diverted by major irrigation districts and leaked into the shallow aquifer. In some locations, such as within the Wapato Irrigation Project, the water table can rise 10 - 20 feet during the irrigation season. This water co-mingles with native groundwater and generally flows downgradient where it is captured by drains, irrigation canals, wells, and baseflow discharge to streams.

Figure 3 – City of Yakima's Gardner Well ASR Site

This assessment has identified potential opportunities to recover a portion of this water for use by the irrigation districts in lieu of releases from reservoirs and diversions from the Yakima River. The concept is to recapture this leaked water for use by the irrigation districts in the latter half of the irrigation season in quantities and locations that do not impair existing water rights. As an alternative to the administrative process, Ecology has recognized capture and reuse of irrigation water as a conservation measure (Focus Sheet F-WR-92-108) that allows water users to achieve maximum beneficial use of their water.

5 QUANTIFY WATER AVAILABLE

One of the primary tasks of this assessment was to estimate the amount of water potentially available to divert for MAR projects. Because all the water in the Yakima Basin has been allocated and reserved by Reclamation there is no "new" water available for appropriation. Three sources of previously appropriated water were assumed to be available for diversion into MAR facilities in the Yakima Basin as follows:

- Water diverted under existing agreements and discharged to ground via leakage from existing facilities.
- Water diverted specifically for MAR from the existing Reclamation reservation or under change in purpose of use of an existing water right. This water would have a very junior priority date.
- Water diverted specifically for MAR from the existing Reclamation reservation that would otherwise be surplus. The estimated volume of these waters is herein referred to as flood flows, generally expected during times of snowmelt or large precipitation events.

The YBIP RiverWare model, historic streamflow data, as well as local knowledge of tributary streams and Yakima Project operations were used to quantify the anticipated timing and amount of water likely to be available from the Yakima River for MAR projects. The goal is to identify the amount and availability of basin water outside the Irrigation districts' operating time period, and potential conservation water amounts that may be used during operations. Information from the YBIP, biological assessment flows and timing, and fish use and timing were considered, along with RiverWare modeling results from existing projects used in conjunction with new modeling efforts.

Calculated water available is an estimate of daily average availability of these flood flows. To evaluate both mainstem and tributary flows, estimates were prepared. The following "skim criteria" are applied to prepare this estimate. The skim criteria are meant as first approximations of other flow needs; they have not been reviewed and approved by team members who estimate those flow needs. These skim criteria are changeable in the spreadsheet created as part of this study.

- During the Non-Irrigation Season, the daily average flow (QD) used is the 75th percentile daily flow (QD) for that month & day at a controlling gauge in the mainstem Yakima River.
- During the Irrigation Season (6/16-10/31) there is no water available in the mainstem Yakima River.
- During the Smolt Outmigration (3/16-6/15)- Daily average flows at the Parker gauge must be maintained at greater than 5000 cfs. The amount skimmed is limited to flows above those required to maintain PARW at or above 5000 cfs.
- Flood flows in tributaries may only be skimmed 10% of the 2-year flood event (50th percentile flows) as estimated by Streamstats (USGS 2019) for the ungauged tributaries.

- Flows at the Umtanum gauge represent the most complete representation of the total water balance in the Roslyn and Kittitas sub basins, thus the best estimate of water availability for MAR. Below this gauge in the canyon groundwater input is negligible and storage opportunities are few.
- USGS daily (1934-2019) and USBR daily (1925-2015) average flows are not significantly different.
- The Parker gauge reports significant flood flow availability from the Naches River system. Flood flow supplied MAR may viable in the Naches drainage. Above the Naches River, MAR opportunities in the Selah-Moxee or Roza Irrigation districts are likely only viable using water diverted from the Yakima River under agreement with Reclamation or flood flows in the mainstem Yakima River.
- In all calculations, leap day (February 29) is deleted.

Quantification, timing, and frequency of water available from each major source of potential recharge in the Yakima Basin, including tributaries, conserved water, and the Yakima River were evaluated. Resulting water availabilities are included in Appendices to this report.

5.1 Yakima River Water Availability Methodology

The water availability analysis for the Yakima River was based on results from Reclamation's RiverWare model for the Yakima basin. This analysis utilized the Yakima Basin Integrated Plan (YBIP), Enhanced Conservation scenario (IP0[1]), which includes all the projected future water conservation measures outlined in the plan, including the Cle Elum Dam Pool Raise project. The model results for this and all scenarios, was based on the 1925-2015 (91 years) historic record.

For this analysis river locations were evaluated for water availability where water could be either diverted using existing infrastructure or pumped, knowing a pump station would be required. Seven locations were evaluated, six in the Yakima River and one in the Naches River. The following is a list of these locations with the corresponding river gauge(s) used to conduct the water availability analysis for the given location:

- KRD Diversion (Easton Dam) - EASW river gauge.
- Ellensburg gauge (assumed pump station) - ELNW river gauge.
- RID Diversion (Roza Dam) - UMTW and RBDW river gauges; RZCW and ROZW canal gauges.
- Naches at Naches gauge (assumed diversion(s) and/or pump station) - NACW river gauge.
- SVID Diversion (Parker Dam) - PARW river gauge and SVID canal gauge.
- WIP Diversion (Wapato Dam - PARW river gauge and WIP canal gauge.

[1] This is the most recent model run of this scenario that occurred November 2018.

- KID Diversion (Prosser Dam) - YRPW river gauge, CHCW power canal gauge, KNCW canal gauge.

Water availability for each location was constrained by four factors:

- minimum flow target(s)
- seasonality
- infrastructure (canal capacity)
- power production (Roza and Prosser dams only)

Specific constraint(s) and conditions are presented below for each location. Please note, the statistical parameters were calculated independently by month and annually. Thus, the annual values in the tables below were calculated using annual values rather than a sum of the monthly values. Results are presented in tables and graphs illustrating average monthly values in units of acre-feet per month and cubic feet per second. Cubic foot per second values represent distribution of the monthly value continuously throughout the entire month. Annual volumes, in acre-feet per year are also presented for each gage for the period of record (1925 – 2015).

5.1.1 Easton Dam (KRD diversion; EASW gauge)

Constraints:

- Flow (EASW) must be greater than 300 cfs during the non-irrigation season (October 21 – March 15).
- No water diverted during the smolt outmigration period (March 16 – June 15).
- No water diverted during the irrigation season (June 16 – October 20).
- KRD canal- main branch capacity is 1145 cfs.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
EASW	Average	413	5,415	9,248	10,440	7,992	6,428	-	-	-	-	-	-	**39,603**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	49	232	508	-	-	-	-	-	-	**9,297**
	50th %	-	207	2,220	5,640	2,920	2,561	-	-	-	-	-	-	**25,682**
	75th %	51	6,132	11,339	13,890	11,289	6,189	-	-	-	-	-	-	**55,136**
	Maximum	7,205	46,948	67,294	63,401	52,819	34,058	-	-	-	-	-	-	**139,084**
	% of Annual Average	1%	14%	23%	26%	20%	16%	0%	0%	0%	0%	0%	0%	**100%**
	% Years Water Available	79%	82%	87%	0%	0%	0%	0%	0%	0%	30%	57%	71%	**99%**

Table 4 – Water Availability (acre-feet) at the KRD Diversion at Easton Dam, 1925 – 2015

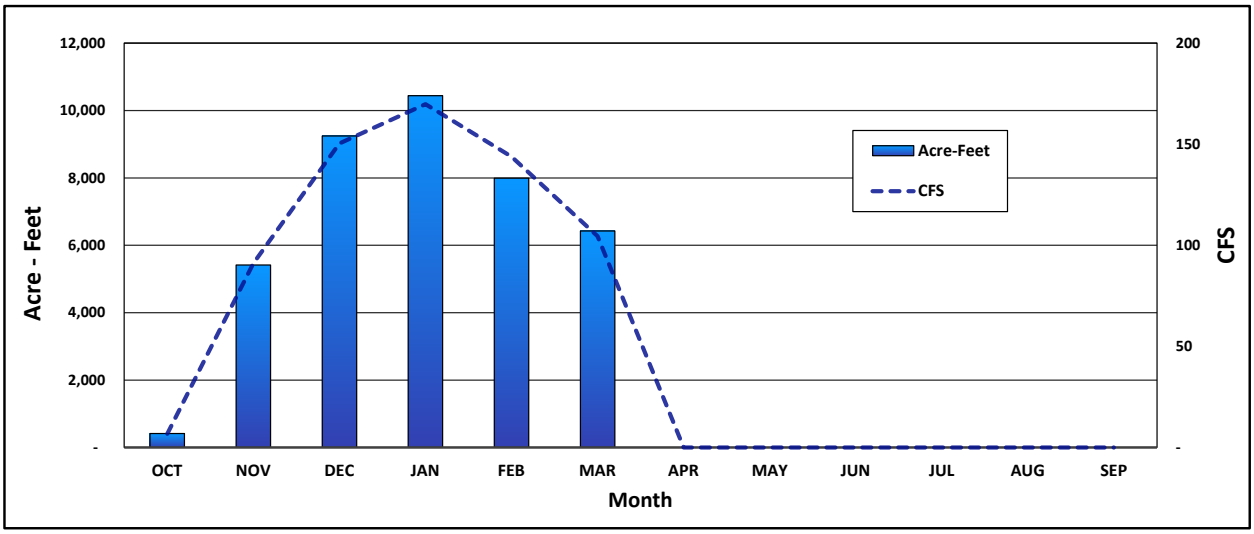

Figure 4 - KRD Average Monthly Water Availability, 1925-2015

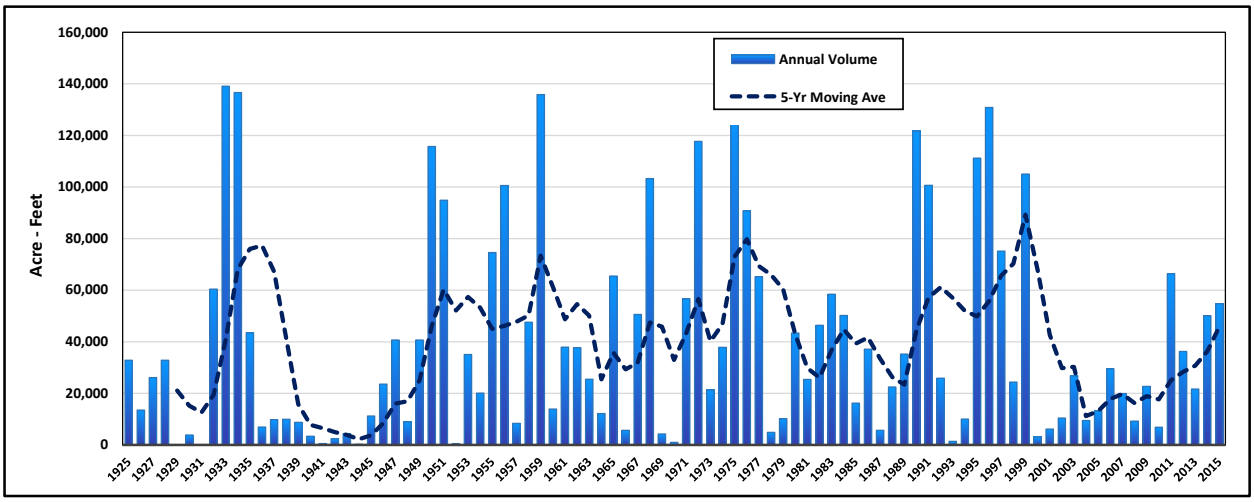

Figure 5 - KRD Annual Water Availability, 1925 - 2015

5.1.2 Ellensburg Gauge (ELNW) with Pump Restrictions

Constraints:

- Flow at the Umtanum gauge (UMTW) must be greater than 1500 cfs during the non-irrigation season (October 21 – March 15).
- Flow below Roza Dam (RBDW) must be greater than 5000 cfs during the smolt outmigration period (March 16 – June 15)[2].
- No water diverted during the irrigation season (June 16 – October 20).

[2] Since there were few days that met this criterion over the period of record, no water was assumed available during the smolt outmigration period.

- Values were calculated for scenarios with 400 cfs pump capacity restrictions.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
ELNW w/ pump capacity restrictions	Average	492	3,882	6,146	7,480	7,575	5,960	1,230	1,720	480	-	-	-	**34,735**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	5	-	-	-	-	-	-	**12,795**
	50th %	-	-	2,343	4,767	3,769	5,317	-	-	-	-	-	-	**31,322**
	75th %	-	5,697	9,512	13,041	16,103	11,898	793	793	-	-	-	-	**52,487**
	Maximum	8,474	23,796	24,589	24,589	23,003	24,589	15,071	21,416	9,282	-	-	-	**102,052**
	% of Annual Average	1%	11%	18%	22%	22%	17%	4%	5%	1%	0%	0%	0%	**100%**
	% Years Water Available	20%	48%	63%	69%	70%	75%	27%	33%	15%	0%	0%	0%	**95%**

Table 5 – Water Availability (acre-feet) for the USBR Ellensburg Gauge with Pump Restrictions, 1925 – 2015

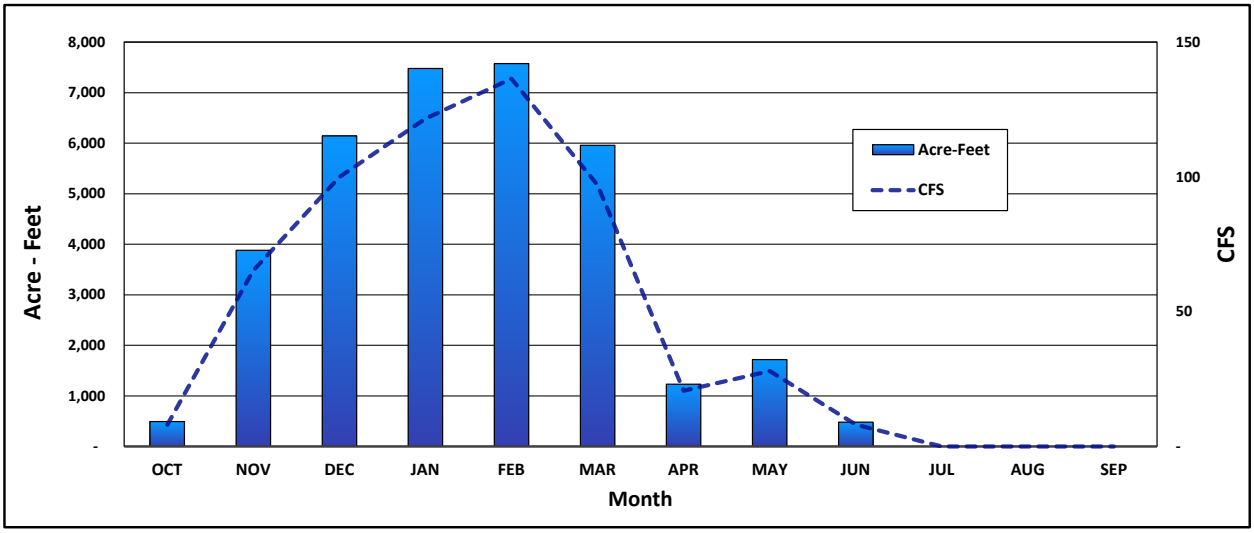

Figure 6 - ELNW Average Monthly Water Availability with Pump Restrictions, 1925-2015

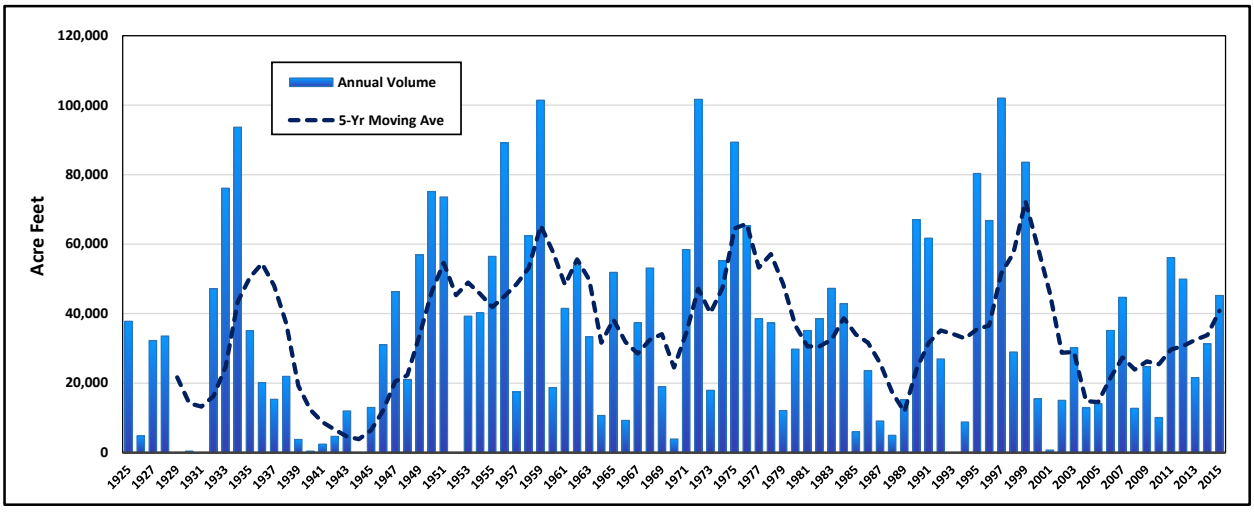

Figure 7 - Ellensburg Annual Water Availability with Pump Restrictions, 1925 - 2015

5.1.3 Ellensburg Gauge (ELNW) without Pump Restrictions

Constraints:

- Flow at the Umtanum gauge (UMTW) must be greater than 1500 cfs during the non-irrigation season (October 21 – March 15).
- Flow below Roza Dam (RBDW) must be greater than 5000 cfs during the smolt outmigration period (March 16 – June 15)[3].
- No water diverted during the irrigation season (June 16 – October 20).
- Values were calculated for scenarios without 400 cfs pump capacity restrictions.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
ELNW w/o pump capacity restrictions	Average	1,012	15,292	29,791	30,773	26,869	26,983	24,543	38,856	9,802	-	-	-	**203,360**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	5	-	-	-	-	-	-	**20,163**
	50th %	-	-	2,975	7,888	5,335	6,143	-	-	-	-	-	-	**103,318**
	75th %	-	11,017	17,790	37,725	34,087	21,368	12,492	19,518	-	-	-	-	**259,099**
	Maximum	38,370	176,312	380,006	275,620	368,362	497,196	314,235	506,499	179,796	-	-	-	**1,489,010**
	% of Annual Average	0%	8%	15%	15%	13%	13%	12%	19%	5%	0%	0%	0%	**100%**
	% Years Water Available	20%	48%	63%	69%	70%	75%	27%	33%	15%	0%	0%	0%	**95%**

Table 6 –Water Availability (acre-feet) for the USBR Ellensburg Gauge without Pump Restrictions, 1925 – 2015

[3] Since there were few days that met this criterion over the period of record, no water was assumed available during the smolt outmigration period.

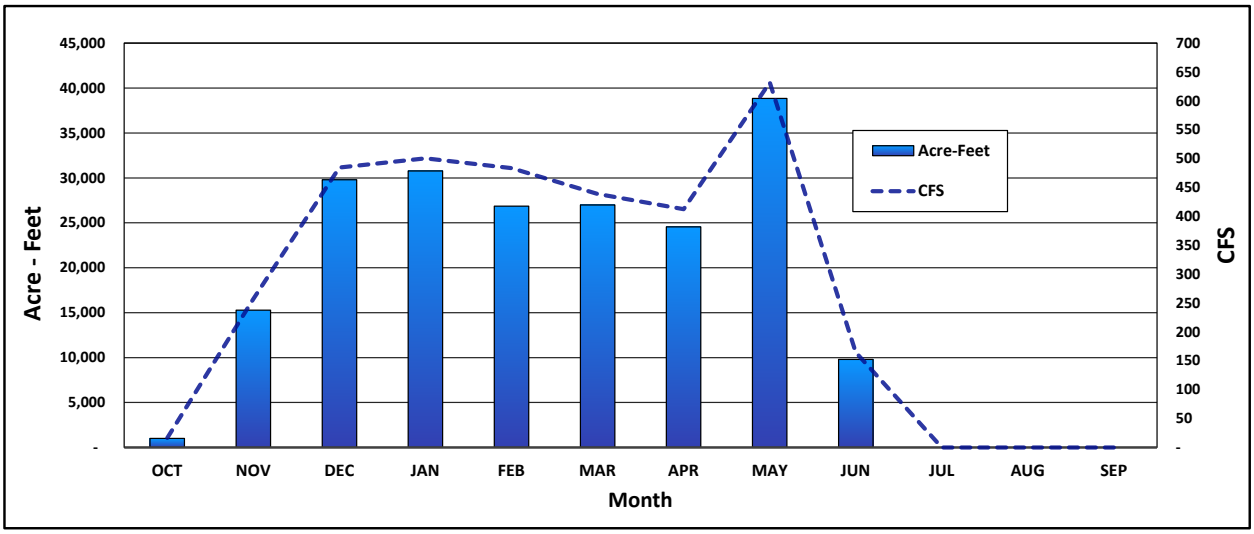

Figure 8 - ELNW Water Availability: Monthly Average, 1925-2015 without Pump Restrictions

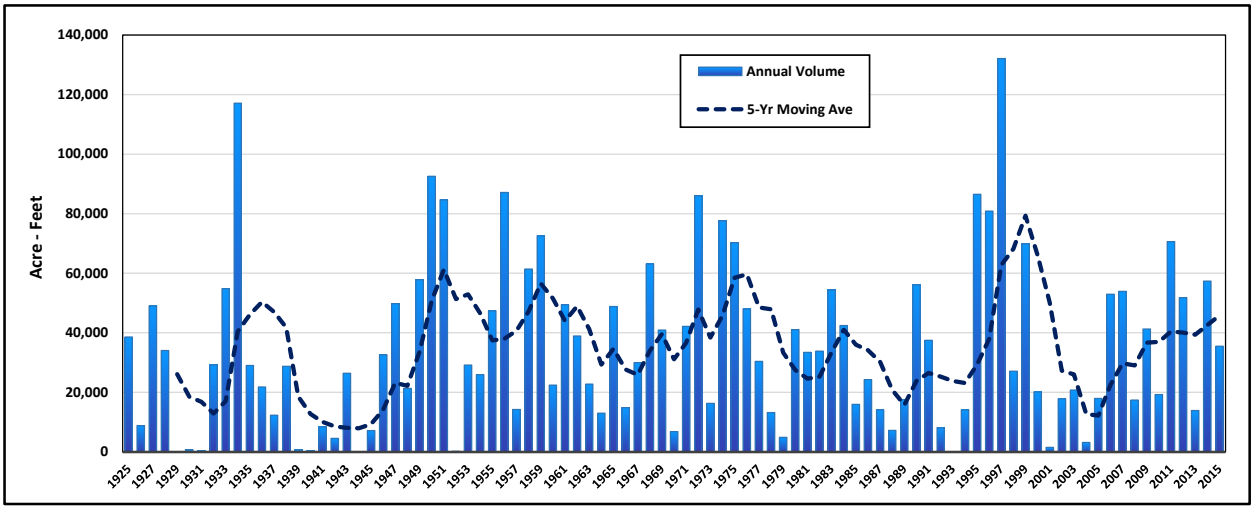

Figure 9 - Ellensburg Annual Water Availability without Pump Restrictions, 1925 - 2015

5.1.4 Naches Gauge (NACW)

Constraints:

- Flow at the Naches at Naches gauge (NACW) must be greater than the daily 75th percentile flow during the non-irrigation season (October 21 – March 15) in order to skim water.
- During smolt outmigration period (March 16 – June 15) two flow criteria must simultaneously be meet in order to skim water; 1) the daily flow the Parker gauge

(PARW) must be greater than 5000 cfs, and 2) the flow at the Naches at Naches gauge (NACW) must exceed the 75th percentile flow value.

- If the 2 criteria for bullet #2 are met; the amount of water available to skim cannot exceed the 75th percentile daily flow[4]. Furthermore, this amount of skimmed water at NACW must maintain the 5,000 cfs Parker gauge (PARW) minimum flow target.
- No water diverted during the irrigation season (June 16 – October 20).
- Assumed a 400 cfs maximum pump capacity[5].
- No water skimming facility limitations were applied.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
NACW	Average	1,139	4,353	4,907	4,873	4,371	4,549	4,333	4,625	1,917	-	-	-	**34,946**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**14,119**
	50th %	-	587	1,128	370	-	-	2,140	986	-	-	-	-	**29,083**
	75th %	824	7,120	6,783	7,846	7,233	7,895	5,609	8,147	2,496	-	-	-	**50,796**
	Maximum	8,725	20,055	24,589	24,589	22,210	24,589	22,162	24,128	11,898	-	-	-	**132,104**
	% of Annual Average	3%	12%	14%	14%	13%	13%	12%	13%	5%	0%	0%	0%	**100%**
	% Years Water Available	47%	64%	62%	56%	49%	48%	56%	54%	36%	0%	0%	0%	**97%**

Table 7 - Water availability (acre-feet) at the USBR Naches at Naches Gauge (NACW), 1925 – 2015

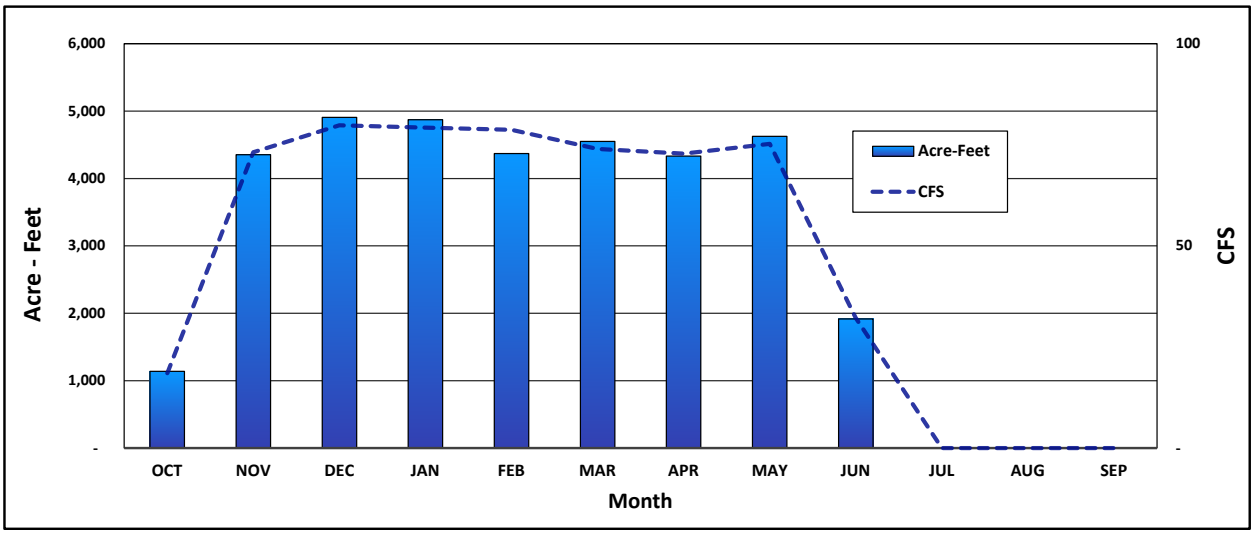

Figure 10 - NACW Average Monthly Water Availability, 1925-2015

[4] Example, NACW flow = 4,111 cfs; NACW 75th daily flow = 1,926 cfs; PARW flow = 10,297 cfs; therefore, the maximum amount of water that can be skimmed at NACW is 4,111 cfs – 1,926 cfs = 2185 cfs.

[5] Note- if flow is diverted into one of the smaller canals (since divert less than 400 cfs), the average amount of water would be further reduced.

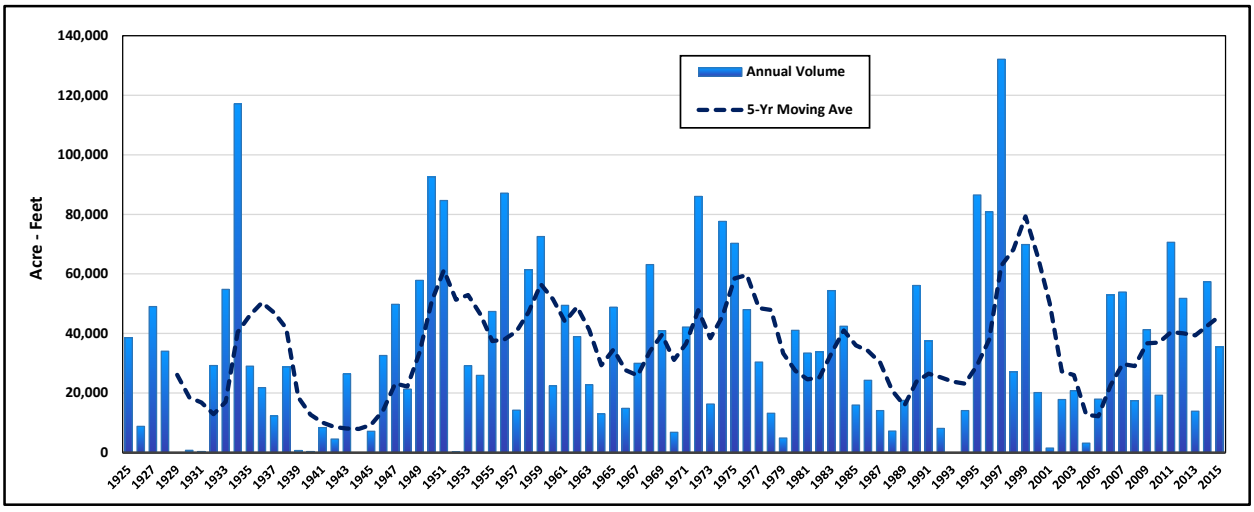

Figure 11 - Naches Annual Water Availability, 1925 – 2015

5.1.5 Roza Dam (Roza Canal), Scenario 1: Maximize Power Generation

Constraints:

- Flow below Roza Dam (RBDW) must be ≥ 500 cfs during the non-smolt outmigration period (October 21 – March 15).
- Flow below Roza Dam (RBDW) must be ≥ 5000 cfs during the smolt outmigration period (March 16 – June 15)[6].
- No water diverted during the irrigation season (June 16 – October 20).
- Skimming flows were subordinated to maximize power generation, which requires 1100 cfs to maximize power generation, which leaves up to a maximum of 900 cfs for skimming water[7].
- Assumed 2000 cfs maximum canal capacity down to the power plant, and 1300 cfs in the canal downstream of the power plant.

[6] Since there were few days that met this criterion over the period of record, no water was assumed available during the smolt outmigration period.

[7] To maximize power generation (1100 cfs) and meet the 500 cfs minimum flow criterion at RBDW, a minimum flow of 1600 cfs at the Umtanum gauge (UMTW) is required. Note- Umtanum Creek adds flow below the UMTW gauge that is not reflected in the UMTW gauge flow measurement.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
RBDW w/max power water of 1100 cfs	Average	616	6,092	10,265	12,340	11,878	8,948	-	-	-	-	-	-	**49,569**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**9,652**
	50th %	-	-	1,962	5,976	3,850	4,106	-	-	-	-	-	-	**42,544**
	75th %	-	7,592	11,610	20,303	20,135	16,813	-	-	-	-	-	-	**82,255**
	Maximum	16,996	48,933	55,326	55,326	51,399	26,771	-	-	-	-	-	-	**171,604**
	% of Annual Average	1%	12%	21%	25%	24%	18%	0%	0%	0%	0%	0%	0%	**100%**
	% Years Water Available	15%	42%	58%	67%	65%	70%	0%	0%	0%	0%	0%	0%	**92%**

Table 8 - Water Availability (acre-feet) at Roza Irrigation District Diversion (Roza Dam) with Maximum Power Generation, 1925 – 2015

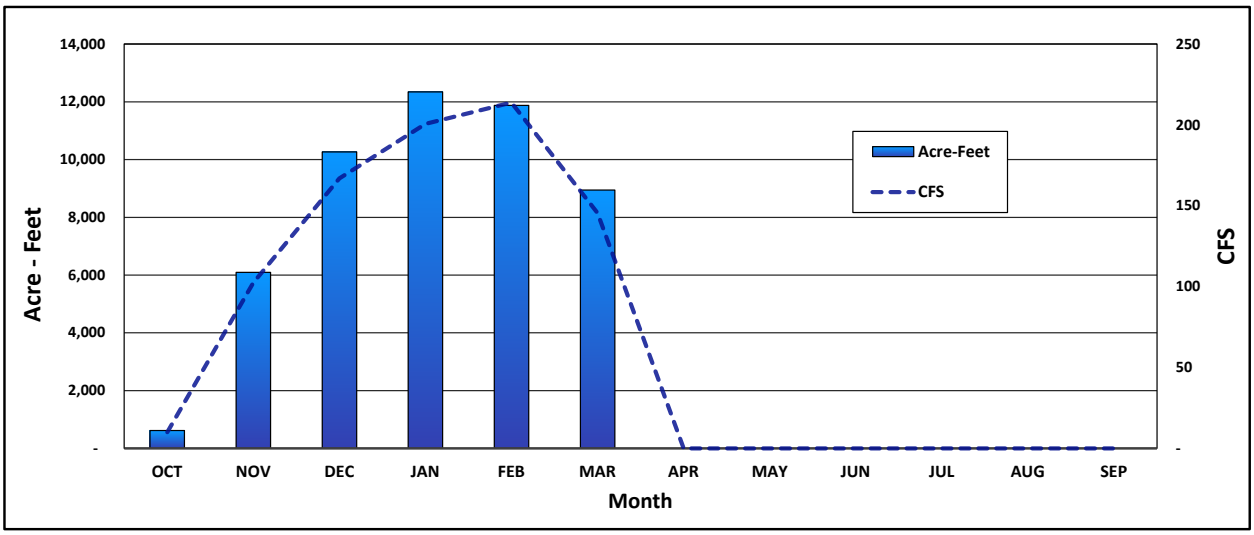

Figure 12 - RBDW Average Monthly Water Availability with Maximum Power Generation, 1925-2015

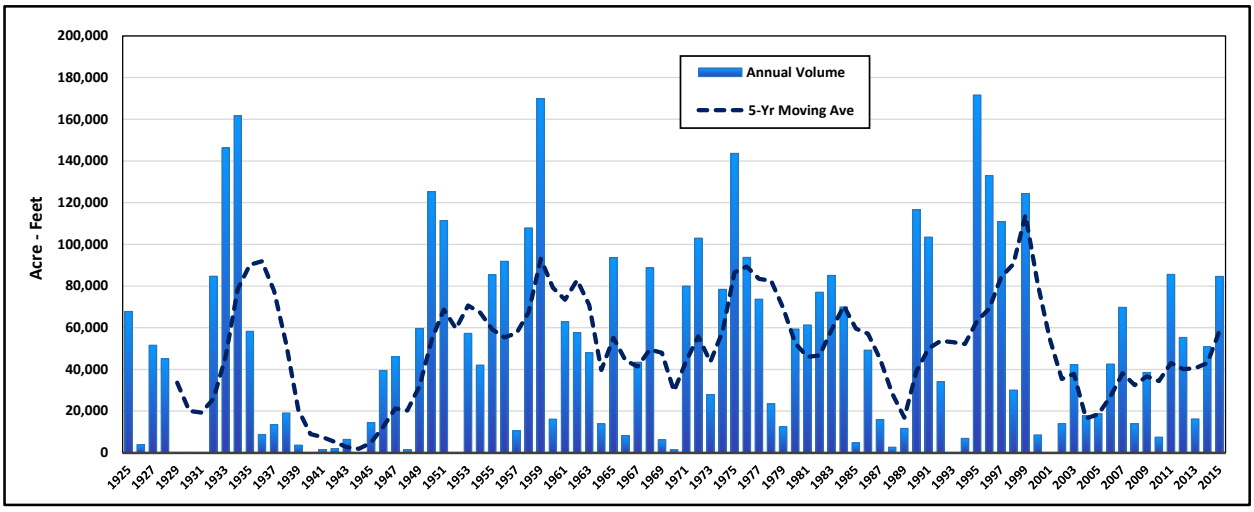

Figure 13 – Roza Annual Water Availability with Maximum Power Generation, 1925 – 2015

5.1.6 Roza Dam (Roza Canal), Scenario 2: Maximize Skimming Water

Constraints:

- Flow below Roza Dam (RBDW) must be ≥ 500 cfs during the non-smolt outmigration period (October 21 – March 15).
- Flow below Roza Dam (RBDW) must be ≥ 5000 cfs during the smolt outmigration period (March 16 – June 15)[8].
- No water diverted during the irrigation season (June 16 – October 20).
- Power generation was subordinated to maximize skimming flows up to 1300 cfs, which allows for a maximum of 700 cfs for power generation[9].
- Assumed 2000 cfs maximum canal capacity down to the power plant, and 1300 cfs in the canal downstream of the power plant.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
RBDW w/ subbordination of power water up to 700 cfs & max canal capacity of 1300 cfs	Average	1,769	12,161	19,079	22,939	22,464	16,871	-	-	0	-	-	-	**94,443**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	59	327	2,255	3,593	-	-	-	-	-	-	**34,665**
	50th %	-	2,377	7,347	15,293	12,169	15,066	-	-	-	-	-	-	**91,717**
	75th %	1,223	16,964	28,603	40,314	40,076	28,496	-	-	-	-	-	-	**140,407**
	Maximum	25,721	72,729	79,915	79,915	74,402	38,669	-	-	0	-	-	-	**283,438**
	% of Annual Average	2%	13%	20%	24%	24%	18%	0%	0%	0%	0%	0%	0%	**100%**
	% Years Water Available	42%	71%	76%	76%	84%	89%	0%	0%	1%	0%	0%	0%	**99%**

Table 9 - Water Availability (acre-feet) at Roza Irrigation Diversion (Roza Dam) with Maximum Water Skimming, 1925 – 2015

[8] Since there were few days that met this criterion over the period of record, no water was assumed available during the smolt outmigration period.

[9] Canal capacity below the power plant is 1300 cfs, which represents the maximum skimming flow (and assumes skimming flows will be wheeled to a MAR site(s) below the power plant); leaving a maximum main canal capacity of 700 cfs available for power generation. This represents a maximum reduction of 600 cfs for power production.

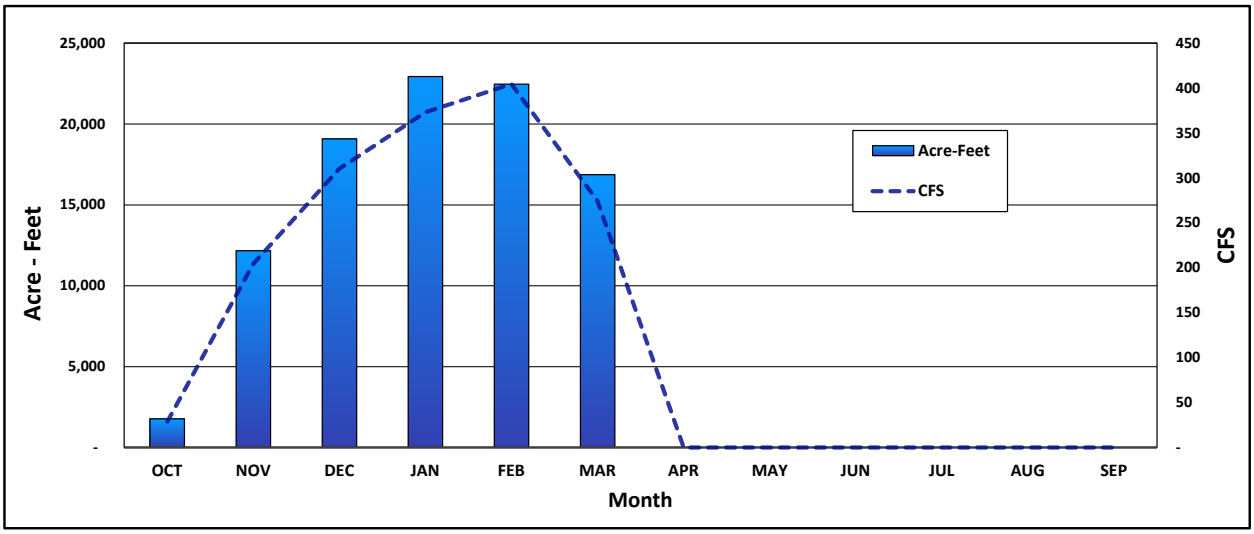

Figure 14 - RBDW Average Monthly Water Availability with Maximum Water Skimming, 1925-2015

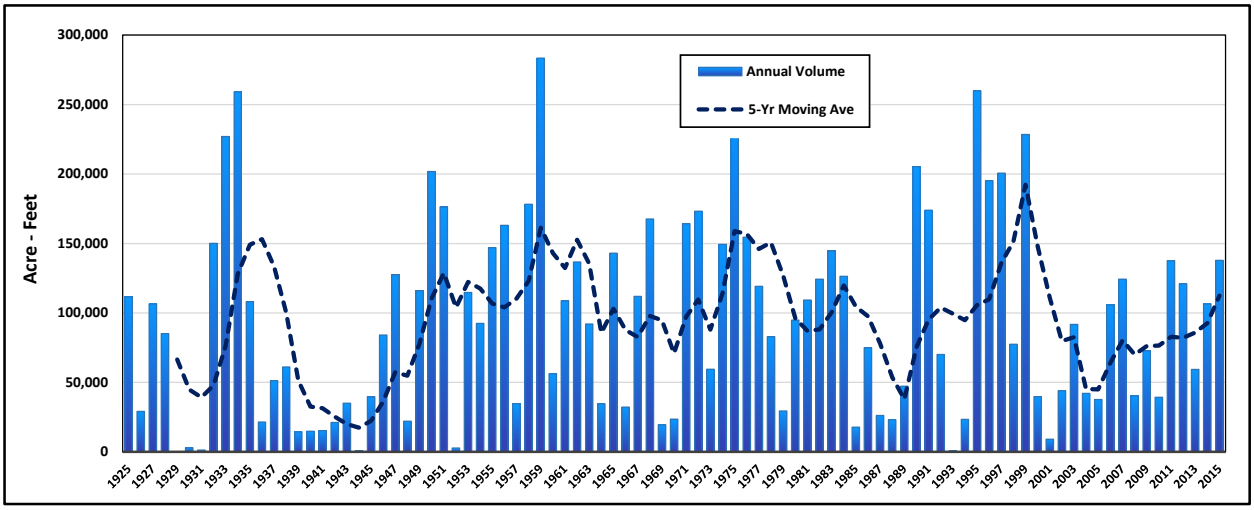

Figure 15 – Roza Annual Water Availability with Maximum Water Skimming, 1925 - 2015

5.1.7 Parker Dam (Sunnyside Valley Irrigation District Diversion Canal) without Canal Capacity Restrictions

Constraints:

- During the non-smolt outmigration period (October 21 – March 15) only skimmed water when the daily flow exceeded the 75th percentile flow for that day based on the 1925 – 2015 period of record.
- Flow at the PARW gauge must be ≥ 5000 cfs during the smolt outmigration period (March 16 – June 15).

- No water diverted during the irrigation season (June 16 – October 20).
- Assumed no canal capacity restrictions.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
PARW	Average	3,966	29,482	48,400	44,402	38,340	40,980	45,466	57,497	17,884	-	-	-	**325,446**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**44,811**
	50th %	-	633	1,757	3,442	985	-	18,108	4,924	-	-	-	-	**232,020**
	75th %	1,888	22,263	29,952	47,041	42,548	30,151	45,562	81,026	16,222	-	-	-	**400,911**
	Maximum	66,383	255,984	745,065	500,824	731,018	730,021	441,156	546,059	202,639	-	-	-	**1,823,884**
	% of Annual Average	1%	9%	15%	14%	12%	13%	14%	18%	5%	0%	0%	0%	**100%**
	% Years Water Available	47%	57%	58%	60%	53%	49%	64%	57%	45%	0%	0%	0%	**99%**

Table 10 - Water Availability (acre-feet) at Sunnyside Valley Irrigation District Diversion (Parker Dam) without Canal Capacity Restrictions, 1925 – 2015

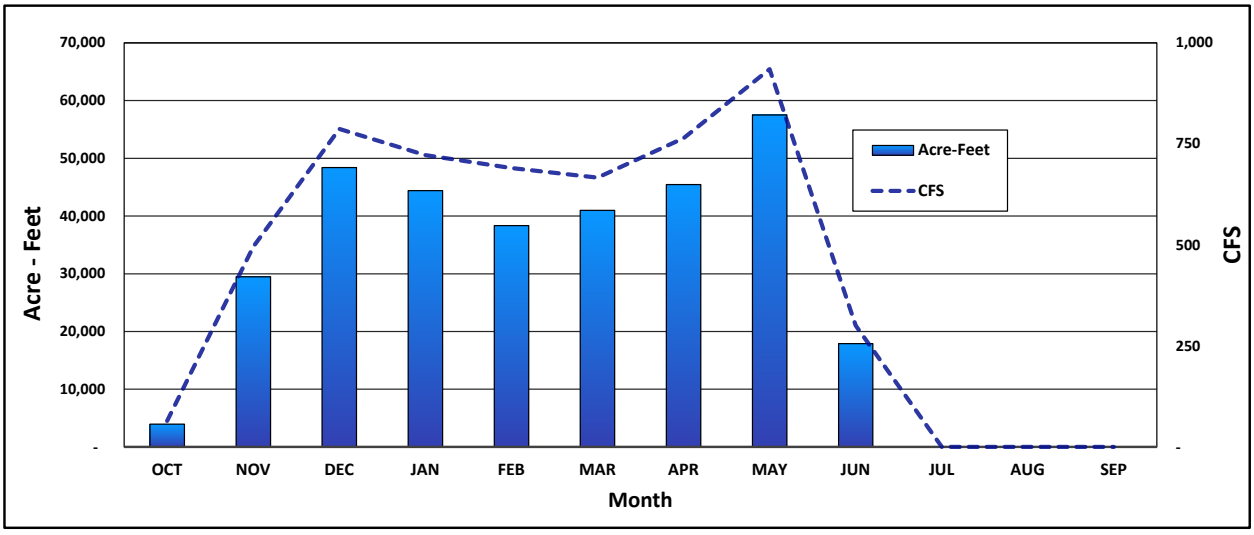

Figure 16 - SVID Average Monthly Water Availability without Canal Capacity Restrictions, 1925-2015

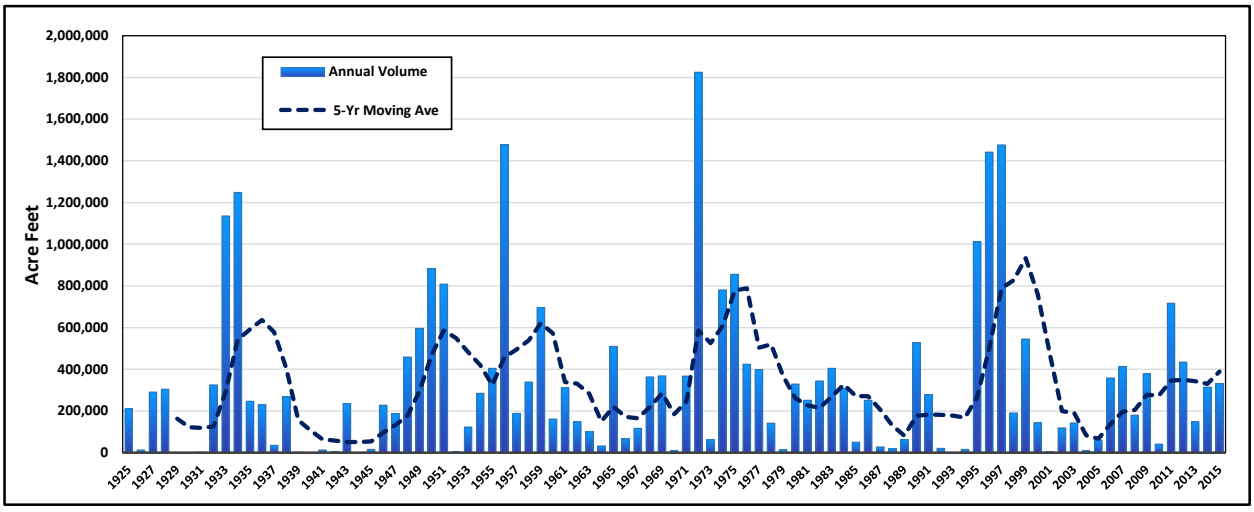

Figure 17 – SVID Annual Water Availability without Canal Capacity Restrictions, 1925 – 2015

5.1.8 Parker Dam (Sunnyside Valley Irrigation Diversion Canal) with Canal Capacity Restrictions

Constraints:

- During the non-smolt outmigration period (October 21 – March 15) only skimmed water when the daily flow exceeded the 75th percentile flow for that day based on the 1925 – 2015 period of record.
- Flow at the PARW gauge must be ≥ 5000 cfs during the smolt outmigration period (March 16 – June 15).
- No water diverted during the irrigation season (June 16 – October 20).
- Assumed 1200 cfs canal capacity restriction.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
PARW w/ 1,200 cfs Canal Capacity Restriction Applied	Average	-	11,811	13,869	14,372	12,621	13,367	16,296	15,995	6,477	-	-	-	**104,499**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	**-**
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**34,047**
	50th %	-	633	1,757	3,442	985	-	8,782	4,388	-	-	-	-	**95,635**
	75th %	-	17,034	16,597	22,487	21,100	20,087	26,235	28,973	10,057	-	-	-	**150,591**
	Maximum	-	63,861	73,768	73,768	66,582	73,768	71,388	73,768	35,694	-	-	-	**378,530**
	% of Annual Average	0%	11%	13%	14%	12%	13%	16%	15%	6%	0%	0%	0%	**100%**
	% Years Water Available	0%	57%	58%	60%	53%	49%	64%	57%	45%	0%	0%	0%	**93%**

Table 11 - Water Availability (acre-feet) at Sunnyside Valley Irrigation District Diversion (Parker Dam) with Canal Capacity Restrictions, 1925 – 2015

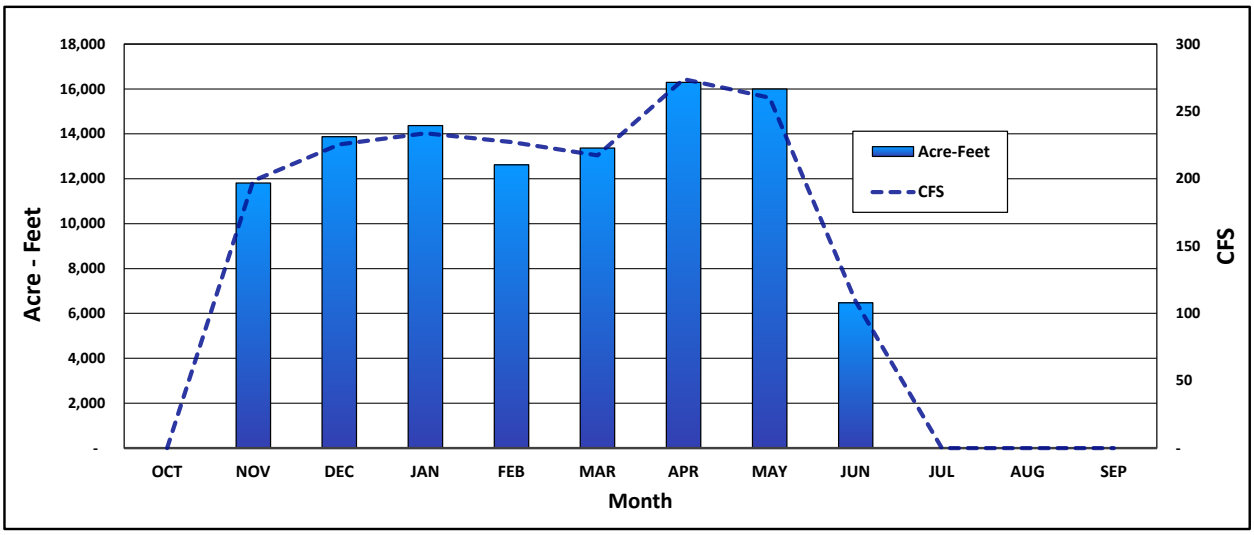

Figure 18 - SVID Average Monthly Water Availability with Canal Capacity Restrictions, 1925-2015

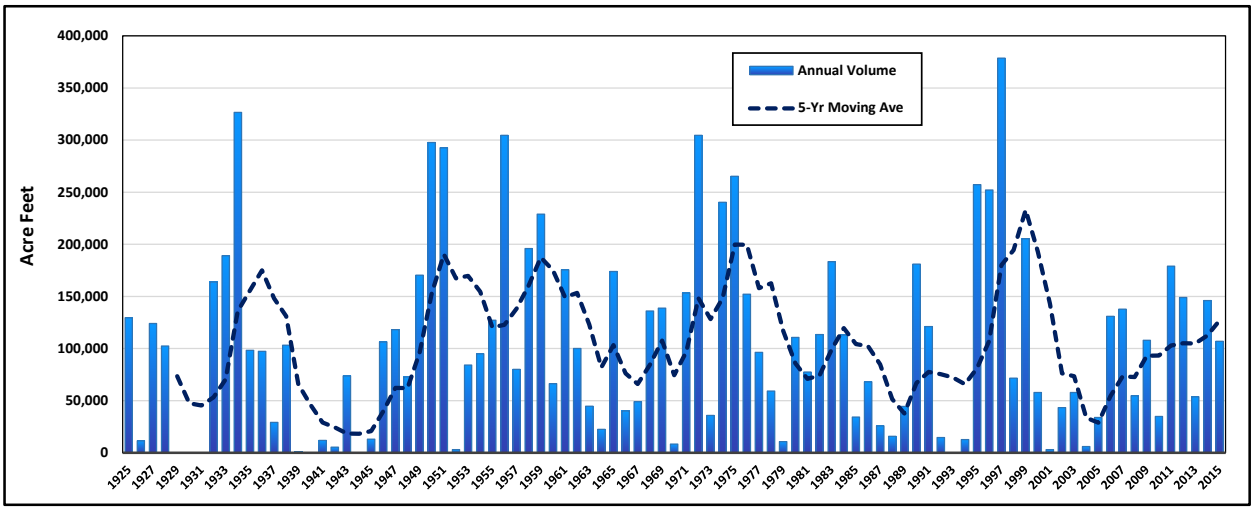

Figure 19 – SVID Annual Water Availability with Canal Capacity Restrictions, 1925 - 2015

*5.1.9 **Wapato (WIP) Wapato Irrigation Project***

Constraints:

- During the non-smolt outmigration period (October 21 – March 15) only skimmed water when the daily flow exceeded the 75th percentile flow for that day based on the 1925 – 2015 period of record.

- Flow at the PARW gauge must be ≥ 5000 cfs during the smolt outmigration period (March 16 – June 15).
- No water diverted during the irrigation season (June 16 – October 20).
- Assumed 2550 cfs maximum canal capacity.
- March 16 – June 15, canal capacity was shared on a daily basis between irrigation demand and the remaining capacity for skimmed water.

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Wapato Dam (Wapato Irrigation Project Diversion Canal)	Average	-	17,193	21,710	22,634	19,425	20,650	18,051	8,768	2,556	-	-	-	**130,027**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**34,003**
	50th %	-	633	1,757	3,442	985	-	8,794	3,103	-	-	-	-	**96,314**
	75th %	-	22,263	20,603	32,488	29,177	27,115	28,957	17,282	3,909	-	-	-	**189,165**
	Maximum	-	100,503	138,314	138,314	120,724	132,084	82,294	36,938	12,067	-	-	-	**507,102**
	% of Annual Average	0%	13%	17%	17%	15%	16%	14%	7%	2%	0%	0%	0%	**100%**
	% Years Water Available	0%	57%	58%	60%	53%	49%	64%	57%	45%	0%	0%	0%	**93%**

Table 12 - Water availability (acre-feet) at the Wapato Diversion Dam (WIP), 1925 – 2015

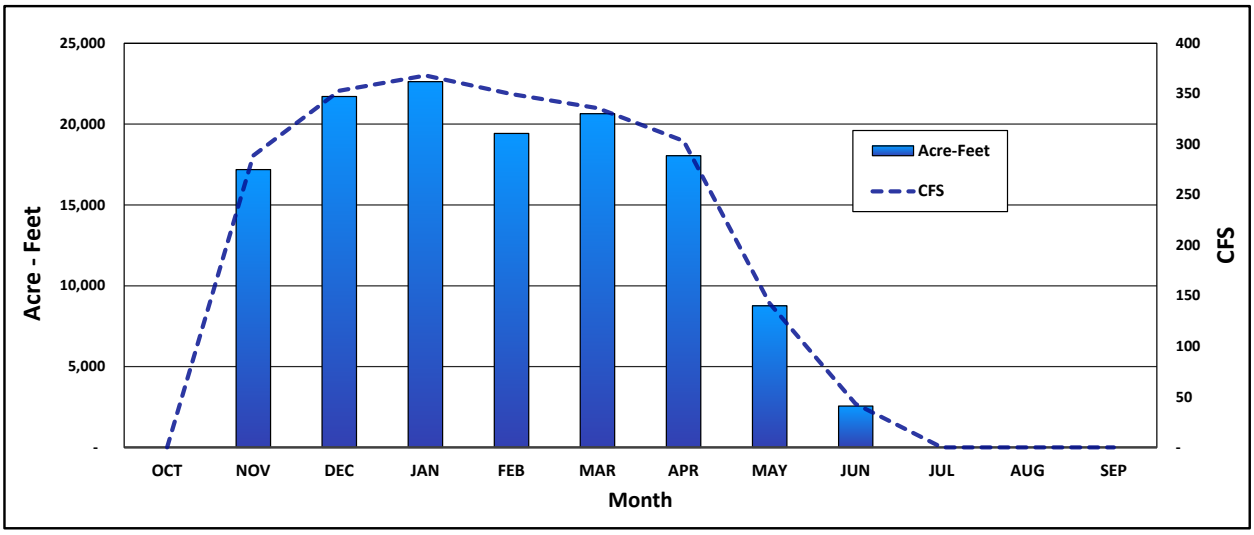

Figure 20 - WIP Average Monthly Water Availability, 1925-2015

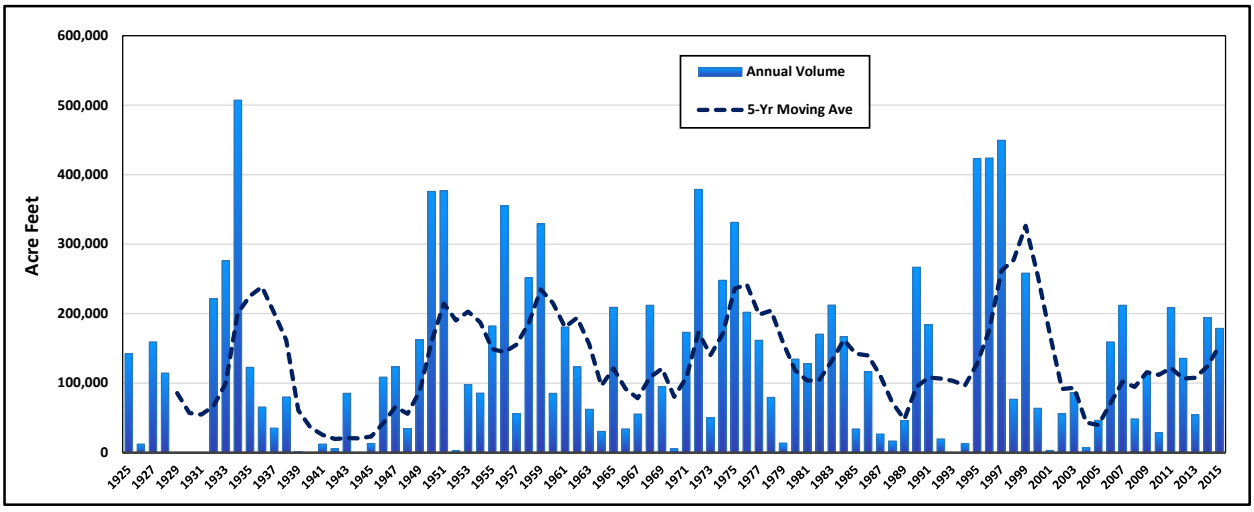

Figure 21 - WIP Annual Water Availability, 1925 - 2015

5.1.10 Prosser Dam (Kennewick Irrigation Diversion Canal), Scenario 1: 50% power water subordination

Constraints:

- During the non-smolt outmigration period (October 21 – March 15) only skimmed water available greater than the 75th percentile daily flow.
- Assumed 50% power water was subordinated.
- No water diverted during the irrigation season (June 16 – October 20)[10].
- Assumed 1500 cfs maximum canal capacity[11].

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
KID w/ 50% power subordination	Average	5,321	11,268	11,420	11,404	10,411	5,526	-	-	-	-	-	-	**54,690**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**14,223**
	50th %	-	1,458	2,915	4,373	1,458	-	-	-	-	-	-	-	**48,595**
	75th %	12,467	19,575	18,219	16,033	15,668	12,389	-	-	-	-	-	-	**83,078**
	Maximum	28,623	43,725	45,183	45,183	42,268	21,863	-	-	-	-	-	-	**182,695**
	% of Annual Average	10%	21%	21%	21%	19%	10%	0%	0%	0%	0%	0%	0%	**100%**
	% Years Water Available	39%	51%	61%	54%	50%	35%	0%	0%	0%	0%	0%	0%	**89%**

Table 13 - Water availability (acre-feet) at Kennewick Irrigation District Diversion (Prosser Dam with 50% power subordination, 1925 – 2015

[10] Available skim water was minimal after meeting flow, power water and/or irrigation water demands; so was excluded for the smolt outmigration period.

[11] The RiverWare model allowed for a maximum canal capacity of 1470 cfs.

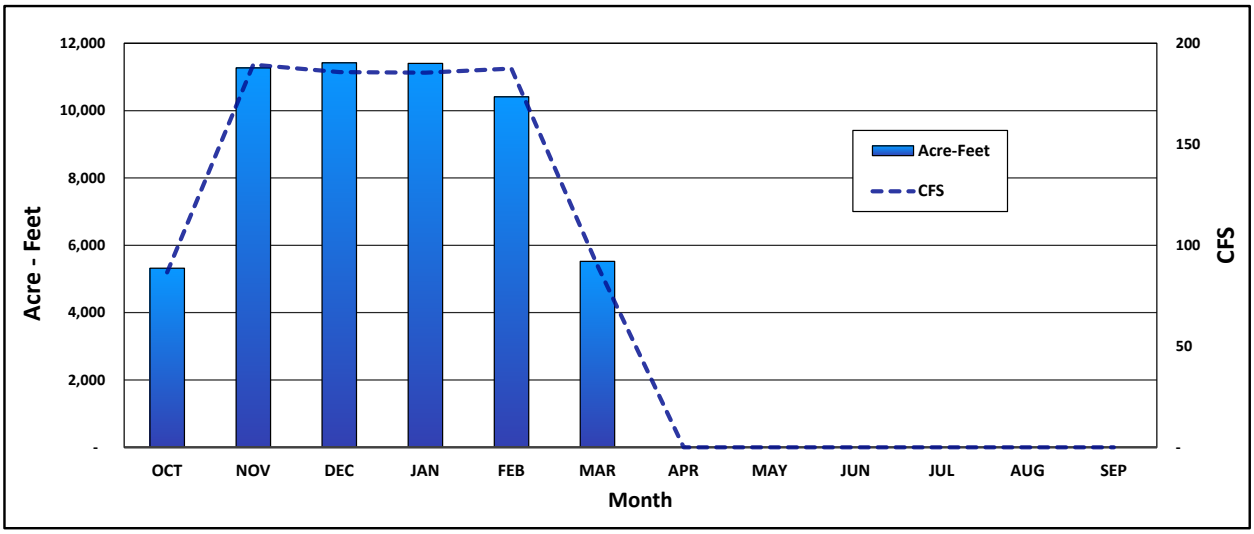

Figure 22 - KID Average Monthly Water Availability with 50% power subordination, 1925-2015

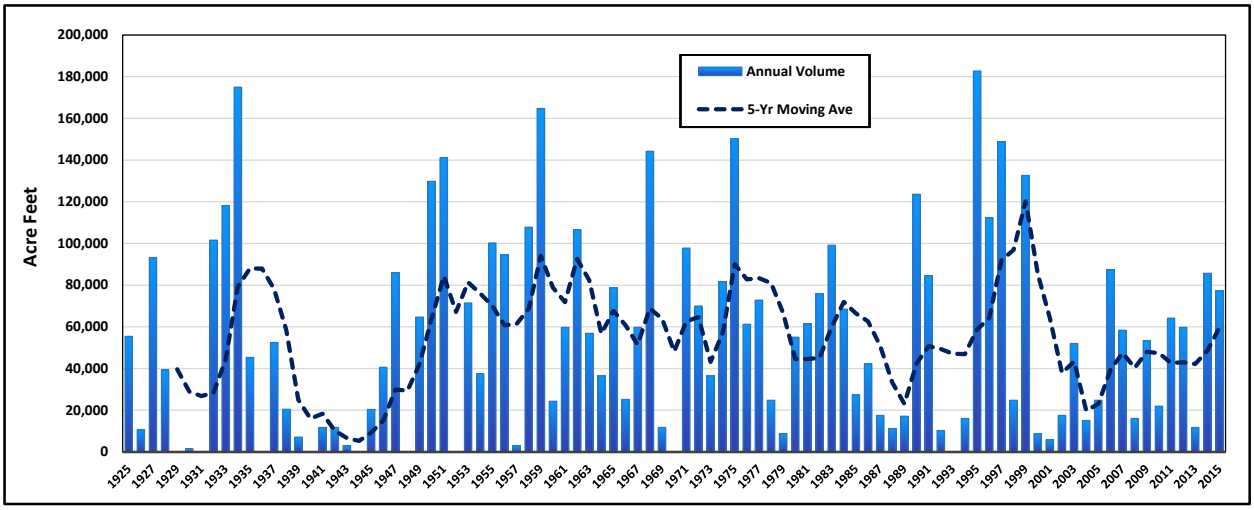

Figure 23 - KID Annual Water Availability with 50% power subordination, 1925 - 2015

5.1.11 Prosser Dam (Kennewick Irrigation Diversion Canal), Scenario 1: 100% power water subordination

Constraints:

- During the non-smolt outmigration period (October 21 – March 15) only skimmed water available greater than the 75th percentile daily flow.
- Assumed 100% power water was subordinated.

- No water diverted during the irrigation season (June 16 – October 20)[12].
- Assumed 1500 cfs maximum canal capacity[13].

Gauge	Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
KID w/ 100% power subordination	Average	7,767	22,079	22,840	22,808	20,821	11,051	-	-	-	-	-	-	**106,115**
	Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-
	25th %	-	-	-	-	-	-	-	-	-	-	-	-	**23,320**
	50th %	-	2,915	5,830	8,745	2,915	-	-	-	-	-	-	-	**94,452**
	75th %	16,388	37,794	36,438	32,065	31,336	24,778	-	-	-	-	-	-	**166,156**
	Maximum	32,065	87,450	90,365	90,365	84,535	43,725	-	-	-	-	-	-	**349,801**
	% of Annual Average	7%	21%	22%	21%	20%	10%	0%	0%	0%	0%	0%	0%	**100%**
	% Years Water Available	39%	51%	61%	54%	50%	35%	0%	0%	0%	0%	0%	0%	**89%**

Table 14 - Water Availability (acre-feet) at Kennewick Irrigation Diversion (Prosser Dam), with 100% Power Subordination, 1925 – 2015

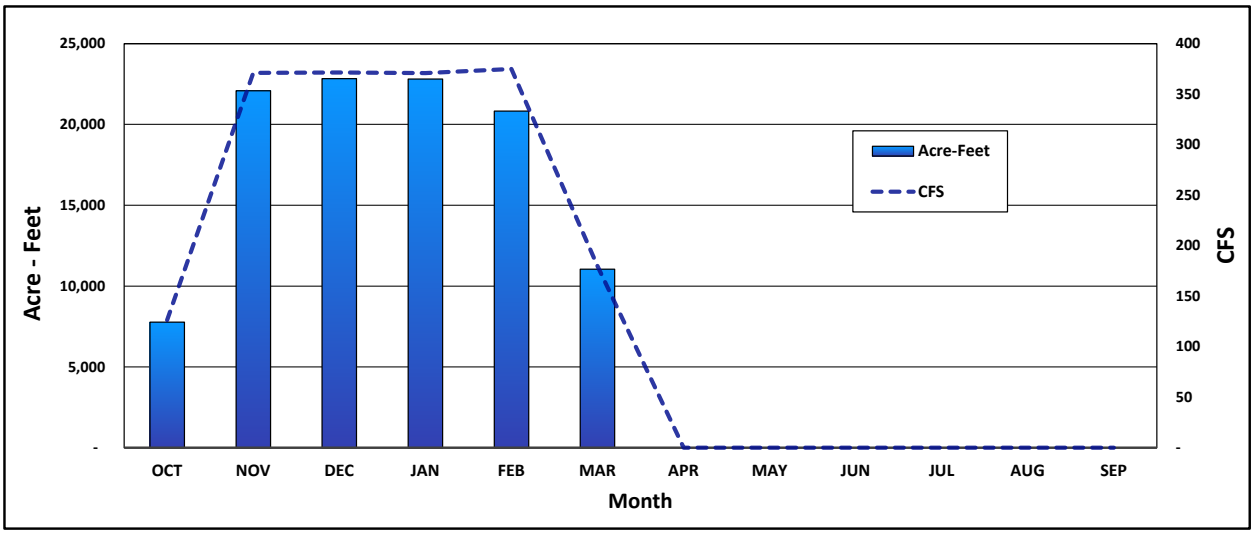

Figure 24 - KID Average Monthly Water Availability with 100% Power Subordination, 1925-2015

[12] Available skim water was minimal after meeting flow, power water and/or irrigation water demands; so was excluded for the smolt outmigration period.

[13] The RiverWare model allowed for a maximum canal capacity of 1470 cfs.

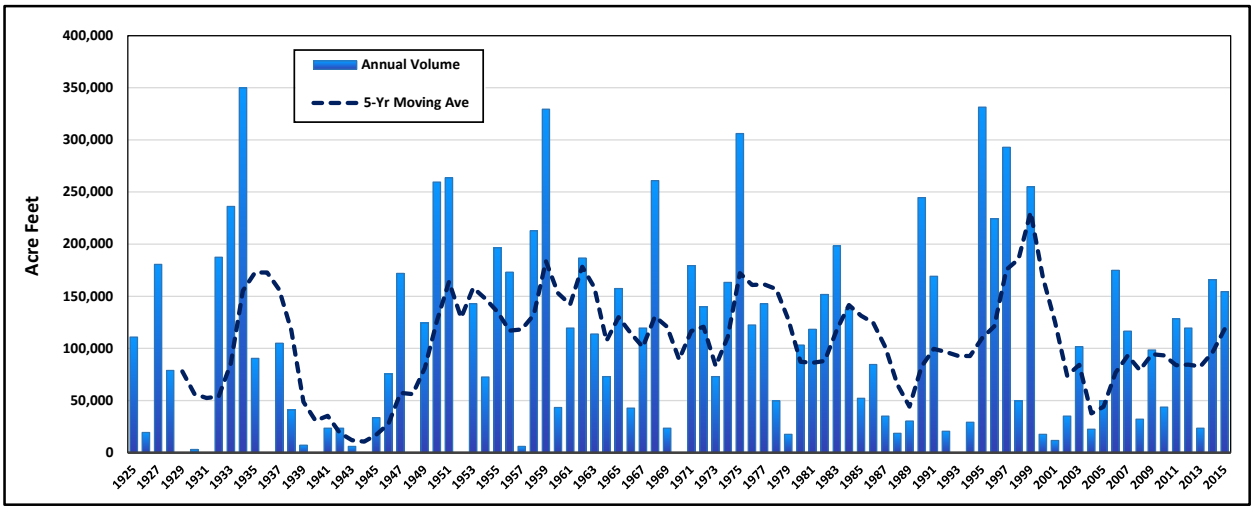

Figure 25 - KID Annual Water Availability with 100% power subordination, 1925 - 2015

The annual average, 25th, 50th and 75th percentile acre-feet of available water for each location is presented in Table 15. Water availability at these locations were constrained by four factors: minimum flow target(s), seasonality, infrastructure, and power production (applied only to Roza and Prosser dams).

Location	Average	25th Percentile	50th Percentile	75th Percentile
KRD Diversion (Easton Dam)	39603	9297	25682	55136
Ellensburg gauge with Pump Restrictions	34735	12795	31322	52487
Ellensburg gauge without Pump Restrictions	202360	20163	103318	259099
Naches River at the City of Naches	34946	14119	29083	50796
Roza Diversion (Roza Dam): no power subordination	49569	9652	42544	82255
Roza Diversion (Roza Dam): power subordination	94443	34665	91717	140407
WIP Diversion Dam	130027	34003	96314	189165
SVID Diversion (Parker Dam) with Capacity Restrictions	104499	34047	95635	150591
SVID Diversion (Parker Dam) without Capacity Restrictions	325446	44811	232020	400911
KID Diversion (Prosser Dam): 50% power subordination	54690	14223	48595	83078
KID Diversion (Prosser Dam): 100% power subordination	106115	23320	94452	166156

Table 15 - Summary of the Annual Average, 25th, 50th and 75th Percentile Water Available (acre-feet) for the Six Yakima River Basin Locations

Figure 26 illustrates the percentage of years that *any* water was available for each month. As shown in the figure, our assumptions and calculations indicate that some water is likely to be available more than 50% of the years between November and March.

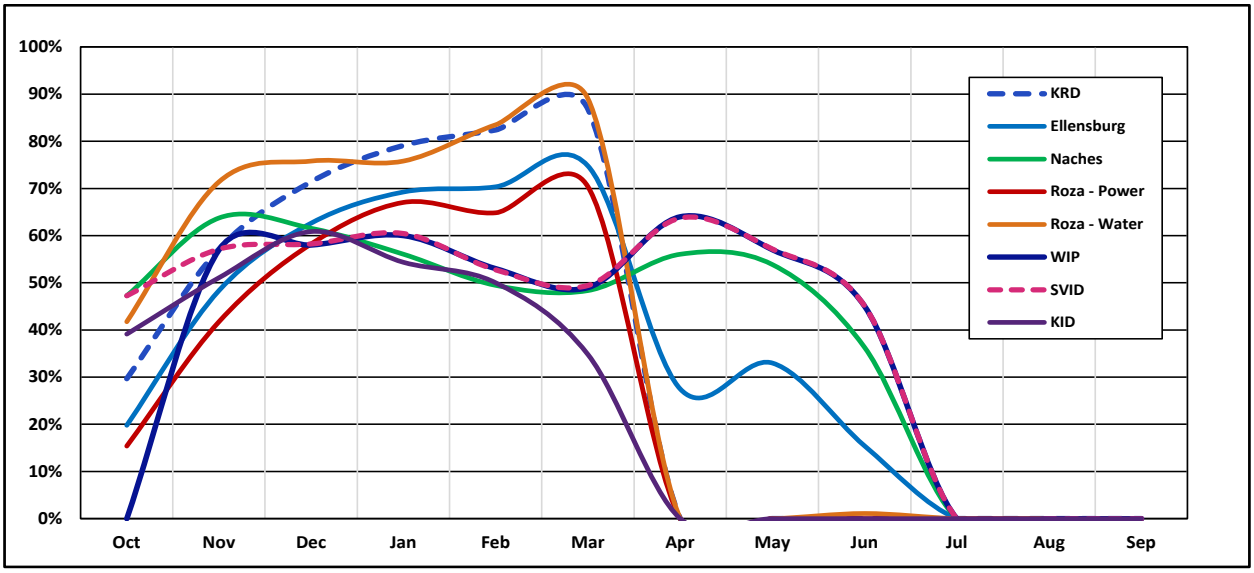

Figure 26 – Percentage of Years when Water was Available, 1925 – 2015

The probability of water being available is generally greater at locations higher in the watershed. Availability is less probable at downstream locations and more limited throughout the watershed between April and June. No water is available for diversion and storage between July and September although recovery of return flow could occur during this time.

Table 16 contains the Ditch Flow criterion score associated with each diversion dam evaluated. Notice that for Roza and Prosser diversions there are two scores (2 or 3) because the annual median water available various with how power generation is managed.

Diversion Dam	Annual Median Water Available (KAF)	Score (1–3)
Easton	25,700	1
Ellensburg	31,300	2
Roza: max power generation[14]	42,500	2
Roza: power subordination	91,700	3
Naches River[15]	34,900	2
Parker	95,600	3
WIP Diversion	96,314	3
Prosser 100% power subordination	48,600	2
Prosser 50% power subordination	94,500	3

Table 16 - Ditch Flows Associated with Each Diversion Dam

[14] For the Matrix scoring assumed no subordination of power generation.
[15] Assumed a maximum pump capacity of 400 cfs.

5.2 Tributary Water Availability Methodology

USGS's StreamStats was used to generate streamflow statistics for several ungauged tributaries. StreamStats v. 4 provides estimates of various streamflow statistics for user-selected sites by solving equations that were developed through a process known as regionalization. This process involves use of regression analysis to relate streamflow statistics computed for a group of selected stream gauges within or near a region of study (usually a state) to basin characteristics measured for the stations.

Streamflow statistics from existing gages in the USGS National Streamflow Statistics Program (NSS) are linked through a background process to StreamStats in which StreamStats provides the needed basin characteristics to NSS for an ungaged site. Then NSS estimates the streamflow statistics, sends them back to StreamStats, and then StreamStats presents the statistics and the basin characteristics to the user.

There are assumptions and errors inherent in all regression processes. Gaged sites have measurement error, so initial statistics reported in NSS are imprecise. Basin characteristics for ungaged basins are also subject to error, and regressions based thereon are also imprecise. Users should be mindful of the potential for large errors in Streamstats estimates for individual basins. Comparisons between basins in similar settings should be valid, but design of structures in individual basins should be empirically assessed.

StreamStats incorporates:

- A map-based user interface for the site selection.
- A relational data base that contains information for data-collection stations and regression equations used to estimate flow statistics for ungauged sites.
- A GIS program that allows locating sites of interest in the user interface, delineates drainage basins and measures basin characteristics.
- A database of geospatial datasets needed for the GIS program to work.

MAR site locations were selected and used to generate streamflow statistics for a given tributary. The parameter of interest selected for each location was the 2-year daily peak flow, as it is assumed that high runoff events would be available for diversion for MAR facilities. Because high flow events are important for several factors, it was assumed that a maximum of 10% of the 2-year daily peak flow would be available for diversion at MAR facilities. A summary of the tributaries evaluated, 2-year daily peak flows, and amount of water estimated to be available at each location above Umtanum are presented in Table 17.

Flood flows downstream from Umtanum are generally subject to flood control activities of the Yakima County Flood Control District or located on the Yakima Nation. Yakima Nation lands are not included in this study.

Tributary Stream	2-Year Daily Peak Flow (cfs)	10 % of 2-Year Daily Peak Flow (cfs)	10% of 2-Year Daily Peak Flow (acre-ft/day)
Badger Pocket	25	2.5	50
Big Creek	2370	237	4693
Coleman Caribou	187	18.7	70
Cottonwood Creek	29.9	2.9	59
Dry Creek	57.7	5.7	114
Little Creek	916	91.6	1814
Manastash Creek	1290	129	2554
Naneum Creek	391	39	774
Reecer Creek	30.6	3.1	62
Robinson Canyon	76.9	7.7	152
Taneum Creek	1820	182	604
Wilson Creek	515	51.5	1020

Table 17 – Estimated Water Availability from Tributary Streams Above the Umtanum Gage

Table 17 projects are located above the Umtanum gage. The Parker gage reports significant flood flow availability from both the Yakima above Umtanum and the Naches River system. Several sites below Umtanum have been assessed in the summary sheets and during the scoring process, they did not score very high.

Flood flow supplied MAR projects may viable in the Naches drainage. The Naches River MAR flows must be viewed in comparison to flood control projects currently underway. To the extent that flood flows in the Naches will be delayed by flood flow projects diverting to the ground, those flows will impact flow timing at Parker, and thus govern availability at Umtanum. This study has no estimate of flood flow control effects in the Naches.

At the Umtanum gage, the average daily water available for skimming is illustrated in Figure 27. There is an average of 276 cfs, or about 546 af/day during periods of available flow. That water is not available every year.

Table 17 is a tabulation of Streamstats estimates of the 2-year flood flows (50% exceedance value) for identified project areas, ranked by flow. There is approximately 824 cfs total project demand above Umtanum.

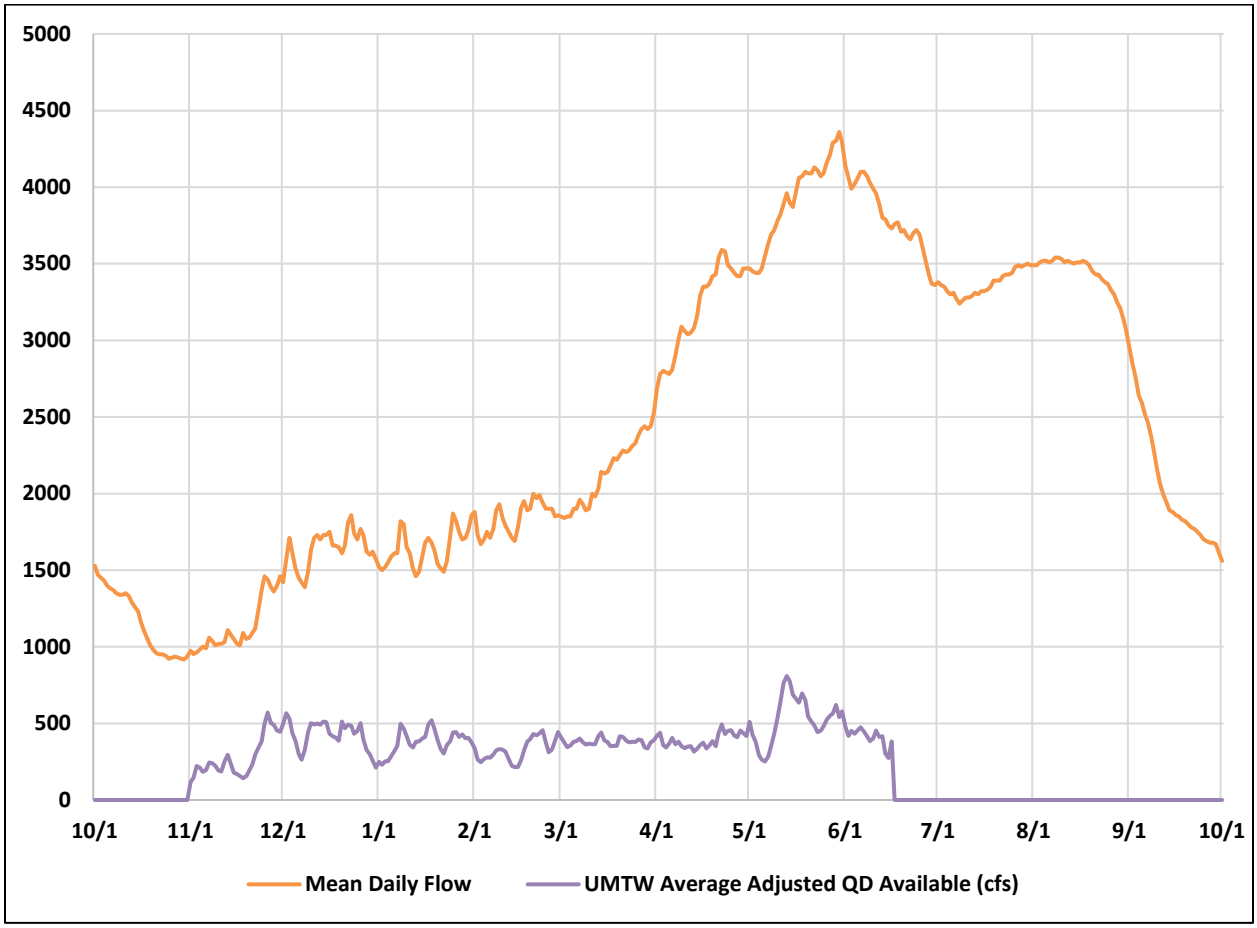

Figure 27 - Average adjusted flood flows v. 1934-2019 average, UMTW gage

6 INFRASTRUCTURE ANALYSIS

After completion of Tasks 3 and 5, the Project Team completed an irrigation infrastructure analysis to define water delivery opportunities or constraints. Existing infrastructure from irrigation districts provides an immediate mechanism for water delivery to select MAR sites. The analysis focused on data research to identify and describe existing infrastructure near applicable project locations. The Yakama Nation and Wapato Irrigation District are conducting their own independent MAR strategy.

6.1 Data Acquisition and Development

6.1.1 GIS Data and Maps

Irrigation districts in the Yakima Basin were contacted to determine the presence and availability of infrastructure data. Yakima County provided GIS data for Roza Irrigation District (Roza), Yakima-Tieton Irrigation District (YTID), and parts of Selah-Moxee Irrigation District (SMID).

Kittitas Reclamation District (KRD) provided GIS-based data for KRD. Geospatial data for SMID was obtained through Jacobs, in line with the services Jacobs provides SMID. The Irrigation Districts provided CAD files, GIS files, and delivery data pertaining to irrigation flows, frost flows, main canals, laterals, and turnouts. Figure 28 shows the location of GIS data by district in the basin.

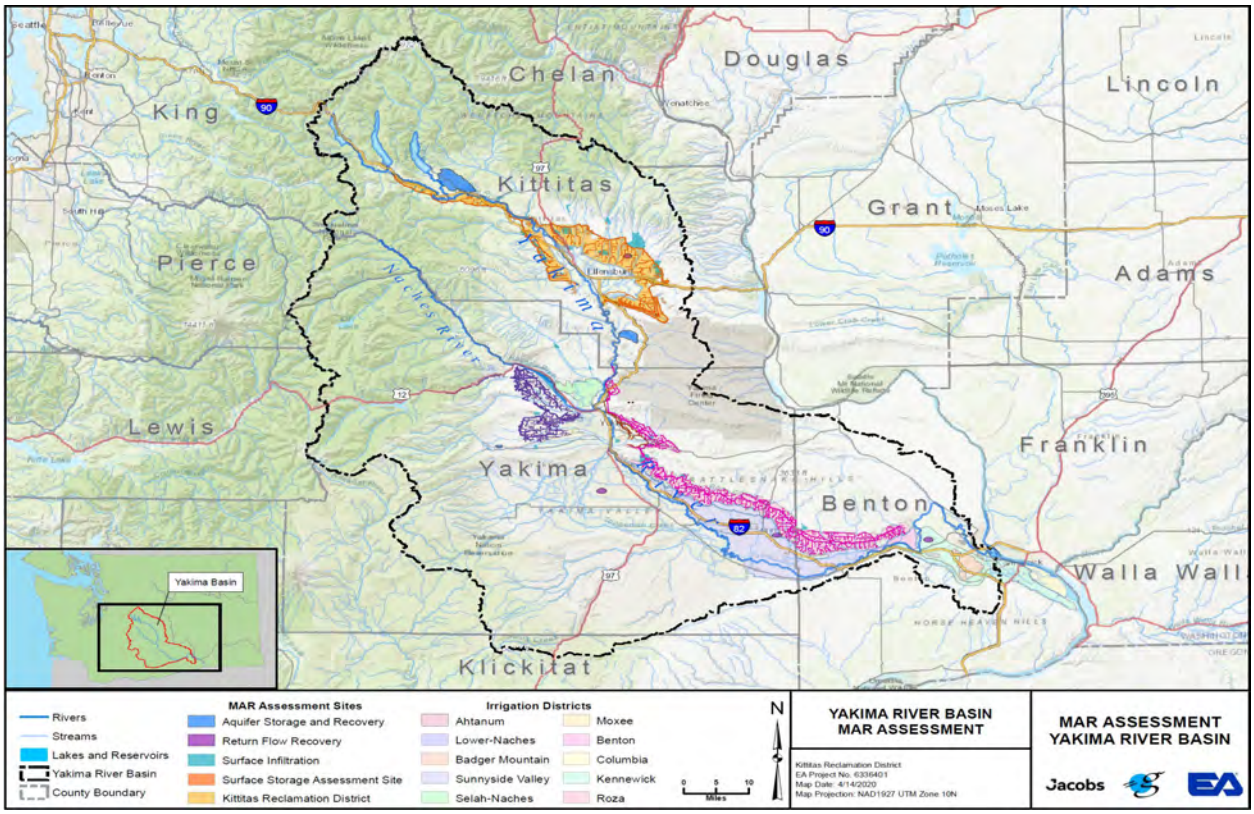

Figure 28 – Irrigation District GIS Data

It is important to note that not all the irrigation districts had the same level of geospatial data or files. A summary description of amount and type of data provided by each district is below.

6.1.1.1 Kittitas Reclamation District

The KRD services approximately two-thirds of the irrigated acres in Kittitas County, approximately 60,000 acres. The KRD's 330 miles of canals and laterals make it the 6th largest irrigation district in Washington State (Figure 29). Thirty siphons and eleven tunnels help the canal keep as much elevation as possible. The longest siphon is 3325 feet in length.

The KRD has a proratable water right. In a drought year, when there is less water than it takes to fulfill all non-prorated water rights in the Yakima River basin, the KRD will receive less than its full entitlement. The KRD receives water from two storage reservoirs, Keechelus and Kachess, both owned and operated by Reclamation. Water from the reservoirs enters the Yakima River and KRD diverts its irrigation water at RM 202, the Easton Diversion Dam. The diversion

structure is a drum gate, two radial gates, fish ladder, and fish screening facilities, and is designed to divert the KRD's maximum authorized instantaneous flow of 1,320 cfs.

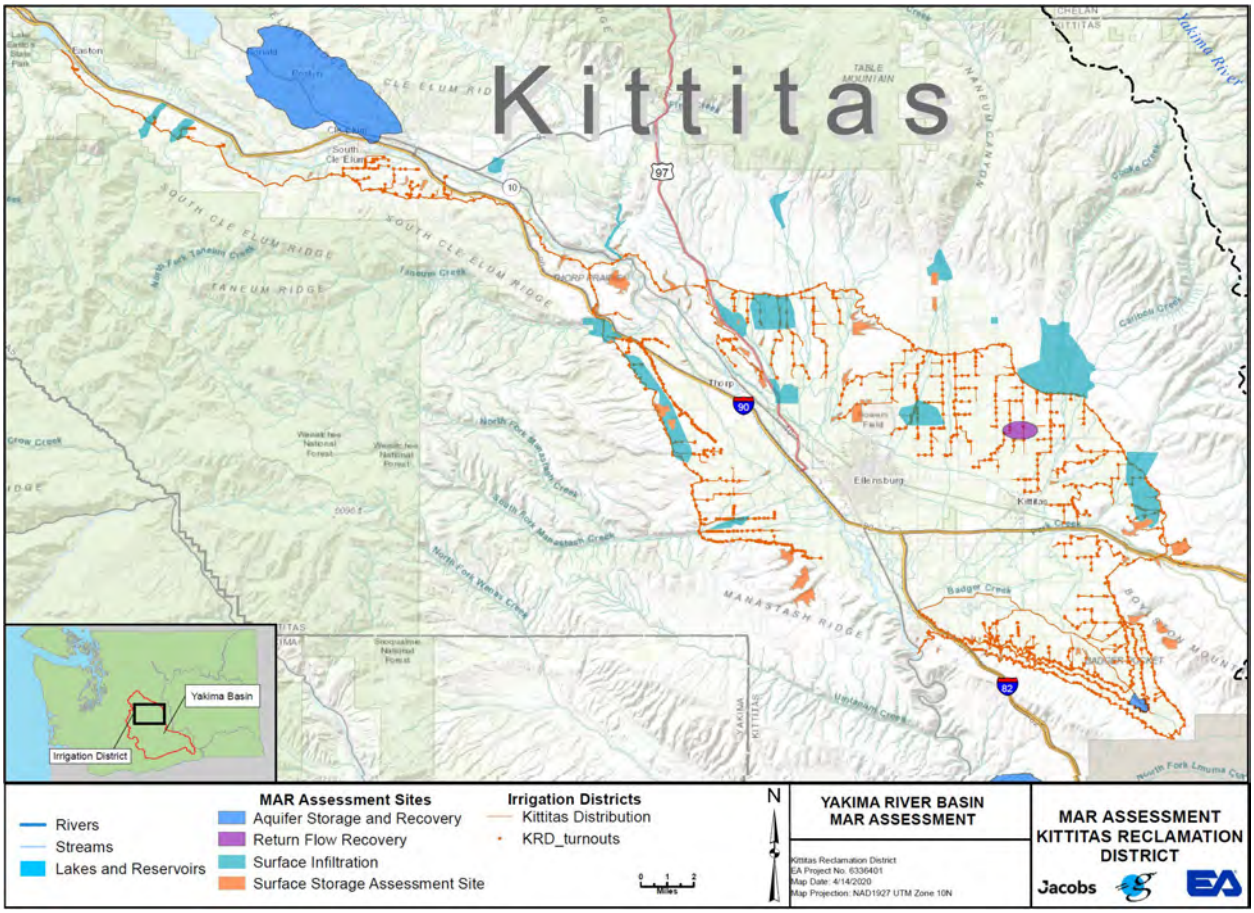

Figure 29 – Kittitas Reclamation District Infrastructure

6.1.1.2 Roza Irrigation District

Roza serves approximately 1,700 users with 72,491 acres served. These lands are served via a 95-mile main canal and approximately 460 miles of laterals (Figure 30). The laterals consist of 340 miles of PVC pipelines and 120 miles of open ditch and concrete pipelines.

The Main Canal consists of about 70 miles of earthen sections and about 25 miles of concrete lined sections. The first 11 miles of the Main Canal, designed for 2,200 cfs, is operated and maintained by the USBR and carries both irrigation water and power water. The USBR operates the power plant that produces the power for the 18 pumping plants that deliver water to the lands above the Main Canal. The remaining 84 miles are operated and maintained by the District and include are 5 tunnels, 13 siphons, 30 automated check structures, and 3 re-regulation reservoirs.

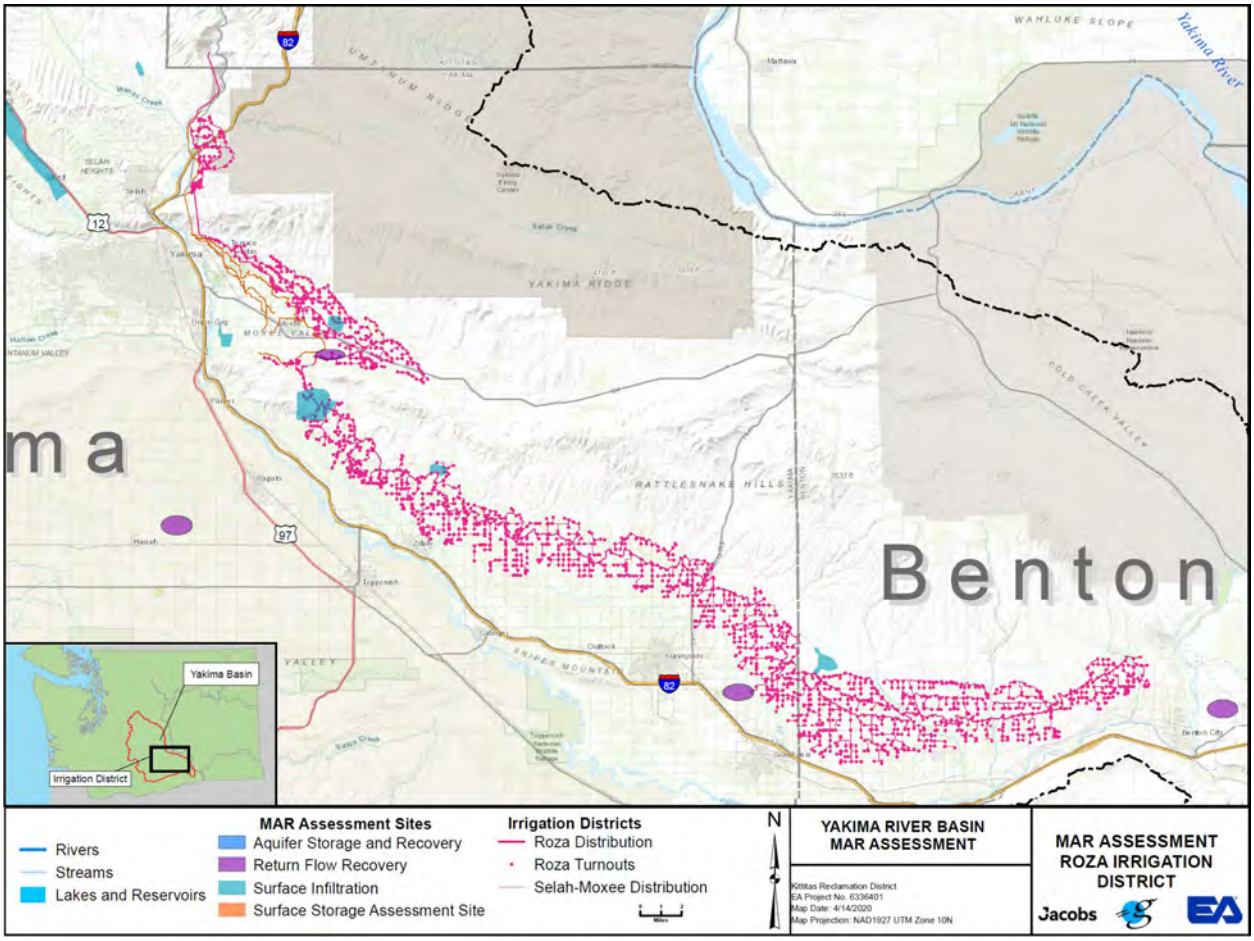

Figure 30 – Roza Irrigation District Infrastructure

Approximately 45,000 acres are served via gravity laterals below the Main Canal, most of which have been converted from open ditch to fully enclosed gravity pressure systems with flowmeters. The remaining 27,000 acres lie above the main canal and are served by the 18 pumping plants that pump water either to head weirs and their respective open ditch laterals or to enclosed piped laterals. About half of the pump laterals have been converted to enclosed systems designed to deliver 7.5 gpm/acre. The remaining 50% of these laterals are open ditch laterals with Cipolletti weirs. There are about 340 miles of enclosed laterals and about 120 miles of open ditch.

The District diverts about 307,000 acre-ft of irrigation water in a typical year. Flows diverted at MP 11.0 range from the low of 450 cfs in the spring and fall to high of 1,100 cfs in the hot part of the summer but, has a current maximum capacity of 1,200 cfs.

6.1.1.3 Yakima-Tieton Irrigation District

YTID takes water from the Tieton River (a tributary of the Yakima River) and the Naches River. The YTID diversion dam is located 7 miles below Tieton Dam and Rimrock Reservoir. The

YTID main canal is 12 miles long with 9 miles of open canal and 3 miles in tunnels (Figure 31). The canal has a design capacity of 347 cfs. The Tieton Division was the second division developed by Reclamation in the Yakima Project. The District encompasses 35,000 acres within its boundaries of which 27,900 acres are in irrigation rotation.

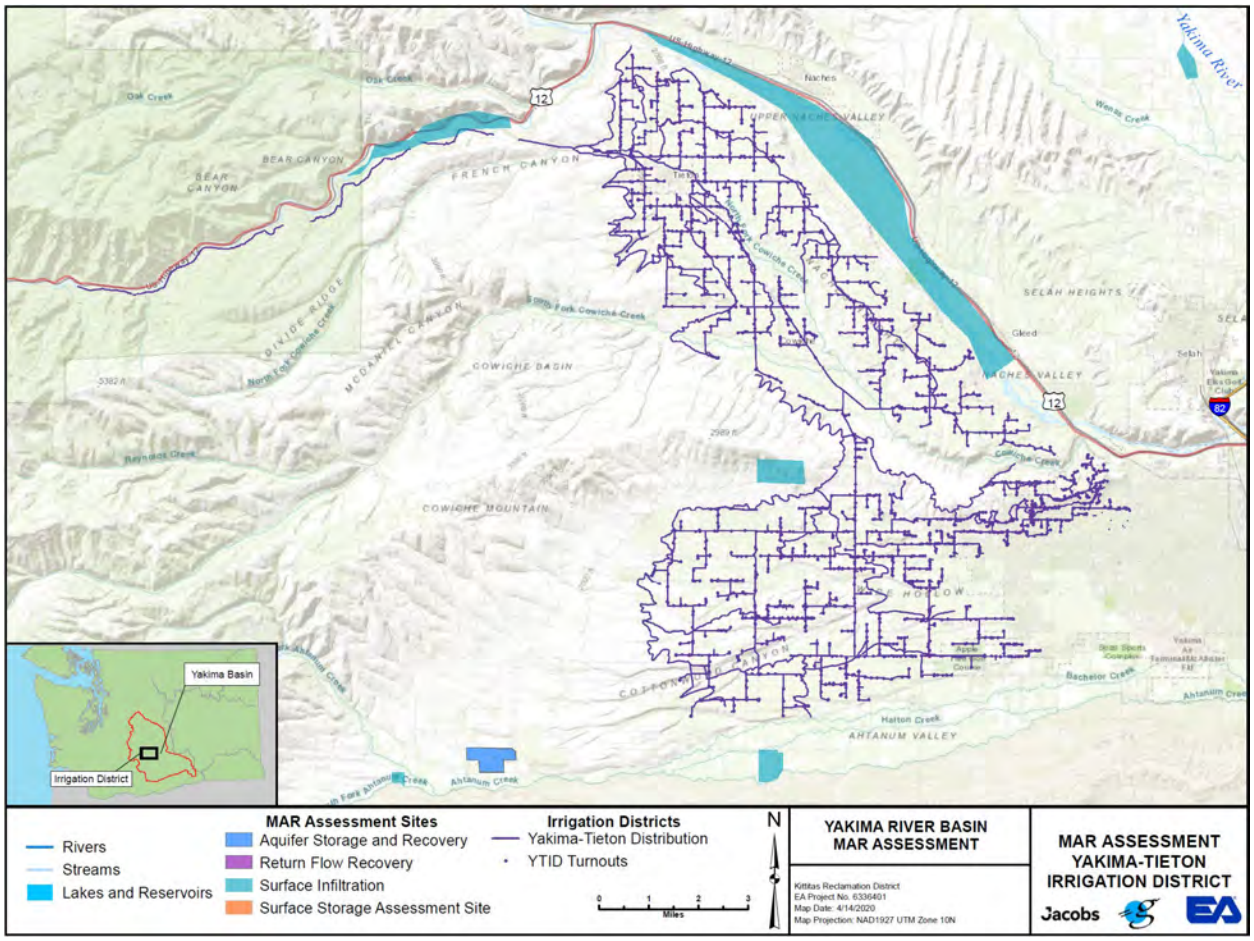

Figure 31 – Yakima-Tieton Irrigation District Infrastructure

In 1977, the District began examining the type of improvements needed to rehabilitate its irrigation system. This led to the replacement of the original open canal delivery system with a new closed pressure pipe distribution system. The pressurized system starts at the end of the main canal at French Canyon It includes a regulating reservoir, six pump stations, two hydroelectric generating facilities, over 200 miles of pipe and 2000 turnouts.

6.1.1.4 Selah-Moxee Irrigation District

SMID is located in East Selah, Terrace Heights, and Moxee areas. SMID irrigates 7,400 acres and operates 3 irrigation canals (Selah Moxee Canal, Moxee Ditch, Hubbard Canal). The Selah Moxee Canal diverts water from the Yakima river approximately 8 miles below the Roza Dam

(Figure 32). The canal is roughly 26 miles in length and is mostly earthen canal with a capacity of 90 cfs at the beginning. SMID maintains a 2-mile-long tunnel through the Yakima Ridge and 3 siphons approximately 200 feet in length for each. The District has slowly been constructing

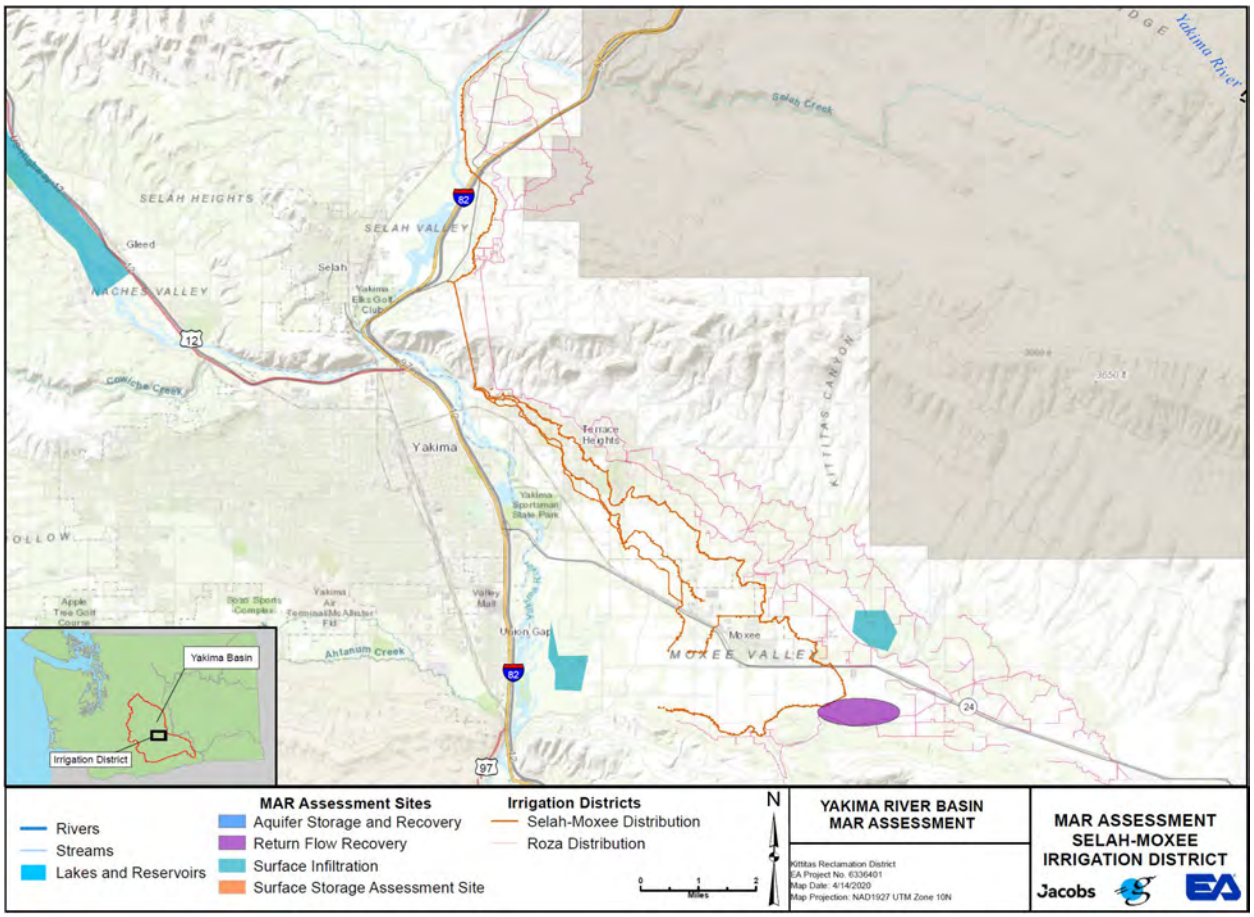

Figure 32 – Selah-Moxee Irrigation District Infrastructure

gravity pressure pipelines for its customers. The Moxee Ditch is 7 miles in length of primarily earthen ditch and has a capacity of 12 cfs. The Hubbard canal is also 7 miles in length of earthen canal and has a capacity of 22 cfs. The District currently diverts 32K-34k acre-feet annually with total water rights totaling over 44K af/year.

6.2 Infrastructure Weighting of Potential MAR Locations

Overall, infrastructure was rated at a medium level of importance. Each potential MAR site was ranked by assessing what infrastructure is currently available and whether any infrastructure needs to be built in order to deliver water. This also includes costs associated with infrastructure development. Additionally, elements of the infrastructure criterion assessed the existing infrastructure and if it matches the instantaneous water quantities and what would be the impacts to land-use and property. The ranking process for Infrastructure is summarized below.

Sites with infrastructure readily available rank high and receive a ranking score of 3. Sites with moderate level of infrastructure or complexity to provide flows rank medium and receive a ranking score of 2. Sites with no infrastructure or high complexity rank low and receive a ranking score of 1 because the likelihood of achieving the project objectives is reduced.

Table 18 displays the top 20 ranked projects from the MAR Matrix and identifies the accessibility of water to the site via the presence or absence of infrastructure.

Rank	Site	Infrastructure Available	Infrastructure not Available	Infrastructure can Provide Water Now	Retrofit Required
1	Taneum Creek	X		X	X
2	Big Creek	X		X	X
3	Tieton River	X			X
4	Little Creek	X		X	X
5	Naneum Creek		X		
6	Rattlesnake	X			X
7	Cottonwood Creek	X			X
8	Roslyn - Cle Elum District		X		
9	Smithson Road	X		X	X
10	Cle Elum	X			X
11	Naches River	X			X
12	Wenas Creek	X			X
13	NB 16 South		X		
14	Schnebly Canyon Public Land		X		
15	Teanaway Gravel Pit	X			X
16	NB 15.2 East	X		X	X
17	NB 15.2-1.9 East	X			X
18	NB 15.2-1.9 West	X		X	X
19	South Branch Area	X		X	X
20	Kittitas Reclamation District	X		X	X

Table 18 - Accessibility of Water via the Presence or Absence of Infrastructure

7 EVALUATON OF INCENTIVIZING MAR PROJECTS IN YAKIMA

MAR projects have many benefits for water users and the community. Although MAR projects are much cheaper than surface storage, they are to operate and establish, thus incentives can assist in attracting necessary public and private funding.

7.1 Benefits of MAR

MAR projects are conceived with the notion of recovery or recharged water in mind. Recovery can be passive, where the recharged water mitigates impacts of existing or future planned uses of water by its very presence or where discharge of the recharged water to connected surface waters increases flow, most desirably during late summer. Both conditions could benefit in and out of stream uses by increasing stream flow when needed or supplementing supply to pro-rated water rights. Typically, passive recharge projects are publicly funded.

For example, MAR projects are currently being widely considered and promoted in other Washington basins to mitigate the impacts of permit exempt well withdrawals on surface water resources under the authority of Ch. 90.94 RCW. This MAR accrues environmental and fisheries benefits for all, mitigating the impact of water supply development. While state funding appears to be available to begin construction of these facilities, as of this writing, no examples of a state or local administrative mechanism is in place to fund, permit, operate, or monitor these facilities over the long term.

Recovery can also be active, where the stored water is effectively and efficiently recovered. Several examples of Aquifer Storage and Recovery (ASR) exist in Washington, operated by municipalities. Active recovery projects are attractive to the private sector (or quasi-private irrigation districts) as there are opportunities for placing recovered water in a water market, making water available to junior users at times of shortage, or to otherwise supplement existing uses by the MAR operator. These sorts of facilities would seem to be attractive in the Yakima basin for junior water users once water is obtained.

7.2 Incentive Mechanisms and Risk

Incentives come in two main forms. First, money can change hands between the MAR operator and private landowners. Second, recovered water, or credit for water stored, can be provided to funding authorities, project landholders, or operators of MAR facilities to use or market, as necessary.

Most of the sites proposed for recovery in this study are under private ownership. Private landowners will expect to be compensated for changes to the use of the land to accommodate whatever MAR facility is to be constructed. In Washington, to date there is no guidance on whether overlying owners own or control the underlying usable space in aquifers. If so, they might prevent, or extract a fee, from those using it to store water. One school of thought, and the one that has prevailed in Washington to date, is that unused aquifer space is a common property resource that can be utilized by any overlying landowner without obtaining consent of or compensation to other landowners. The alternative view is that overlying owners own the aquifer space underlying their property and have the right to exclude or be compensated for others using that space. While these concepts have been raised in permit discussions for existing facilities in Washington, no court rulings or legislation are in place. This view considers that use either a taking or a trespass. See Mortimer and Tuthill, 2014, for a discussion of how these issues have been addressed elsewhere in the west.

Upon the event that damage to property should occur by virtue of MAR operations some liability would fall to the MAR project operator. Mitigation of this risk will be considered when prioritizing sites.

7.3 Obtaining Water for a MAR Project

Recharge of ground water for mitigation of other uses, wildlife or fisheries enhancement or restoration is traditionally considered a beneficial use in Washington.

Reclamation has the senior storage rights in the Yakima Basin. In addition, they have withdrawn under RCW 90.40.030 all unappropriated surface waters in the basin for "purposes of continuing implementation of the Yakima River Basin Water Enhancement Project objectives". This withdrawal began February 13, 1981. It has been subsequently extended by the State of Washington through January 18, 2023. Future extensions can be expected. Additional measures, including assessment, design, permitting and operation of MAR facilities, by Reclamation, the Yakama Nation, and Yakima Basin irrigation districts toward implementation of the Yakima River Basin Water Enhancement Project is unlikely to be complete by the current expiration date.

Thus, new water for MAR will need to be secured from Reclamation and, by extension, from the State of Washington. The mechanism for securing this water is either through negotiation with Reclamation, or through notice from Reclamation to the water right applicant that water applied for is not of interest to Reclamation. Reclamation could designate some water from their unappropriated withdrawal to an MAR purpose and then file a new water right application for that water with the state. Incentivization actions would then fall back to Reclamation or their assigns. The Yakama Nation also reviews, and agrees, before any new water right can be issued.

Capture of water annually recharged to the shallow aquifer system resulting from irrigation practices could potentially provide large volumes of water in lieu of diversions from the Yakima River. Although permitting such projects could be complicated and contentious, one way to do this would be to declare that volume artificially stored and construct recapture facilities in accordance with RCW 90.44.130. Recent Ecology policy (Ecology Focus Sheet F-WR-92-108, Revised 2007: Focus on Capture and Reuse of Irrigation Water) suggests a less complicated path, simply recovering the water to increase irrigation efficiency. A firm commitment will be required from the agency.

Another pathway adds a purpose of use to an existing water right under Ch. 90.03.380 RCW. MAR generally is only feasible if the "four-part test" is met, and an impairment assessment is often the crucial issue in evaluation. Most water right holders prefer the change to an existing use not be done, as that change requires a validity and extent determination of the existing right ("looking under the hood") to assess the amount and timing of water availability for MAR, though the language of RCW 90.03.255 seems to advocate for MAR as an alternative to make water available or otherwise offset the impact of a diversion of surface water proposed in an application for water right, transfer, or change. Some water right holders contemplating a change in purpose of use of an existing right may find this pathway attractive.

7.4 Obtaining Water from a MAR Project

Under current Washington rules, recovery of MAR water must be demonstrable. Thus, in order to achieve a permit each facility must have a significant hydrogeologic assessment, including establishment of a monitoring system capable of providing initial hydrogeologic information, together with physical and chemical monitoring data into the future of the project. For specifics on permitting, see the permitting section of this report, or Nazy and Woody, 2017.

Active recovery of stored aquifer water must recover at least some of the water injected. This is typically addressed through case by case analysis, but to date these demonstrations rely on physical modeling or geochemistry. As of this writing, incentives for recovery of this stored water are largely negative, as underground reservoirs are inherently leaky. Discrete recharge events leak away out of the reservoir and are ultimately lost to the larger hydrogeologic system. The incentive is, then, to recover the water before it goes away. Some permits have been issued allowing discounted future volumes, but there is no mechanism for future credits to be issued on or traded for this water.

MAR projects for aquifer health or streamflow improvement have been implemented in Walla Walla, Washington. The incentive for the Walla Walla program is twofold: mitigation of aquifer declines, and increased streamflow for anadromous fish. MAR water injected for streamflow mitigation is not seen as mitigation for new water rights, but it may function to delay regulation of existing rights. So far, this program has not generated significant increased streamflow nor fully mitigated aquifer declines. While there is discussion of a broad range of reasons for this, the program has not generated enough local enthusiasm to fund locally or rise to be a priority to locals proposing to continue state funding. (Patten, 2018)

7.5 MAR in the Western States

Other states are working toward building MAR programs. California and Idaho are leaders, but each state system varies a bit due to variation in Water Resource custom, law, policy, and customer need. Oregon has a system for both active and passive recovery that is an illustrative example. (Nazy and Woody, 2017). Burchenal et. Al., 2018 propose and evaluate costs and benefits in the Teton Valley, Idaho in an innovative way. In the East Snake River Plain, Idaho's complete adjudication of ground and surface waters provides incentives for junior users to work with senior right and storage holders to construct and operate facilities to store winter water for future use (Tuthill and others, 2014). They have recently moved toward a model where non-profits formed by project partners operate, monitor, and allocate water.

In the Walla Walla Basin, Washington and Oregon have operated shallow aquifer recharge facilities since 2005 for purposes of streamflow augmentation and ground water decline mitigation. Permitting of these facilities in Washington is done under special conditions that apply in the Walla Walla basin, eliminating the need for water right extent and validity determination prior to adding mitigation as a purpose of use. (See

https://www.wwbwc.org/projects/recharge.html for thorough overview of the program and datasets, and Cobb and Keller, 2019)

All states with systems involving transfer of water absolutely require good understanding of the hydrogeologic system; robust monitoring of ambient conditions, infiltration volumes, and removals; streamlined and timely decision-making, and transparent information systems.

7.6 The Arizona Example

Given that the majority if not entirety of the water available for MAR in Yakima is engaged in a Reclamation project, the Arizona example is instructive. Nearly all the water stored in Arizona is supplied by Reclamation's Central Arizona Project (CAP). For a brief, yet concise history and description, see Silber-Coats and Eden, 2017. Two systems actively managing artificial recharge exist.

7.6.1 The Arizona Water Bank Authority System

In 1986, the Arizona Legislature established the Underground Water Storage and Recovery program to allow persons with surplus supplies of water to store that water underground and recover it later for use. In 1994, the Legislature enacted the Underground Water Storage, Savings, and Replenishment Act which further defined the recharge program. The recharge program is administered by the Arizona Department of Water Resources (ADWR).

Each year, the Arizona Water Bank Authority pays the water delivery and storage costs to bring Colorado River water into Central and Southern Arizona through the CAP canal. The water is either stored underground in aquifers (direct recharge) at underground storage facilities (USF) or is used by irrigation districts in lieu of pumping groundwater (indirect or in lieu recharge) at groundwater savings facilities (GSF). Recharge projects are owned and operated by municipalities, irrigation districts, and individual farms.

Direct recharge is the process of flooding an area and allowing water to percolate down through the soil, replenishing underground aquifers in a USF. In the future, the recharged water can be pumped out with recovery wells for use in meeting demand. The Arizona Water Banking Authority participates in direct recharge by partnering with operators of recharge projects to store excess CAP supplies at those facilities.

Indirect recharge or in lieu recharge is the process of using renewable surface water supplies (CAP water) instead of groundwater to irrigate farmland. The diversion is a GSF. The reduction in groundwater pumping results in allowing groundwater to remain in the aquifer and is referred to as "groundwater savings". AWBA administers this program and tracks the amounts used to assess progress toward their goal of sustainability.

These actions take place in Active Management Areas (AMAs), which are generally discrete ground water basins. Water recharged within an AMA can be recovered and used anywhere

within that AMA, subject to some decrease in volume, or "cut" to the aquifer. The annual cut to the aquifer is deducted as five percent (5%) of the amount stored, as modified by specific situations. The remaining amount is then posted to the storer's long-term storage account.

Recharging a volume of water allows a nearly equal volume to be recovered anywhere within the same AMA. Recharge & recovery can occur within the same year, or a Long-Term Storage Credit is issued to the recharger for future use. There are some restrictions, but holders of long-term storage credits may assign by grant, gift, sale, lease or exchange all or part of the holder's long-term storage credits, so long as the stored water would have qualified for long-term storage credits had the assignee stored the water.

The AWBA also accrues a long-term storage credit that can be recovered and used in the future during times of a shortage in supply. In 2014, the AWBA was given the authority to purchase existing long-term storage credits for the same purpose for which the AWBA has historically stored water. The AWBA then markets these storage credits in times of shortage of supply from the CAP to water short users.

In recent times, funding for water banking purposes has come from two sources: groundwater withdrawal fees collected by ADWR and ad valorem property taxes collected by other authorized users. While the AWBA has used state general fund appropriations to develop credits in the past, such funds have not been available since FY 2007. For each source of monies, there are restrictions regarding the way these funds can be expended. The AWBA has also stored water on behalf of the State of Nevada. Interstate storage costs are paid by Nevada in years when storage occurs. (See Silber-Coats and Eden, 2017)

7.6.2 The Central Arizona Water Conservation District (CAWCD) System

The CAWCD operates in a three-county, urban service area. Generally, CAWCD is responsible for contracting with the United States for the delivery of CAP water, repayment of CAP costs and operation and maintenance of the CAP aqueduct. The ground water replenishment authority of CAWCD is commonly referred to as the Central Arizona Groundwater Replenishment District ("CAGRD").

The purpose of the CAGRD is to provide a mechanism for landowners and water providers to demonstrate an assured water supply under the new Assured Water Supply Rules ("AWS Rules") which became effective in 1995.

The AWS Rules are designed to protect groundwater supplies within each Active Management Area ("AMA") and to ensure that people purchasing or leasing subdivided land within an AMA have a water supply of adequate quality and quantity. In each AMA, new subdivisions must demonstrate to the Arizona Department of Water Resources ("ADWR") that a 100-year assured water supply is available to serve the subdivision before sales can begin. An assured water supply (AWS) can be demonstrated in two ways. First, the owner of the subdivision can prove an AWS and receive a certificate of AWS from ADWR. Or, the owner of a subdivision can

receive service from a city, town or private water company, which has been designated by ADWR as having an AWS. (See CAGRD, 2010)

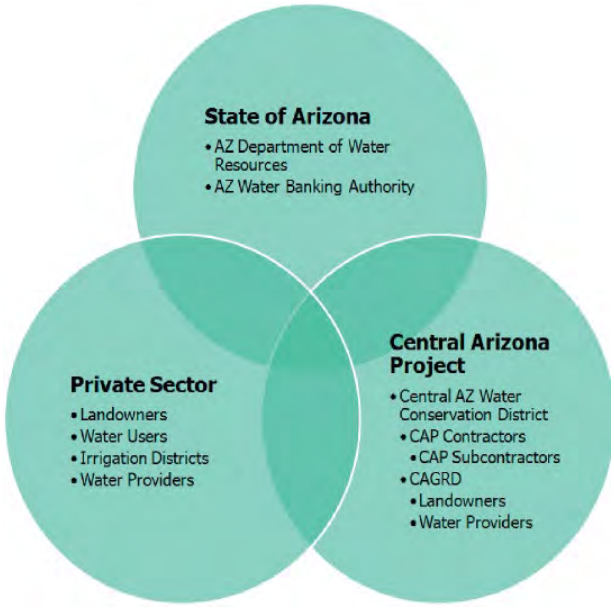

Figure 33 - Public-Private Partnership Framework in Arizona (Tuthill and others, 2014)

7.6.3 Summary of Arizona Actions

Arizona considers MAR a crucial element in their efforts to utilize their entire allocation from the CAP. In partnership with Reclamation, a system is in place that satisfies both Reclamation and Arizona State Water Resource rules, while recognizing the importance of keeping the groundwater system sustainable. The major pitfall is the need to develop and staff institutions that account for and manage the water, plus the attendant costs, as well as the need for existing institutions to give up authority over small portions of the basin in favor of system wide management The essential elements of this program are:

- Discrete and understood aquifer basins.
- Robust monitoring systems to empirically assess system performance and account for volumes recharged and removed system wide.
- An enabled local banking authority in each aquifer basin to monitor recharge and withdrawal, and account for third party transactions.
- A “credit agency”, to separately meet time sensitive needs in high growth basins.
- Transparent, widely available information on performance and cost, and timely decision making.

7.7 Conceptual Application in Yakima

Successfully Incentivizing MAR in Yakima requires an understanding of the benefits. The clearest beneficiary of MAR in Yakima is flow in the Yakima River. The availability section indicates that there is water available for recharge in the basin most years, and recharge of that water may mitigate for new or existing uses, as well as potentially delaying the date of storage control, and increasing the total water supply available in summer.

Junior rights are curtailed most years. MAR can mitigate that in time and space. Also, during times of shortage, many farmers turn to drought wells. But those wells have a cost, negatively affecting Yakima River streamflow over time. An incentive program could be designed to either mitigate the effect of drought wells on the River, or to earn recharge credits to operate wells later.

A favorable system for MAR exists in the Yakima valley. Favorable elements include discrete ground water basins or aquifers; organized irrigation districts; individuals, organizations, and municipalities with junior rights who presumably would like to avoid curtailment, and available water.

As discussed elsewhere in this report, the ground water system in Yakima is well understood. Structural basins above the Parker gauge include Roslyn, Kittitas, Selah, and Yakima. MAR in any of these basins would benefit the ground water resource within that basin. Additionally, there are discrete aquifers defined in the Columbia River Basalt units, regulated as specific bodies of public ground water. Recharge delivered to those aquifers could similarly benefit users in those aquifer units.

In the Roslyn basin, for example, recharge of floodwaters from Big Creek could benefit the local ground water regime. Junior water users within the Roslyn basin include the City of Roslyn and Suncadia, both of which may be interested in funding or participating in a recharge facility if they would receive credits extending their rights.

But, extended through this example, to successfully implement an incentive program, the basin needs several things.

First, an administrative element, preferably under local control with participation by all sovereigns, whose purpose is to construct and operate MAR recharge and monitoring facilities. This might be accomplished by an organization of irrigation districts including the Yakama Nation. One favorable configuration would include Reclamation, the Yakama Nation, local government, and water user group representatives.

Second, a banking authority element which would account for recharged water and the effect of that water in time and space and allocate stored water and credits to water users. This could be performed by the irrigation districts as currently conceived, but if it bridged several basins and aquifers it may be best a stand-alone group for the sake of independence.

Lastly, a robust water quantity and quality monitoring system element is desirable. Current technology provides systems where data is available to all interested parties in near-real time. Construction of this kind of system is the sort of thing that elsewhere in Washington requires the participation of the Counties or other local government and is funded through a variety of methods mostly involving universities and state agencies. The Counties are invaluable due to their access to public land and rights of way, while they benefit for access for various water quality and water resource programs.

The goal would be to make these agencies independent, self-sustaining, covering costs of operation and maintenance with fees assessed on mitigation transactions. They would need authorization to make decisions under some plan with the Department of Ecology.

Though daunting, the decreased costs of litigation on all public and private entities, and increased certainty of water supply, plus flexibility to meet needs in times of shortage, should encourage on the ground participation by agricultural groups, and encourage growing municipalities to participate through conservation and operational recharge systems rather than acquisition and retirement of agricultural rights.

7.8 Adopting IMAR in Yakima

*7.8.1 **Key elements outline for adopting IMAR in Yakima***

Key elements for adopting IMAR in the Yakima Basin are listed below.

- Identify Project Area, Facility, and Likely Volumes Available
- Identify Potential Beneficiaries
- Begin Permit Process
    - Identify source water
        - *"New" water will by necessity come from Reclamation's RCW 90.40 reservation. Assigned water will have a very junior priority date.*
        - *"Old" water will by necessity come from existing water rights and will most likely require a change in purpose of use, adding new purposes. This will trigger a validity and extent determination, including annual consumptive quantity determination, and precipitate a new and very junior priority date.*
    - Estimate volume of recovered water and timing of availability
        - *Note: Potential change to WAC 173-157 to allow volume for volume exchange instead of "artificial storage and subsequent recovery" would create additional incentives and marketing opportunities.*
- Investigate and Identify Limits of Reservoir

- Construct and Operate Reservoir Monitoring System
- Create IMAR Administrative Framework
    - Single proponent to beneficiary
        - *Note: likely simplest for irrigation district to water user situations*
    - Regional or other management authority allowing multiple entities and multiple beneficiaries
        - *Note: complex, but allows for distribution of benefits to multiple beneficiaries, i.e. junior water users, permit exempt mitigation, environmental compartments, multi-year storage benefits, etc. and flexibility in that distribution over time to accommodate changing land use or beneficiary needs*
- Create IMAR Data Framework
    - Realtime input/output volume and quality monitoring and reporting
    - Realtime reservoir monitoring and reporting
    - Cost structure
    - Seasonal and annual numerical assessment and updates to empirical evaluation tools
- Obtain Permit and Operational Parameters
    - Point of diversion
    - Priority date
    - Reservoir boundaries and recovery requirements
    - Secondary permit for use of recovered water
- Operations
    - Accounting for input, use, and recharge
    - Operational risk management

8 SCORES AND RANKING OF MAR SITES

This section provides a summary table (Table 7) of potential MAR sites that have been identified, scored, and ranked. Please note that this list of projects should be considered preliminary and it is likely that lower ranking projects may never be built. Summary sheets for all ranked sites are included in Appendix A.

Project Type	RANK	Project Name	Scoring Criteria	Relative Importance of Scoring Criteria												Total Score
				Required		High					Medium			Low		
				Property Access	Suitable Hydrogeology	Ditch flows	Flood Flows	Water Quality	Out-of-Stream Benefits	Instream Benefits	Infrastructure	Operational Risk	Estimated Cost	Permitting	Conceptual Facility Type	
			Range	0-10		0-3					0-3			0-3		
SAR	1	Taneum Creek		10	6	1	3	3	2	3	3	3	3	2	3	123
SAR	2	Big Creek		4	6	1	3	3	3	3	3	2	3	2	3	100
SAR	3	Tieton		7	6	0	3	3	1	1	3	3	3	2	2	98
SAR	4	Little Creek		4	6	1	2	3	3	3	3	2	2	2	3	95
SAR	5	Naneum Creek		4	6	1	2	3	2	3	3	2	3	2	3	94
SSS	5	Rattlesnake		7	5	2	1	3	1	2	2	2	3	3	2	94
SAR	7	Cottonwood Creek		5	7	0	1	3	3	1	3	2	3	2	3	93
ASR	7	Roslyn - Cle Elum District		7	7	0	1	3	3	2	1	2	1	1	1	93
SAR	9	Smithson Road		5	4	1	1	3	3	3	3	2	3	2	2	89
SSS	9	Cle Elum		3	7	3	1	3	1	2	2	3	2	3	2	89
SAR	11	Naches River		1	7	1	3	3	3	2	3	3	2	1	3	88
SAR	11	Wenas		4	5	0	2	3	2	3	3	3	3	2	2	88
SSS	11	NB 16 South		4	6	0	2	3	2	2	3	2	3	2	3	88
SAR	14	Schnebly Canyon Public Land		7	5	0	1	3	1	1	3	2	3	2	3	87
SAR	14	Teanaway Gravel Pit		4	6	0	3	3	2	1	3	2	3	2	2	87
SSS	14	NB 15.2 East		6	5	2	1	3	1	2	2	2	2	2	2	87
SSS	14	NB 15.2-1.9 East		6	5	2	1	3	1	2	2	2	2	2	2	87
SSS	14	NB 15.2-1.9 West		6	5	2	1	3	1	2	2	2	2	2	2	87
SAR	19	South Branch Area		5	5	1	1	3	2	1	3	2	3	3	3	86
RFR	19	Kittitas Reclamation District		6	6	0	0	3	3	1	3	2	2	1	2	86
RFR	19	Roza Irrigation District		6	6	0	0	3	3	1	3	2	2	1	2	86
RFR	19	Sunnyside Valley Irrigation District		6	6	0	0	3	3	1	3	2	2	1	2	86
RFR	19	Wapato Irrigation Project		6	6	0	0	3	3	1	3	2	2	1	2	86
SSS	19	Horseshoe		3	6	3	1	3	1	3	2	2	2	3	2	86
SSS	19	Morrison Canyon		3	6	3	1	3	1	3	2	2	2	3	2	86
SAR	26	Reecer Creek		4	6	1	1	3	1	2	3	2	3	2	3	85
SAR	27	Swauk Creek		8	2	1	2	3	1	2	2	2	2	2	3	84
SSS	27	Erickson South		6	5	0	1	3	2	1	2	3	2	3	2	84
SSS	27	NB 16 North		4	5	0	2	3	2	2	3	2	3	2	3	84
SAR	30	Roza Moxee		3	6	2	0	3	3	1	2	3	3	1	3	83
SSS	30	MB 16.6 East		4	5	3	1	3	1	2	2	2	2	3	2	83
SSS	30	MB 16.6 West		4	5	3	1	3	1	2	2	2	2	3	2	83
SSS	30	SB 11.7		3	6	3	1	3	1	2	2	2	2	3	2	83
SSS	30	Yakima		6	5	1	1	3	1	2	1	2	2	3	2	83
SSS	35	Wipple		4	5	1	2	3	1	2	2	3	2	2	2	81
ASR	36	Badger Pocket		6	4	1	1	3	2	2	2	1	2	1	1	79
SSS	36	NB 14.7 #1		4	4	3	1	3	1	2	2	2	2	3	2	79
SSS	36	NB 14.7 #2		4	4	3	1	3	1	2	2	2	2	3	2	79
SSS	36	SB 16.7		4	5	1	1	3	2	1	2	3	2	3	2	79
SSS	36	Springwood		4	4	3	1	3	1	2	2	2	2	3	2	79
SSS	36	Turner		4	6	1	1	3	1	2	1	2	2	3	2	79
SAR	42	Dry Creek		3	3	1	1	3	3	3	3	2	3	2	3	78
SAR	42	Whiskey Dick Creek		4	4	1	1	3	2	3	2	2	2	2	2	78
RFR	42	South Branch Area		5	5	0	0	3	3	1	3	2	2	1	2	78
SSS	42	Pump Ditch East 1		4	5	1	1	3	1	2	2	3	2	2	2	78

Table 19 – Scoring and Ranking Table for Potential MAR Sites

Project Type	RANK	Project Name	Scoring Criteria	Relative Importance of Scoring Criteria												Total Score
				Required		High					Medium			Low		
				Property Access	Suitable Hydrogeology	Ditch flows	Flood Flows	Water Quality	Out-of-Stream Benefits	Instream Benefits	Infrastructure	Operational Risk	Estimated Cost	Permitting	Conceptual Facility Type	
			Range	0-10		0-3					0-3			0-3		
SSS	42	Pump Ditch East 2		4	5	1	1	3	1	2	2	3	2	2	2	78
SAR	47	Manastash SAR		3	3	1	3	3	2	3	2	2	2	2	3	77
SSS	47	Hayward Canyon Upper		4	4	3	1	3	1	2	1	2	2	3	2	77
SSS	47	SB 1.5		3	5	3	1	3	2	1	2	1	2	3	2	77
SSS	47	SB 1.71		3	6	1	1	3	1	2	2	2	2	3	2	77
SSS	47	Sheepdip Canyon Upper		4	4	3	1	3	1	2	1	2	2	3	2	77
SSS	52	Erickson North		4	5	0	1	3	2	1	2	3	2	3	2	76
SSS	52	NB 15.2-1.9		4	4	2	1	3	1	2	2	2	2	3	2	76
SSS	52	NB 4.1 Winter		4	3	2	1	3	1	2	3	2	3	2	3	76
SSS	52	T 6.2		3	6	1	1	2	1	2	2	2	3	3	2	76
SSS	52	T 6.7		3	6	1	1	2	1	2	2	2	3	3	2	76
SAR	57	Coleman Caribou		3	5	0	2	3	2	1	3	2	2	2	3	75
SSS	57	NB 30.4		4	4	1	2	3	2	1	2	2	2	2	2	75
SSS	57	NB 5.8		3	3	1	1	3	2	3	3	2	3	2	3	75
SSS	57	NB 6.4 East		3	3	1	1	3	2	3	3	2	3	2	3	75
SAR	61	Robinson Canyon		3	5	1	1	3	2	1	2	2	2	2	3	73
SSS	61	Hayward Canyon Lower		4	3	3	1	3	1	2	1	2	2	3	2	73
SSS	61	Sheepdip Canyon Lower		4	3	3	1	3	1	2	1	2	2	3	2	73
ASR	64	Konnowac Pass		5	4	2	0	3	2	1	3	1	1	1	1	72
SSS	64	Foggy		2	5	2	1	3	1	2	2	2	2	3	2	72
SSS	64	Johnson Siphon		4	4	1	1	3	2	1	2	2	2	2	2	72
SSS	64	Little Johnson		4	4	1	1	3	2	1	2	2	2	2	2	72
SSS	64	NB 26.1		4	4	1	1	3	2	1	2	2	2	2	2	72
SSS	64	NB 29.2		4	4	1	1	3	2	1	2	2	2	2	2	72
SSS	64	Page		2	5	2	1	3	1	2	2	2	2	3	2	72
ASR	71	Wymer ASR		6	2	0	2	3	2	2	1	3	1	1	1	71
SSS	71	NB 15.2 West		4	3	2	1	3	1	2	2	2	2	2	2	71
SSS	71	Pump Ditch West 1		3	5	1	1	3	2	1	2	1	2	3	2	71
SSS	71	Pump Ditch West 2		3	5	1	1	3	2	1	2	1	2	3	2	71
SSS	75	Big Johnson		4	4	1	1	3	2	1	2	1	2	2	2	70
ASR	75	Whiskey Canyon		3	5	1	0	3	2	1	2	3	2	1	1	69
SSS	75	NB 4.1 North		3	3	1	1	3	1	2	3	2	3	2	3	69
SSS	75	NB 4.1 South		3	3	1	1	3	1	2	3	2	3	2	3	69
SSS	75	NB 4.1-4.41		3	3	1	1	3	1	2	3	2	3	2	3	69
SSS	80	Dodge		3	5	1	1	2	2	1	2	1	2	3	2	68
SSS	80	Webster		3	5	1	1	2	2	1	2	1	2	3	2	68
SAR	82	Wilson Creek		3	2	1	2	3	2	3	2	1	2	2	2	67
SAR	83	West Valley HS		7	4	0	0	2	1	1	1	1	1	2	2	66
SSS	84	T 16.1		3	4	1	1	3	1	1	1	2	2	3	2	64
SSS	84	T 16.2		3	4	1	1	3	1	1	1	2	2	3	2	64
ASR	86	Yakima DNR		8	2	0	0	3	1	1	1	1	1	1	1	63
SAR	87	Sagebrush Ridge		3	4	0	0	3	2	1	2	1	2	2	3	61
ASR	88	Manastash ASR		3	3	1	0	3	2	3	1	1	1	1	1	59
SAR	89	Sportsmans Park		1	1	0	2	3	1	1	1	3	2	1	3	45

Table 19 – Scoring and Ranking Table for Potential MAR Sites (cont.)

9 CONCLUSIONS AND RECOMMENDATIONS

This assessment used available information to identify, score and rank potential MAR projects in the Yakima Basin. Methods included assessment of land ownership, hydrogeology, infrastructure, stream flow, groundwater, fisheries, and habitat data, as well as review of the large volume of technical publications and reports regarding water resources conditions in the Yakima Basin. The primary purpose of this assessment was to assess how much water is potentially available for storage, locations that can be utilized for storage, and to identify and rank potential MAR sites that could be used to help meet the goals and objectives of the YBIP. In addition, the project team has identified investigative field work intended to continue to move the highest-ranking MAR sites toward construction and implementation.

Conclusions that can be drawn from this work include the following:

- Tens of thousands of acre-feet of water are available most years for diversion and storage from the Yakima River.
- Smaller amounts are likely available during high runoff events from tributary streams, primarily in the Kittitas Basin.
- Water is generally available for diversion and storage most years between November and March.
- There are many sites, large and small, within the basin that could be used to capture, slow down, and re-time surface water runoff.
- Basalt aquifers have the potential to store large volumes of water.
- The abandoned coal mines between Roslyn and Cle Elum could be used to potentially store approximately 20,000 acre-feet of water annually.
- More than 100,000 acre-feet of water is being artificially recharged by leaky irrigation canals and irrigation practices. Capture and use of this water, in lieu of releases from Reclamation's reservoirs, could potentially save tens of thousands of acre-feet per year.
- An incentivized MAR program could be implemented in the Yakima Basin, although more data, as well as an administrative system to manage the program would be required before this could be successfully implemented.

Recommendations for future work include:

- Identify data gaps and specific needs for MAR implementation at the highest-ranking MAR locations.
- Continue feasibility study investigative activities at the highest-ranking MAR sites.
- Enhance existing groundwater monitoring efforts in the basin, including construction of monitoring wells at the highest-ranking MAR locations.
- Collect discharge data from tributary streams to further refine water availability from tributary streams at the highest-ranking MAR locations.
- Conduct investigative work at the Roslyn – Cle Elum abandoned coal mines to assess groundwater movement and potential impacts from pumping and refilling the coal mines.

- Use the Yakima Basin groundwater model, as revised by Reclamation, to assess the impacts of recovering groundwater present because of annual irrigation activities. The model could be used to identify potential quantities, as well as the best time periods and locations for recovering water while minimizing impacts to surface waters during the critical low flow periods.
- Throughout most of the Study Area, subsurface conditions are highly vertically and laterally variable as expected in Glacial terranes. Tills, drifts, and associated sediments have highly variable hydraulic conditions which may preclude significant recharge. Site specific assessment of existing conditions is critical to project success.

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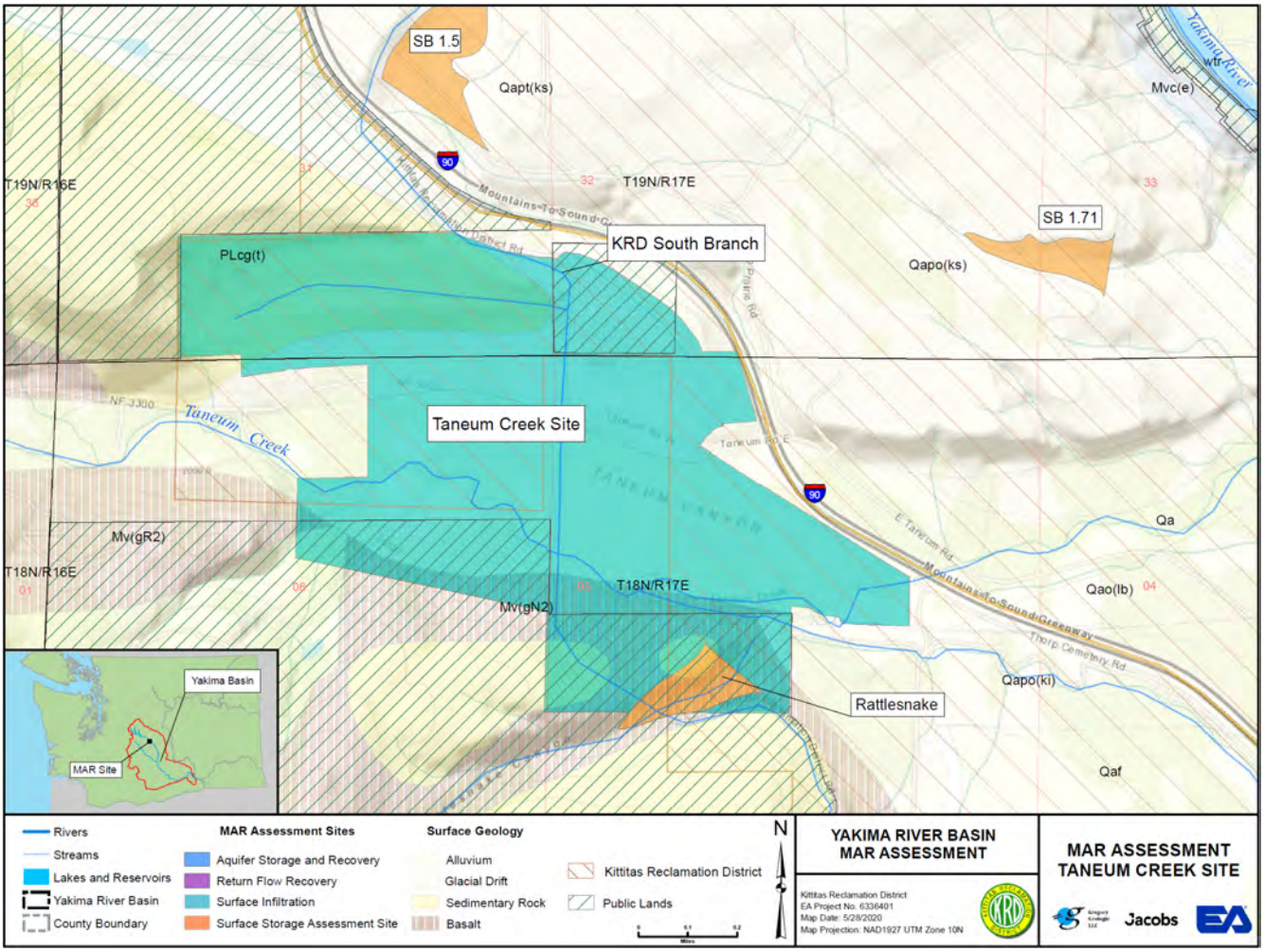
Appendix A

MAR Site Information Sheets

Project Area Characteristics – Taneum Creek

Rank: 1

MAR Project Type: Surface Infiltration



Location (TRS): T18N R17E Sections 5 and 6 and T19N R17E Sections 31 and 32

Property Availability

Public/Private Land

Site Surface Geology

Quaternary Alluvium/Glacial Drift/Colluvium

Project Area Subsurface Conditions

Basalt and Ellensburg formation at 80'.

Depth to Water

Up to 30 feet in Alluvium

Hydraulic Conductivity Estimate

Estimate relatively high in colluvium and alluvium.

Water Source and Availability

Flood Flows: Peak 50% flood flows 1820 cfs

Flows from nearby Irrigation Canals: Easton Diversion Dam. See Appendix Table 1. Served by KRD South Branch Canal.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using flood flows and canal deliveries.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Taneum Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mouth of Taneum Creek at approximately RM 166

Location of Benefits to Water Users: Groundwater users near Thorp.

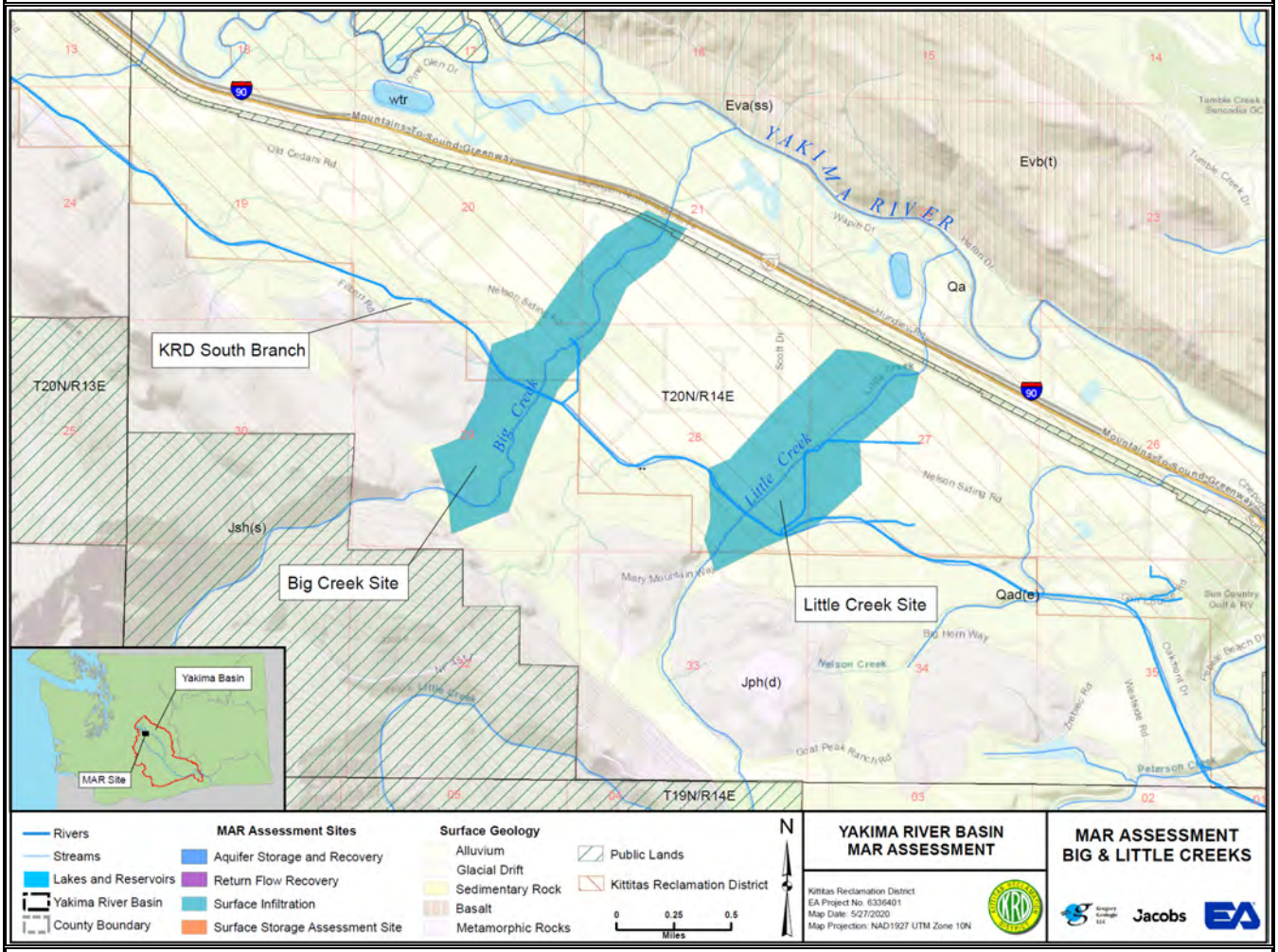
Integration with proposed Integrated Plan or other projects

MAR project would integrate with proposed, in progress and completed instream habitat improvements and fish screens as well as flow supplementation for Coho in Taneum Creek. Overlap with Rattlesnake Surface Storage Site.

Project Area Characteristics – Big Creek

Rank: 2

MAR Project Type: Surface Infiltration



Location (TRS): T20N, R14E, Section 29

Property Availability

Private Land, USFS upstream

Site Surface Geology

Unconsolidated sand and gravel, glacial debris

Project Area Subsurface Conditions

Volcanics at about 60', texture unknown, groundwater flow in fractures in bedrock.

Depth to Water

Water at 40' to locally flowing artesian conditions.

Hydraulic Conductivity Estimate

0.02 ft/day in Volcanics (Gendaszek et al, 2014)

Water Source and Availability

Flood Flows: Peak 50% flood flows 2370 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1).

Conceptual Operational Model

Surface infiltration or gravity injection beneath local confining layers into losing reach of Yakima River.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Big Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects and adds to TWSA. Mitigation of permit exempt and junior use.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use			X
Mitigate effect of permit exempt withdrawals			X
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mile 195

Location of Benefits to Water Users: Local mitigation for Permit exempt and potentially junior right holder users.

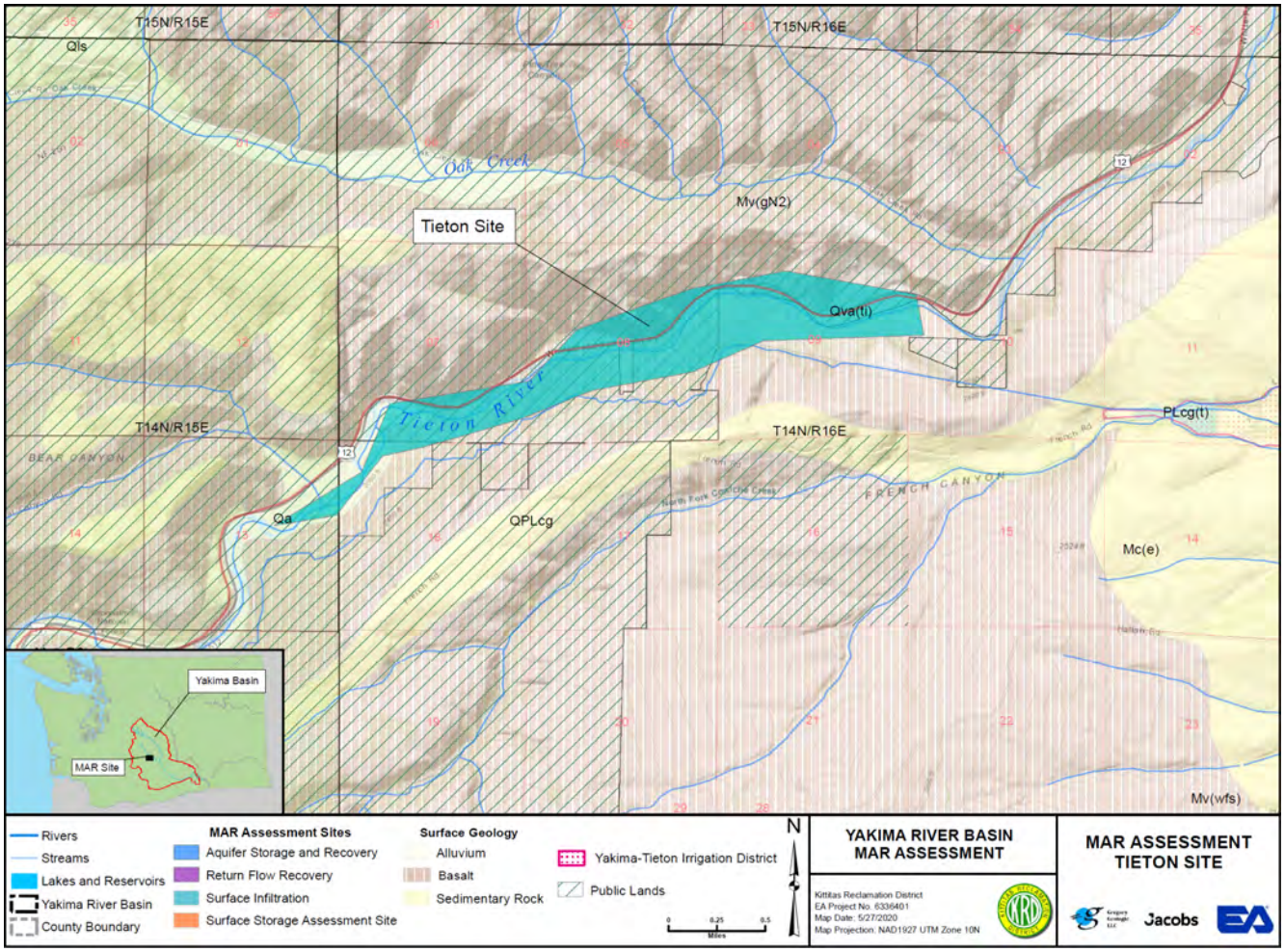
Integration with proposed Integrated Plan or other projects

MAR project would integrate with proposed, in progress and completed fish screens and passage projects.

Project Area Characteristics - Tieton River

Rank: 3

MAR Project Type: Surface Infiltration



Location (TRS): T14N R15E, Section 13 and T14N R16E, Section 7, 8, 9, 10 and 18.

Property Availability

All on Oak Creek Wildlife Area.

Site Surface Geology

Quaternary Alluvium/Slide Debris: steep rocky terrain.

Project Area Subsurface Conditions

Grande Ronde Basalt.

Depth to Water

No wells available, likely to be shallow in floodplain.

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: Peak 50%, 1910 cfs.

Flows from nearby Irrigation Canals: Yakima-Tieton Diversion Dam. *Note*- water availability analysis not completed, pending further refinement of the YTID storage proposal.

Conceptual Operational Model

Diversion of high flows onto the floodplain for surface infiltration, slowing runoff and providing delayed baseflow to the Tieton River.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Reduction of flood flows, increase baseflows in the Tieton River, improves riparian habitat and cold water refugia.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: At mouth of Naches River at Yakima RM 116.

Location of Benefits to Water Users: Ground water diverters in Naches valley.

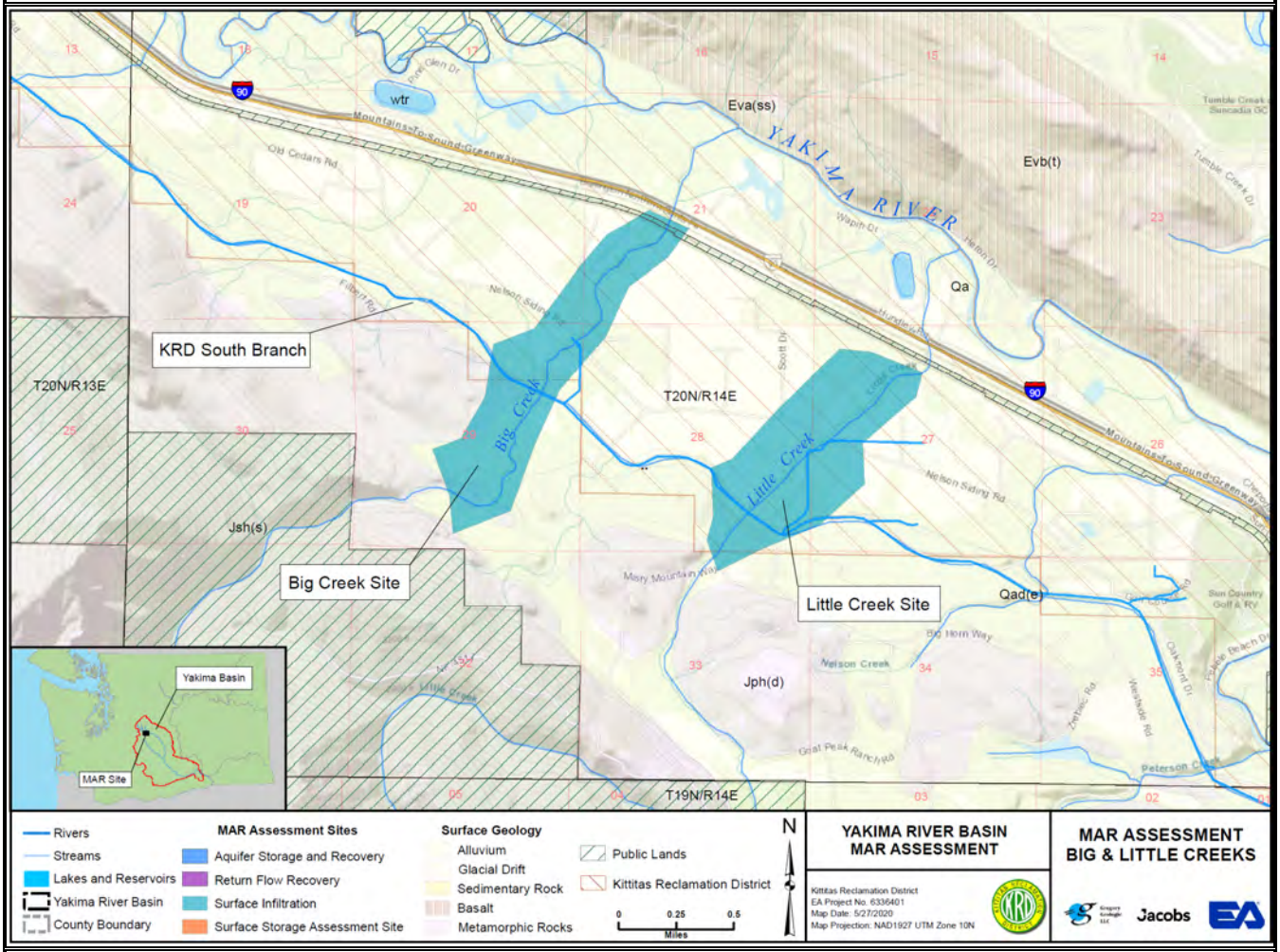
Integration with proposed Integrated Plan or other projects

MAR project would integrate with proposed, in progress and completed instream habitat improvements and fish passage projects as well as flow supplementation in the Tieton and Naches rivers.

Project Area Characteristics – Little Creek

Rank: 4

MAR Project Type: Surface Infiltration



Location (TRS): T20N, R14E, Sections 27 and 28

Property Availability

Private Land

Site Surface Geology

Coarse Quaternary sediments.

Project Area Subsurface Conditions

Volcanics at depth, texture unknown, groundwater flow in fractures in bedrock.

Depth to Water

Water table 20-30 feet below land surface.

Hydraulic Conductivity Estimate

4 – 1,600 ft/day in alluvium (Gendaszek et al, 2014)

Water Source and Availability

Flood Flows: Peak 50% flood flows 916 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1).

Conceptual Operational Model

Infiltration pond capturing flood flows for recharge.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Little Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects and adds to TWSA. Mitigation of permit exempt and junior use.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use			X
Mitigate effect of permit exempt withdrawals			X
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mile 194

Location of Benefits to Water Users: Potential for mitigation of permit exempt withdrawals in Roslyn structural basin.

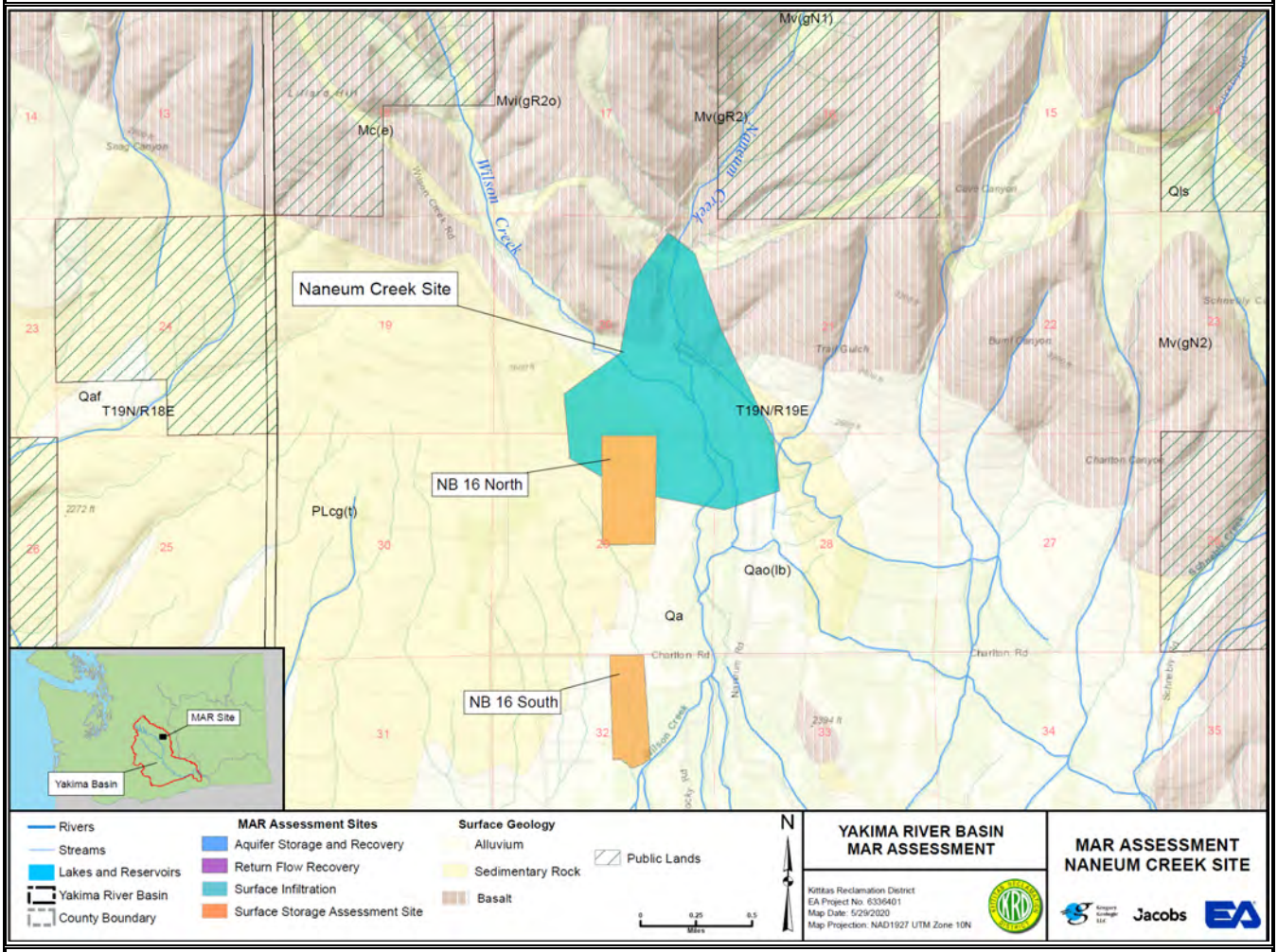
Integration with proposed Integrated Plan or other projects

MAR project would integrate with proposed, in progress and completed fish screens and passage projects.

Project Area Characteristics – Naneum Creek

Rank: 5

MAR Project Type: Surface Infiltration



Location (TRS): T19N R19E Sections 20, 21, 29, 28.

Property Availability

Private Land

Site Surface Geology

Quaternary Alluvium, recent outwash from Naneum Canyon.

Project Area Subsurface Conditions

Alluvium 30-100 feet thick, quite coarse, overlying basalt or Thorp-like cemented sands.

Depth to Water

Few wells, but groundwater seems shallow (30') in creek channel.

Hydraulic Conductivity Estimate

4 – 1,600 ft/day in alluvium (Gendaszek et al, 2014)

Water Source and Availability

Flood Flows: Flood Flows Peak 50% flood 391 cfs.

Flows from nearby Irrigation Canals: N/A, upgradient of KRD North Branch Canal.

Conceptual Operational Model

Infiltration ponds of flood flows into shallow aquifer and alluvial fan sediments. In this case, likely very low tech to enhance existing percolation operations.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Enhanced ground water in Naneum/Wilson Ck. Drainage, additional flow in North Branch Canal.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: MP 154.

Location of Benefits to Water Users: North Branch vicinity.

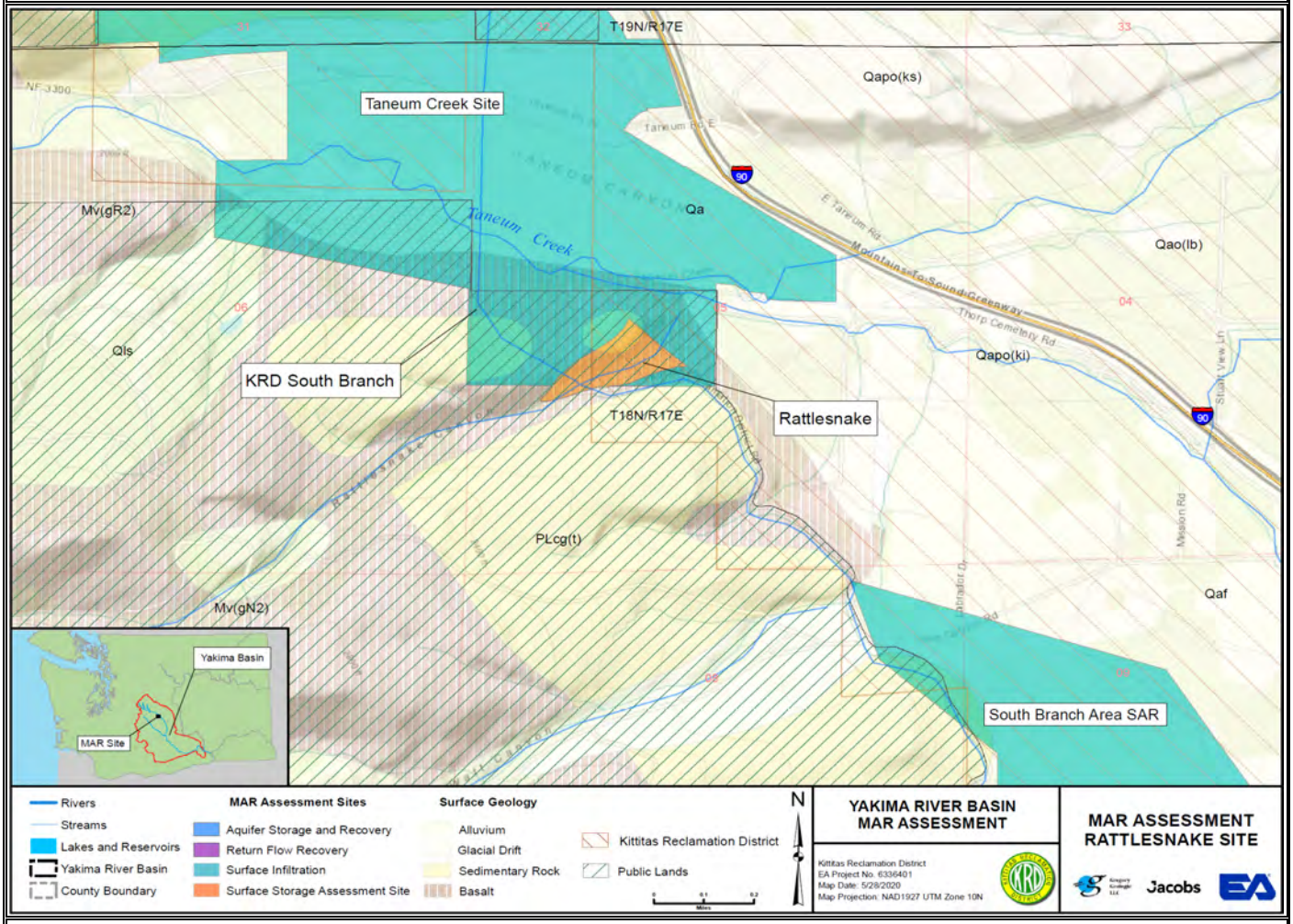
Integration with proposed Integrated Plan or other projects

MAR project would integrate with proposed, in progress and completed fish passage projects.

Project Area Characteristics – Rattlesnake Site

Rank: 5

MAR Project Type: Surface Storage Assessment Site – Surface Infiltration



Location (TRS): T18N R17E Sections 5

Property Availability

Public Land

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Ellensburg formation around 100’ or greater.

Depth to Water

No wells in area, likely > 150 ‘

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam. See Appendix Table 1. Served by KRD South Branch Canal.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using flood flows and canal deliveries.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Taneum Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: Mouth of Taneum Creek at approximately RM 166

Location of Benefits to Water Users: Groundwater users near Thorp.

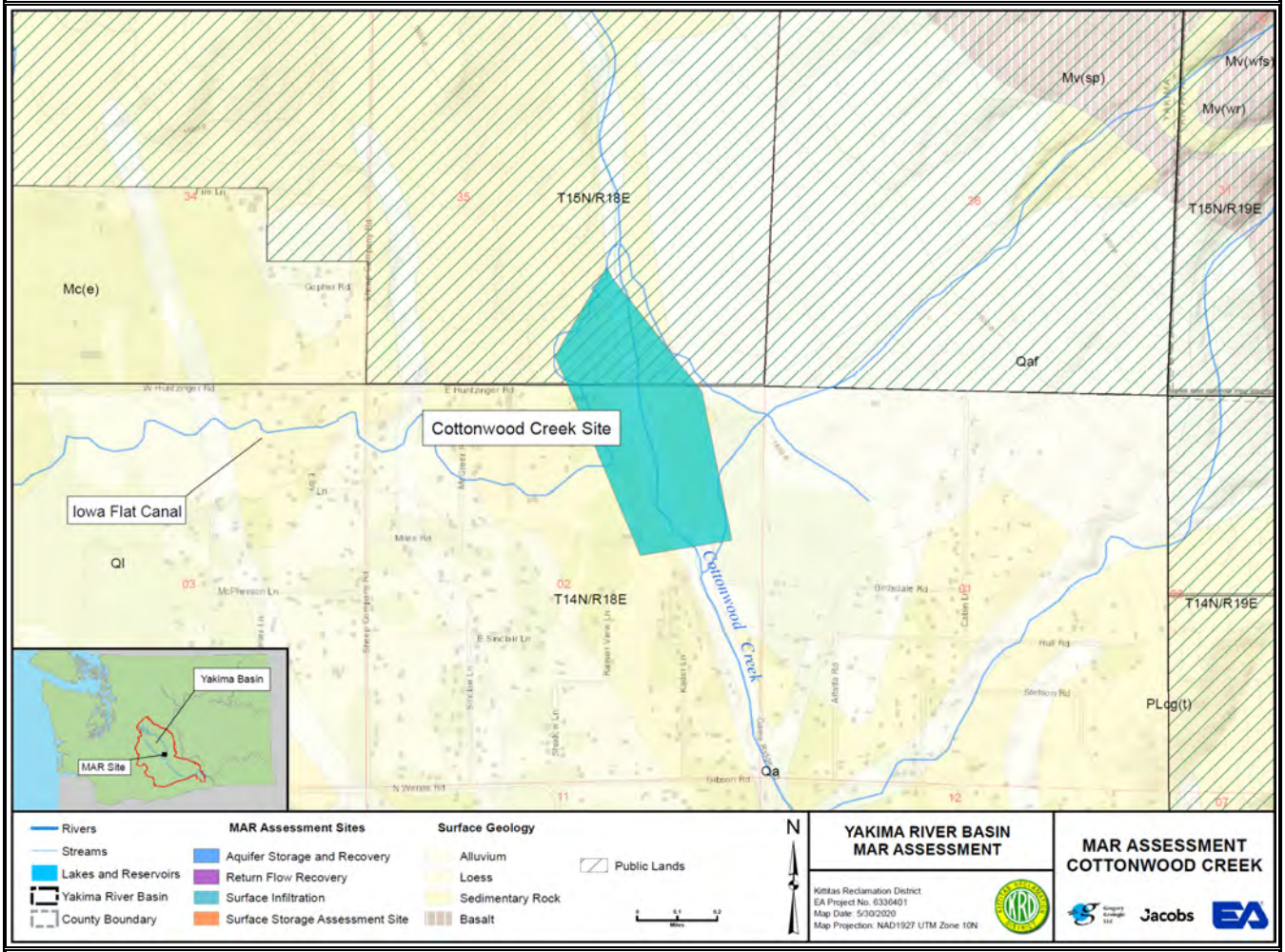
Integration with proposed Integrated Plan or other projects

MAR project would integrate with proposed, in progress and completed instream habitat improvements and fish screens as well as flow supplementation for Coho in Taneum Creek. This site overlaps with the Taneum Creek MAR site so could be used in conjunction with that site to increase seasonal storage.

Project Area Characteristics - Cottonwood Creek

Rank: 7

MAR Project Type: Surface Infiltration



Location (TRS): T14N R16E Section 2; T15N R18E Section 35,

Property Availability

T15N R18E Section 35 in LT Murray Wildlife Area, remainder private.

Site Surface Geology

Quaternary Alluvium/colluvium.

Project Area Subsurface Conditions

Quaternary interfingered with Ellensburg formation sands, silts, gravels, variably cemented.

Depth to Water

The only log shows 139 static, NWIS measurement from the 80's indicates 150 feet.

Hydraulic Conductivity Estimate

Moderate to low based upon cementation, thin Alluvium high.

Water Source and Availability

Flood Flows: Peak 50% flood flow estimate: 30 cfs.

Flows from nearby Irrigation Canals: N/A (Outside of irrigation districts). NOTE- potential of the proposed YTID storage project to create a side channel to divert flow from the mainstem Tieton on to this floodplain.

Conceptual Operational Model

Surface infiltration pond, discharge to ground.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration pond, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase late summer flows in lower Wenas Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals			X
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 122

Location of Benefits to Water Users: Lower Wenas Creek

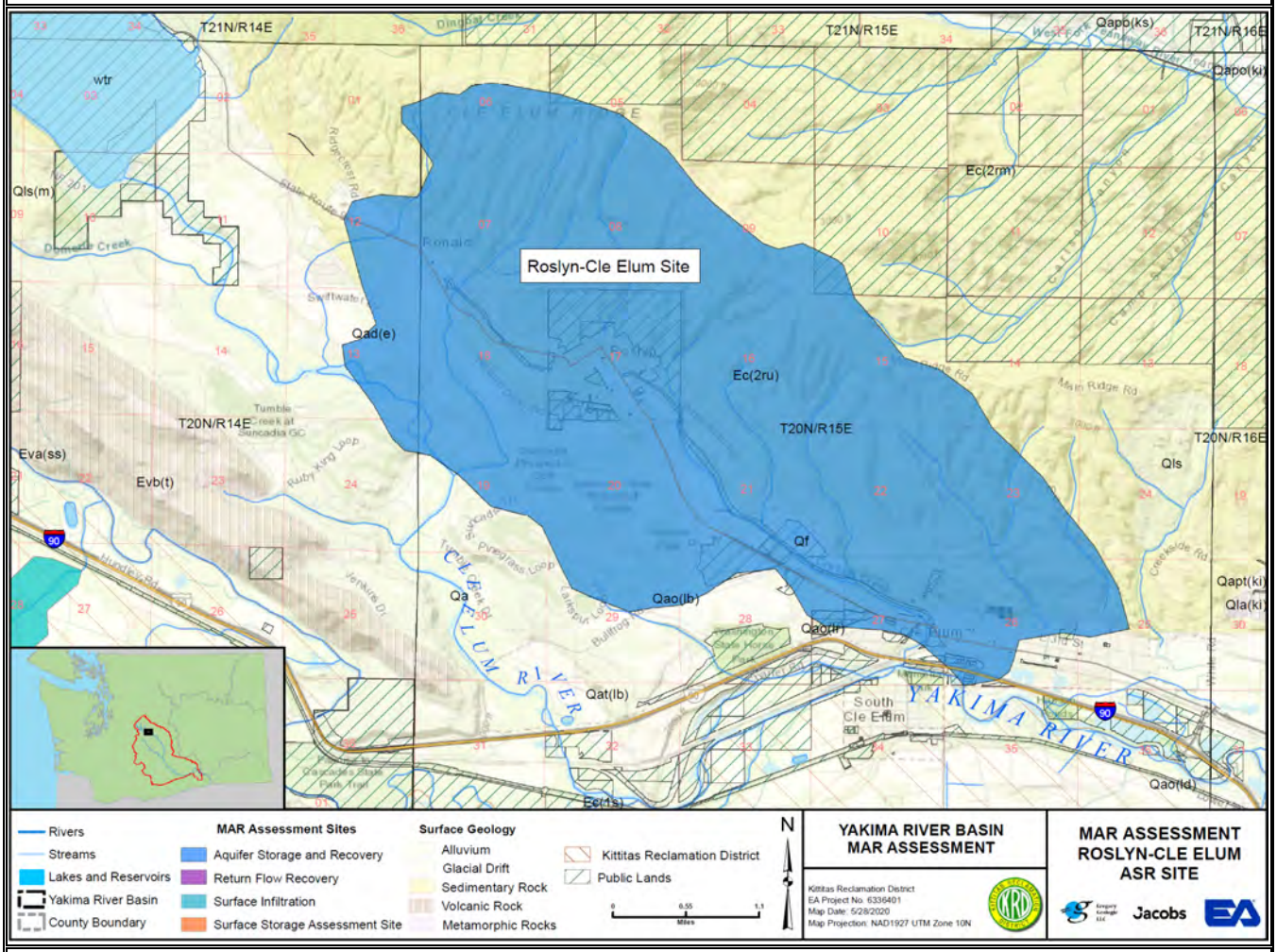
Integration with proposed Integrated Plan or other projects

MAR project on Cottonwood Creek, a tributary to Wenas Creek, would integrate with proposed and in progress fish passage projects as well as flow supplementation in Wenas Creek.

Project Area Characteristics – Roslyn-Cle Elum

Rank: 7

MAR Project Type: Aquifer Storage and Recovery



Location (TRS): T20N R15E, Several Sections

Property Availability

Public/Private

Site Surface Geology

Eocene sandstone and conglomerate with shale and coal in the Roslyn Formation and Quaternary alluvium

Project Area Subsurface Conditions

Eocene sandstone and conglomerate with subordinate shale and coal in the Roslyn Formation

Depth to Water

Highly variable, 0 – 200’

Hydraulic Conductivity Estimate

Unknown, from 1 ft/day in sandstone and conglomerate to very high values in mined coal deposits

Water Source and Availability

KRD Conserved water

Flood Flows from Cle Elum River: N/A

Conceptual Operational Model

Recovery of groundwater from abandoned coal mines using deep wells for discharge to the Yakima River followed by recharge of the mines using diversions from Cle Elum River.

Estimated Costs and Cost Elements

High – Diversion structures, land acquisition, piping, deep wells, monitoring, permitting.

Water Quality Concerns

Unknown, potentially sulfates.

Benefits of Operation

Benefits: Water could be used to increase TWSA, mitigate downstream water withdrawals, and instream flows on the mainstem.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow			X
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use			X
Mitigate effect of permit exempt withdrawals			X
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 183

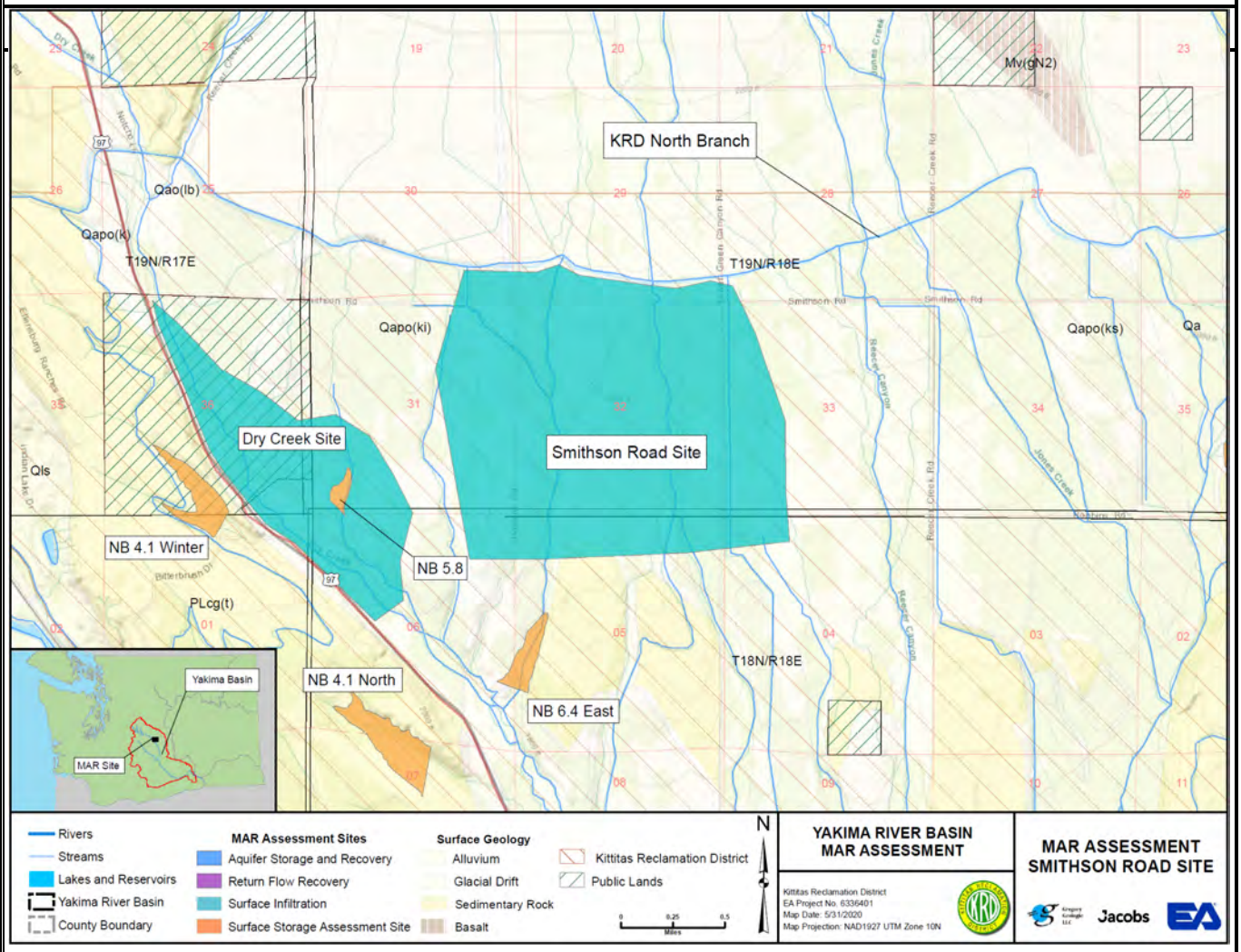
Location of Benefits to Water Users: Downstream from Roslyn Basin.

Integration with proposed Integrated Plan or other projects

This project has the potential for storage and recovery of 20,000 acre-feet which could operate in conjunction with any of the large storage and conservation projects in the basin.

Project Area Characteristics - Smithson Road

Rank: 9



Location (TRS): T19N, R18E, Sections 31 through 33.

Property Availability

Private Land

Site Surface Geology

Thin Quaternary alluvium, distal alluvial fan sediments.

Project Area Subsurface Conditions

Thorp formation with water bearing sands at approximately 120, local basalt under the thin alluvium.

Depth to Water

120-150’

Hydraulic Conductivity Estimate

Water Source and Availability

Flood Flows: (See Coleman Caribou) Approx. 92 cfs peak 50% flood flows.

Flows from nearby Irrigation Canals: Easton Diversion Dam (See Appendix Table 1). Served by KRD Canal, North Branch.

Conceptual Operational Model

Infiltration ponds, canal leakage capture with horizontal drains, flood water and canal delivery capture.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Dry Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: Same as Dry Creek project, Yakima RM 157.

Location of Benefits to Water Users: Lower Dry Creek groundwater users.

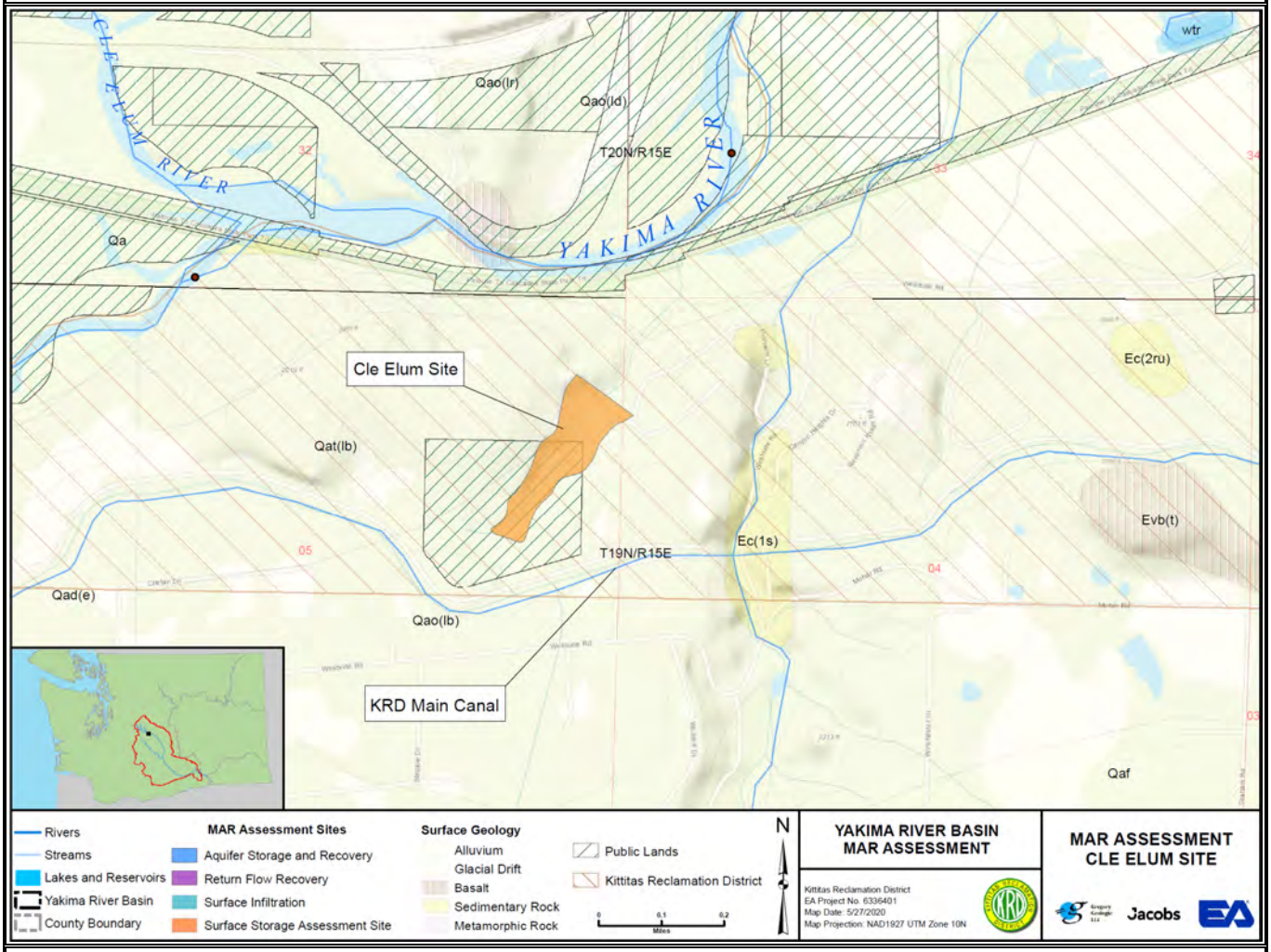
Integration with proposed Integrated Plan or other projects

No habitat projects in the immediate vicinity.

Project Area Characteristics – Cle Elum

Rank: 9

MAR Project Type: Surface Storage Assessment Site – Surface Infiltration



Location (TRS): T19N, R15E, Section 5

Property Availability

Private/Public Land

Site Surface Geology

Fraser-aged alpine glacial outwash of the Lakedale Drift

Project Area Subsurface Conditions

Glacial drift above sedimentary rock 100 – 200 feet below land surface, texture unknown, groundwater flow in fractures in bedrock.

Depth to Water

Water table 50-70 feet below land surface.

Hydraulic Conductivity Estimate

4 – 1,600 ft/day in unconsolidated glacial outwash and drift (Gendaszek et al, 2014)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1).

Conceptual Operational Model

Infiltration pond using KRD Main Canal for recharge.

Estimated Costs and Cost Elements

Low - Diversion structure, infiltration pond, piping, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in lower Tillman Creek and Yakima River, improves riparian habitat and cold water refugia. Mitigation of permit exempt and junior use.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow		X	
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals			X
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mile 185

Location of Benefits to Water Users: Potential for mitigation of permit exempt withdrawals in Roslyn structural basin.

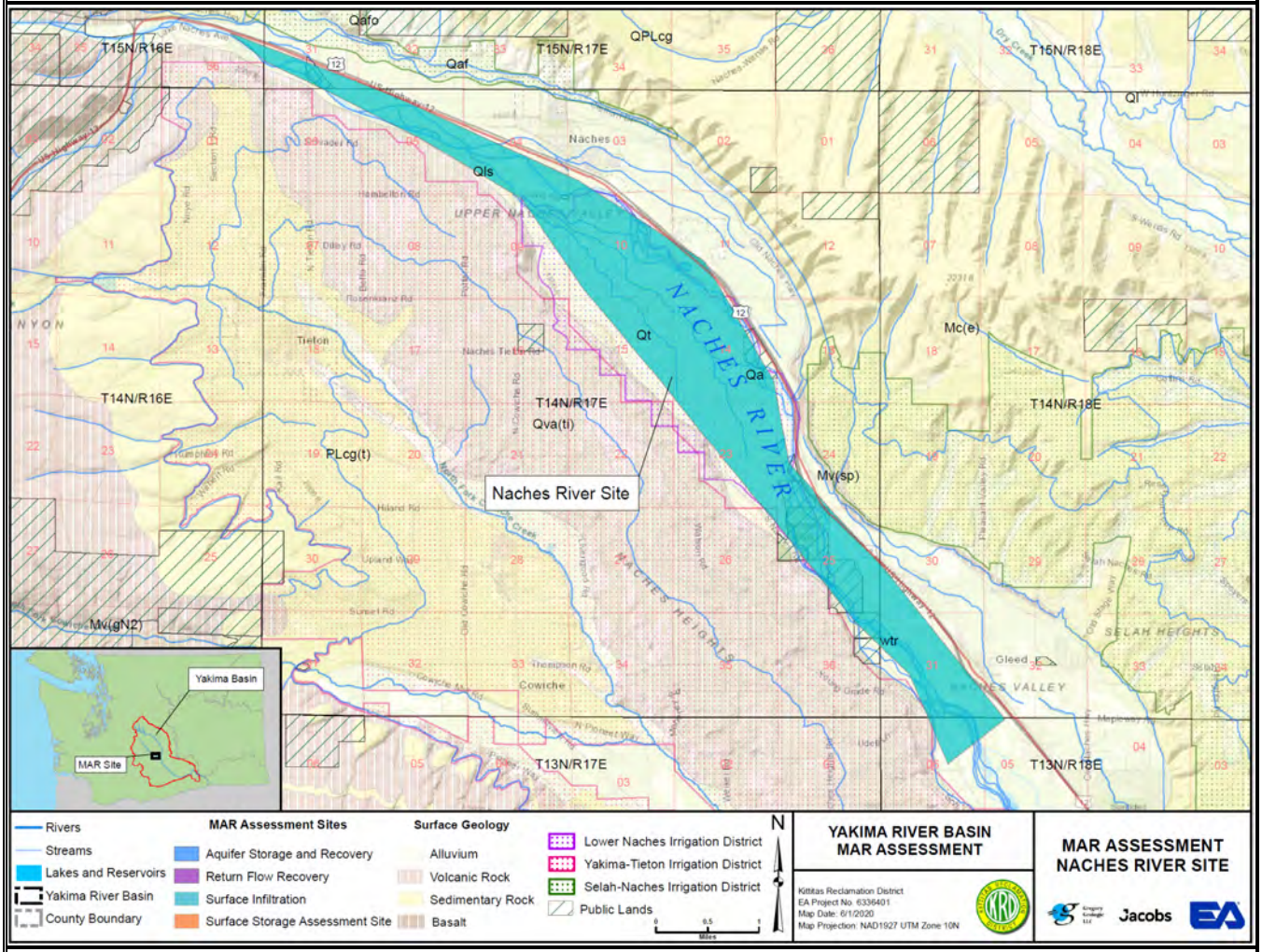
Integration with proposed Integrated Plan or other projects

Unknown

Project Area Characteristics – Naches River

Rank: 11

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T14N, R17E Section 14 and others.

Property Availability

Private Land, intensively cultivated or urbanized.

Site Surface Geology

Thin Quaternary Alluvium.

Project Area Subsurface Conditions

Gravel and Boulders, recent alluvium.

Depth to Water

Shallow.

Hydraulic Conductivity Estimate

Hydraulic Conductivity high in alluvial materials.

Water Source and Availability

Flood Flows: Peak 50% flood flow 7340 cfs.

Flows from nearby Irrigation Canals: Most feasible is South Branch ditch/side channel. See Appendix Table 8 (NACW); Note- limitations to infrastructure not yet defined. Lower Naches, Naches R., Naches Union Districts.

Conceptual Operational Model

Work of the Yakima County Flood control district is in many respects attempting to divert flood flows to recharge. Partnering with this group to monitor and construct facilities to increase flood flow recharge would provide significant savings.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

None.

Benefits of Operation

Benefits: Reduce flooding, connect floodplain to river, delay runoff.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries			X
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of River Benefits: Naches River: RM 18 to 0; Yakima River: Below Yakima RM 116.

Location of Benefits to Water Users: Cities of Naches and Yakima, etc.

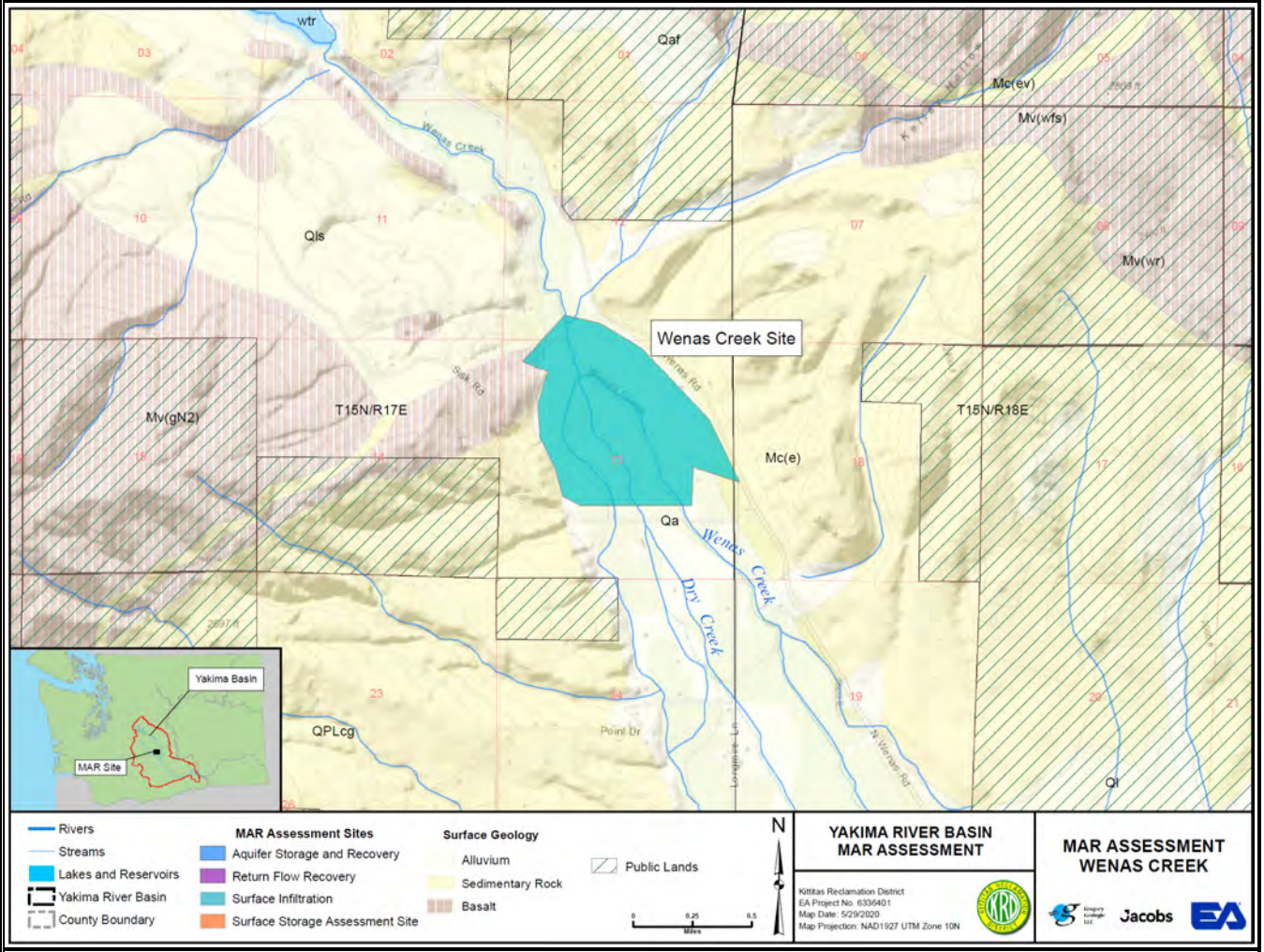
Integration with proposed Integrated Plan or other projects

Yakima County Flood control efforts in Naches Drainage will benefit groundwater conditions and enhance flows at Parker.

Project Area Characteristics – Wenas Creek

Rank: 14

MAR Project Type: Surface Infiltration



Location (TRS): T15N, R17E, Section 13.

Property Availability

Private Land

Site Surface Geology

Quaternary Alluvium, thin soils.

Project Area Subsurface Conditions

Sandstones, sands and clays. Glacial debris or reworked drift.

Depth to Water

200’ depth to water.

Hydraulic Conductivity Estimate

Deep Alluvium, high hydraulic conductivity.

Water Source and Availability

Flood Flows: Peak 50% Flood flow estimate 1740 cfs.

Flows from nearby Irrigation Canals: N/A.

Conceptual Operational Model

Flood flow infiltration ponds.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, stream gaging, monitoring wells.

Water Quality Concerns

Unknown

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mouth of Wenas River. Yakima RM 122.

Location of Benefits to Water Users: Groundwater users in the Wenas Valley.

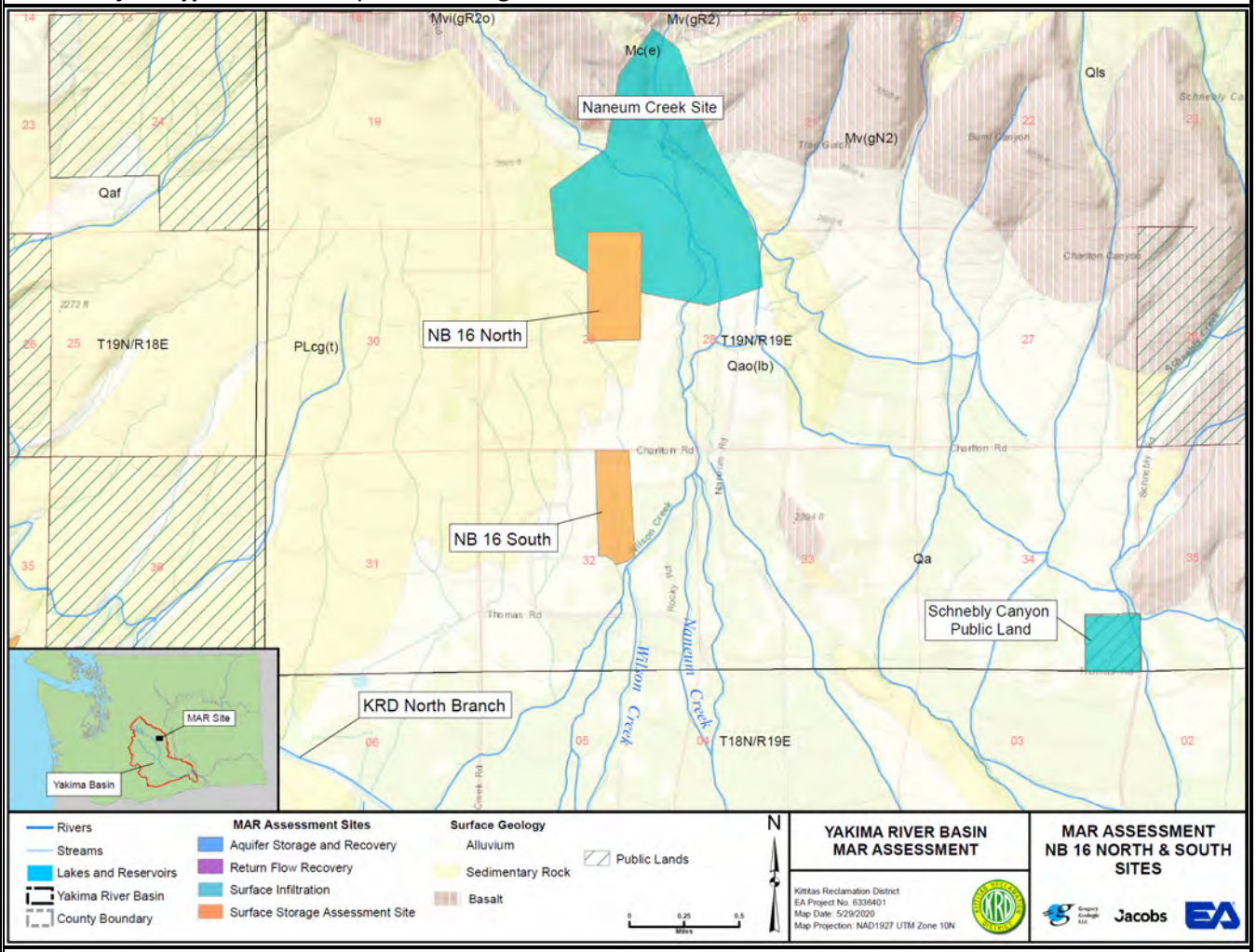
Integration with proposed Integrated Plan or other projects

Proposed fish screen/passage project nearby.

Project Area Characteristics – NB 16 North and South

Rank: NB 16 South – 11, NB 16 North - 27

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T19N, R19E, Section 29 (North) and T19N, R19E, Section 32 (South).

Property Availability

Private land.

Site Surface Geology

Thorp Gravel at NB 16 North, Quaternary Alluvium, recent outwash from Naneum Canyon at NB 16 South.

Project Area Subsurface Conditions

Alluvium 30-100 feet thick, quite coarse, overlying basalt or Thorp-like cemented sands.
Few wells, but groundwater seems shallow (30') in creek channel.

Depth to Water

Shallow.

Hydraulic Conductivity Estimate

Highly variable.

Water Source and Availability

Flood Flows: Naneum Creek, Flood Flows Peak 50% flood 391 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.

Conceptual Operational Model

Infiltration ponds of flood flows into shallow aquifer and alluvial fan sediments at NB 16 South. In this case, likely very low tech to enhance existing percolation operations. Low permeability of Thorp Gravel at NB 16 North makes SAR infeasible.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards.

Benefits of Operation

Benefits: Enhanced ground water in Naneum/Wilson Ck. Drainage, additional flow in North Branch Canal.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: KRD diversion at Easton, RM 202. Baseflow at RM 154

Location of Benefits to Water Users: KRD North Branch canal water users.

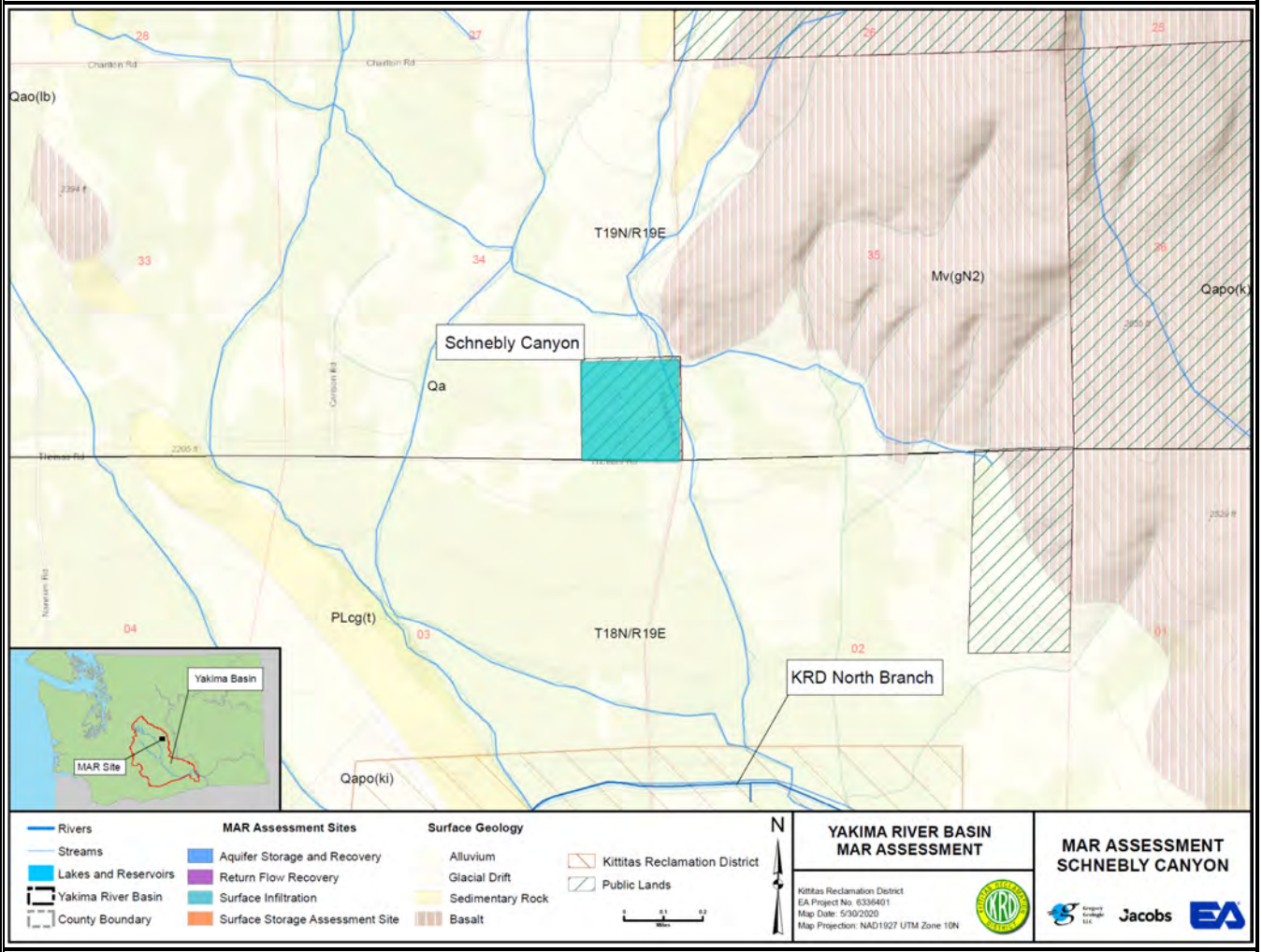
Integration with proposed Integrated Plan or other projects

These sites are two of the surface storage assessment sites which could be used in conjunction with a SAR facility. NB 16 North may be suitable for surface storage and NB 16 South may be suitable for surface infiltration. NB 16 is the 3rd highest ranking surface storage site in Jacobs, 2017.

Project Area Characteristics – Schnebly Canyon

Rank: 14

MAR Project Type: Surface Infiltration



Location (TRS): T19N, R19E, Section 34, SE SE 1/4.

Property Availability

Public land.

Site Surface Geology

Quaternary Alluvium.

Project Area Subsurface Conditions

Basalt at 200'.

Depth to Water

40-50' Static water levels.

Hydraulic Conductivity Estimate

Water Source and Availability

Flood Flows: See Coleman-Caribou: 92 cfs total; Schnelby Canyon 19 cfs Peak 50% flood flow.

Flows from nearby Irrigation Canals: N/A.

Conceptual Operational Model

Infiltration pond or horizontal drain gallery.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Vicinity of Grandview. Yakima RM 147.

Location of Benefits to Water Users: Ground water users in the vicinity of KRD, KRD Canal users downstream from this location.

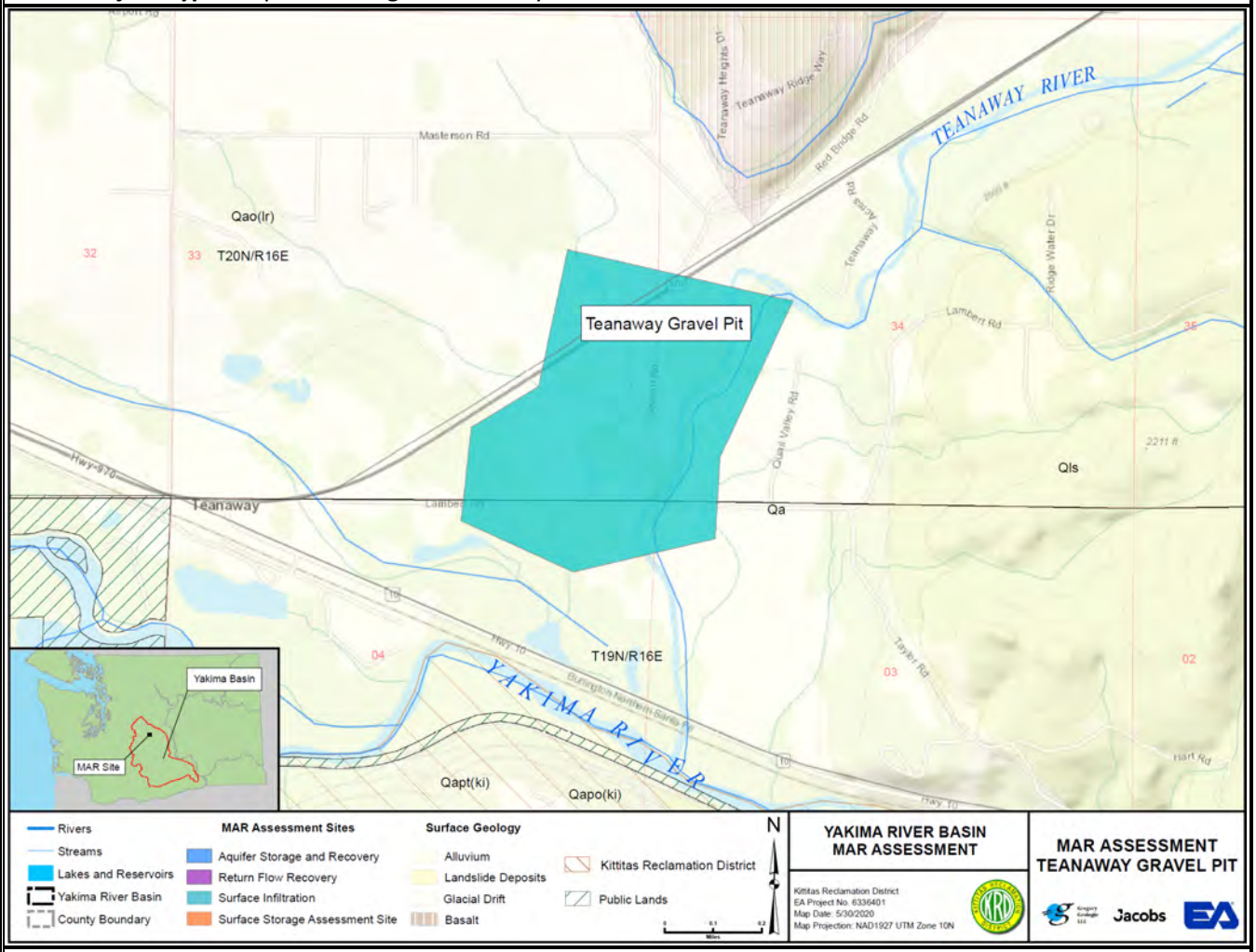
Integration with proposed Integrated Plan or other projects

No habitat projects in the immediate vicinity.

Project Area Characteristics – Teanaway Gravel Pit

Rank: 14

MAR Project Type: Aquifer Storage & Recovery



Location (TRS): T20N, R16E Section 33 (SE1/4).

Property Availability

Private Land

Site Surface Geology

Deep Quaternary Alluvium.

Project Area Subsurface Conditions

Quaternary Alluvium.

Depth to Water

Water table very shallow.

Hydraulic Conductivity Estimate

Deep Alluvium, high Hydraulic Conductivity.

Water Source and Availability

Flood Flows: Peak 50% Flood flow estimate 1740 cfs.

Flows from nearby Irrigation Canals: N/A.

Conceptual Operational Model

Increase head in gravel pit using flood flows diverted from Teanaway River.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, stream gaging, monitoring wells.

Water Quality Concerns

Unknown

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia			X
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mouth of Teanaway River. Yakima RM 176.

Location of Benefits to Water Users: Instream benefits only.

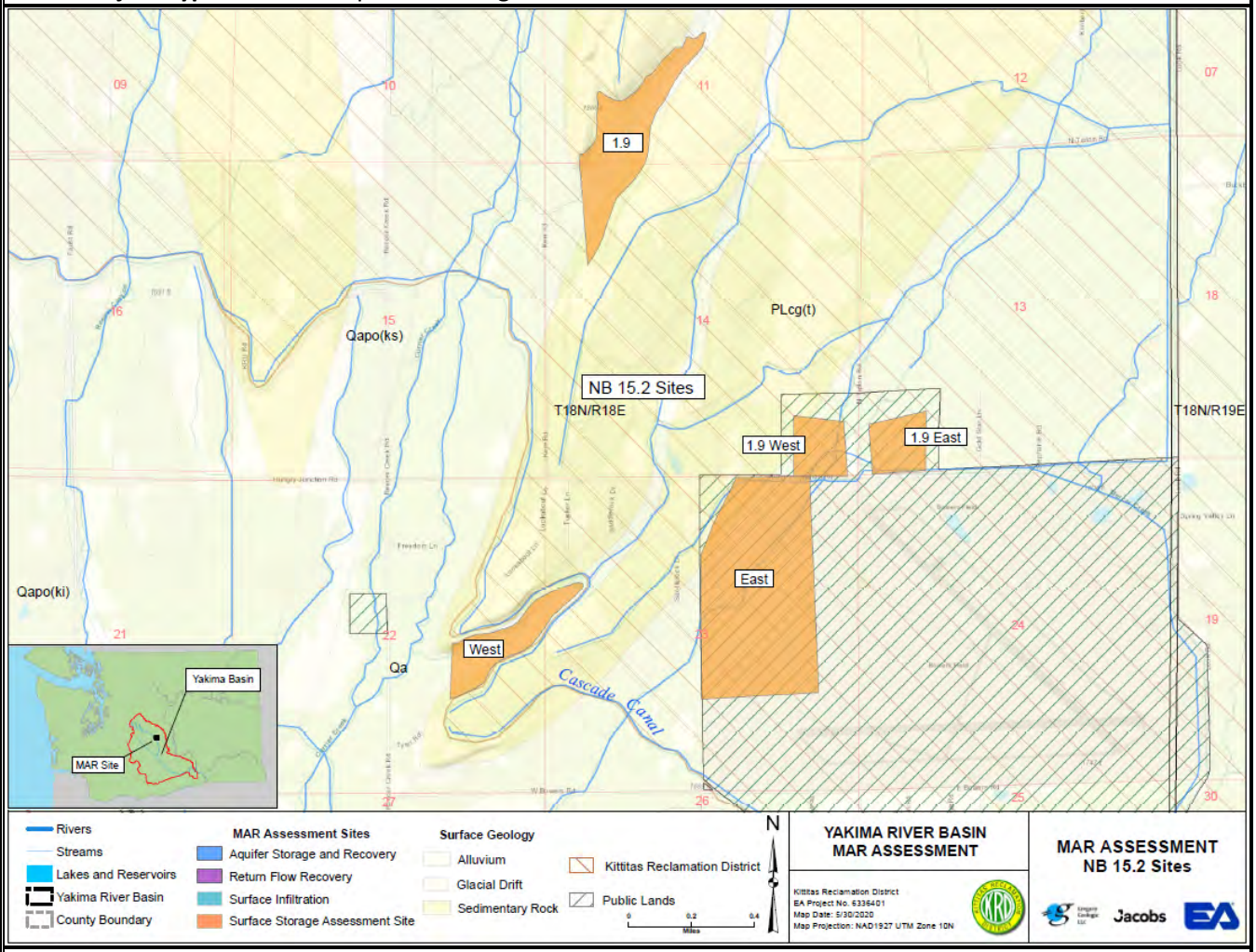
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – NB 15.2 Sites

Rank: 1.9 - 52, West - 73, East - 14, 1.9 West - 14, 1.9 East - 14

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T18N, R18E, Sections 11, 13, 14, 22, and 23.

Property Availability

Private and Public land (sites 1.9 West, 1.9 East and East are located on Bowers Field).

Site Surface Geology

Thorp Gravel and Quaternary Alluvium, recent outwash from Naneum Canyon.

Project Area Subsurface Conditions

Alluvium 30-100 feet thick, quite coarse, overlying basalt or Thorp-like cemented sands.
Few wells, but groundwater seems shallow (30') in creek channel.

Depth to Water

Shallow, variable with irrigation season.

Hydraulic Conductivity Estimate

Highly variable.

Water Source and Availability

Flood Flows: Naneum Creek, Flood Flows Peak 50% flood 391 cfs, Wilson Creek 387 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.

Conceptual Operational Model

Infiltration ponds of flood flows into shallow aquifer and alluvial fan sediments at NB 16 South. In this case, likely very low tech to enhance existing percolation operations. Low permeability of Thorp Gravel at NB 15.2 1.9 and West sites makes SAR less feasible. Other sites on alluvium and public land. Need to be compatible with airport operations.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards.

Benefits of Operation

Benefits: Enhanced late season ground water in Naneum/Wilson Creek drainages.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: KRD diversion at Easton, RM 202. Baseflow at RM 154

Location of Benefits to Water Users: KRD North Branch canal water users.

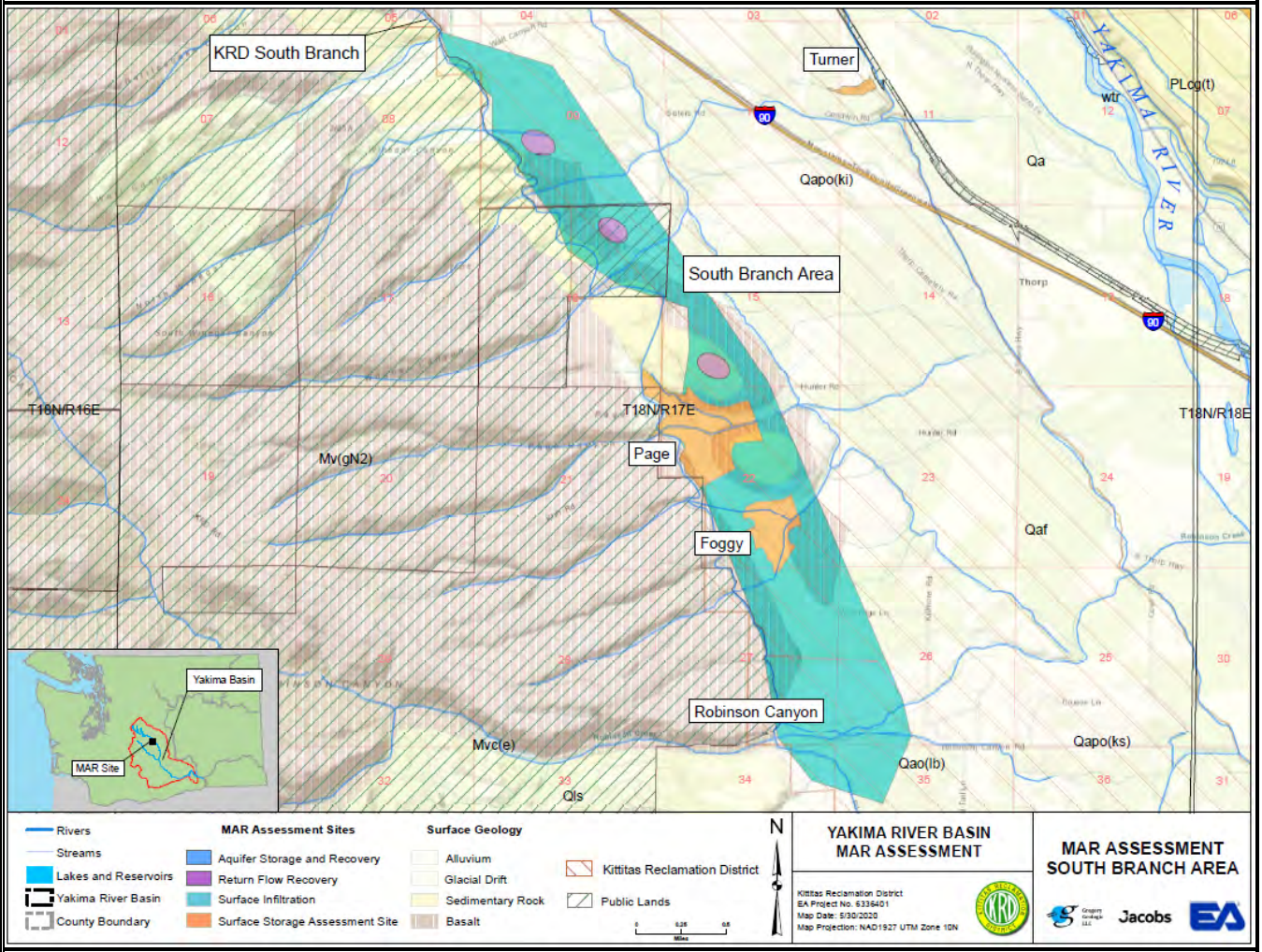
Integration with proposed Integrated Plan or other projects

These sites are five of the surface storage assessment sites (Jacobs, 2017) which could be used in conjunction with a SAR facility.

Project Area Characteristics – South Branch Area

Rank: SAR – 19, RFR - 42

MAR Project Type: Shallow Aquifer Recharge and Return Flow Recovery



Location (TRS): T18N R17E Sections 8, 9, 15, 16, 22, 23, 26, and 27.

Property Availability

Mostly Private land, some DNR.

Site Surface Geology

Quaternary Alluvium, Thorp Gravel, Basalt.

Project Area Subsurface Conditions

Quaternary alluvium of varying thickness over sediment and Grande Ronde Basalt.

Depth to Water

40’ in shallow units to up to 200’ in basalt.

Hydraulic Conductivity Estimate

Highly variable.

Water Source and Availability

Flood Flows: Small drainages.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.

Conceptual Operational Model

Install facilities to intercept, store, and return South Branch Canal leakage. Horizontal drains to collectors, small impoundments and pumping stations.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

None.

Benefits of Operation

Benefits: Any storage and use of recovered water can reduce diversion from Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: KRD diversion at Easton, RM 202.

Location of Benefits to Water Users: KRD South Branch canal water users.

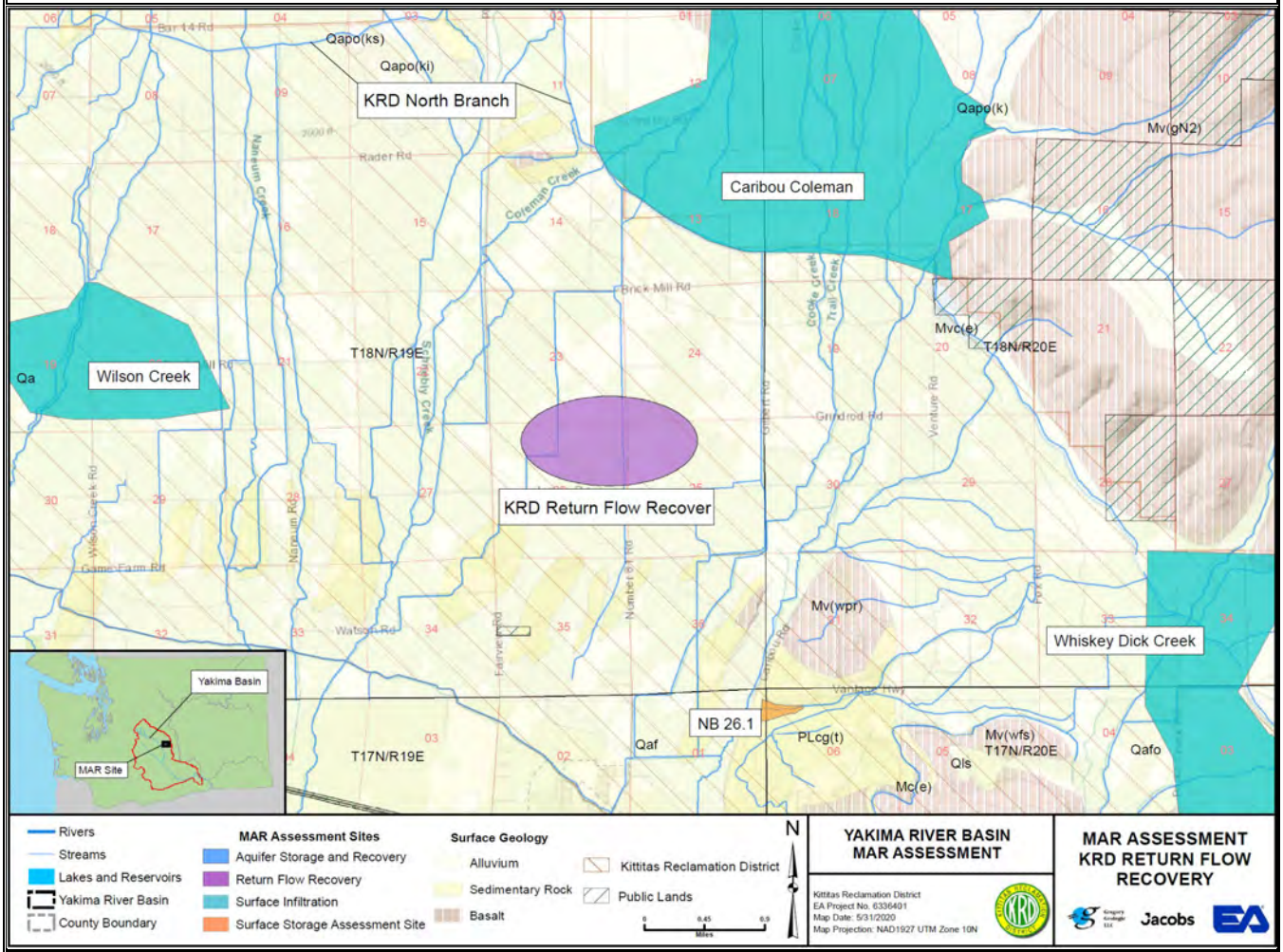
Integration with proposed Integrated Plan or other projects

There are no know fish or habitat projects in the vicinity of this project.

Project Area Characteristics – Kittitas Reclamation District

Rank: 19

MAR Project Type: Return Flow Recovery



Location (TRS): Kittitas Reclamation District

Property Availability

Public and Private – Specific project locations have not been defined.

Site Surface Geology

Variable – Target alluvial deposits with large seasonal variation in groundwater levels near irrigation canals.

Project Area Subsurface Conditions

Alluvial sedimentary deposits

Depth to Water

Less than 50 feet

Hydraulic Conductivity Estimate

5 – 500 ft/day

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD Canal.

Conceptual Operational Model

Shallow production wells would be used to recover water recently leaked to the shallow aquifer system by irrigation practices in the second half of the irrigation season. Recovered water would be discharged back into the irrigation system in leu of diversions from the Yakima River.

Estimated Costs and Cost Elements

Medium – Investigative costs, production wells, monitoring wells, pumps, and pipes. Project includes new power costs to replace gravity-fed diversion with groundwater withdrawals.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increased water supply to KRD, reduced diversions from the Yakima River, increased carry-over storage. Saved water could be used for storage at other locations or for instream flows.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow			X
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: KRD diversion at RM 202

Location of Benefits to Water Users: KRD water users and other junior water rights holders.

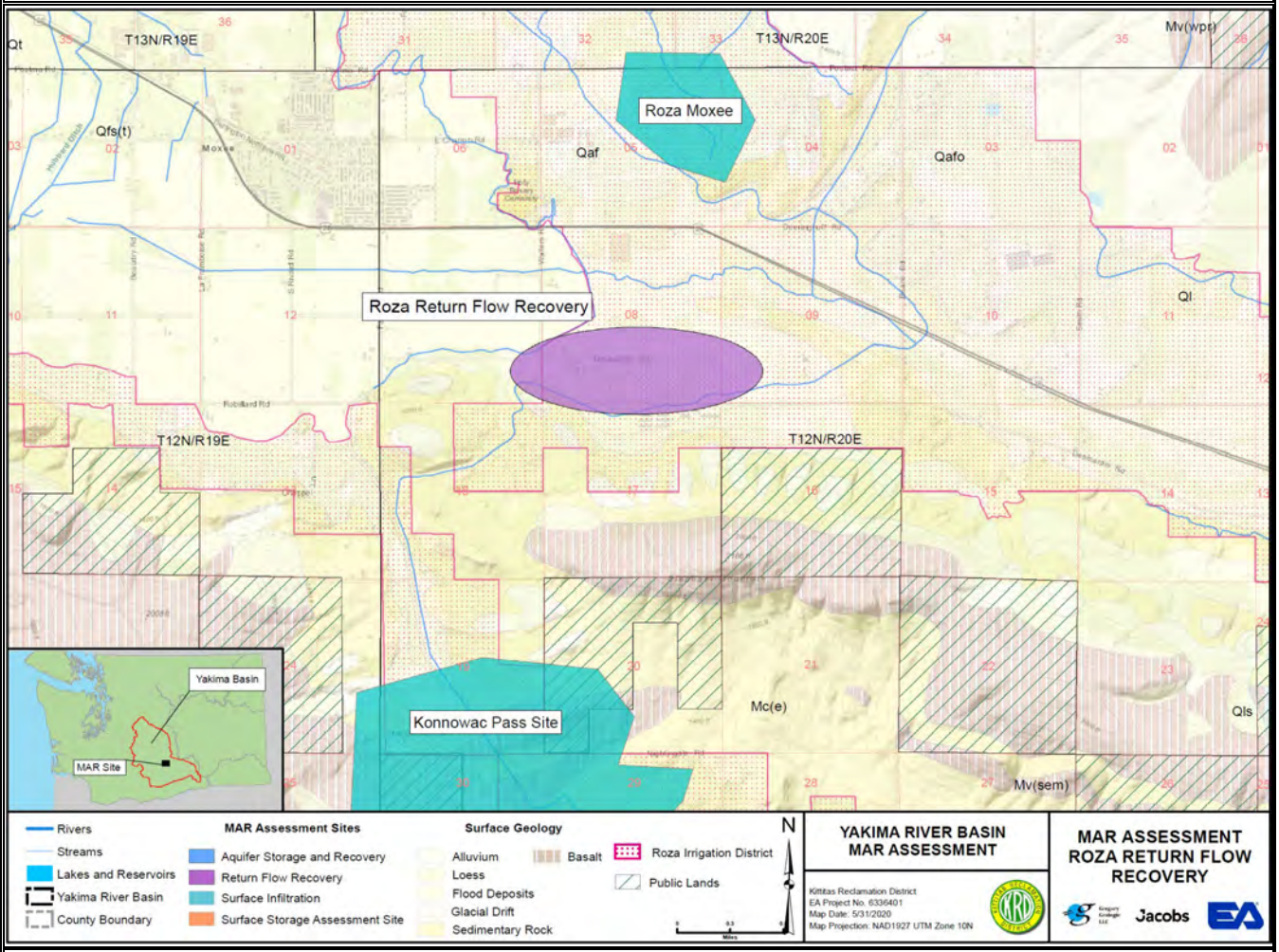
Integration with proposed Integrated Plan or other projects

Water savings and addition to carry-over storage could support all other water savings and habitat projects on the mainstem Yakima River downstream of the diversion.

Project Area Characteristics – Roza Irrigation District

Rank: 19

MAR Project Type: Return Flow Recovery



Location (TRS): Roza Irrigation District

Property Availability

Public and Private – Specific project locations have not been defined.

Site Surface Geology

Variable – Target alluvial deposits with large seasonal variation in groundwater levels near irrigation canals.

Project Area Subsurface Conditions

Alluvial sedimentary deposits

Depth to Water

Less than 50 feet

Hydraulic Conductivity Estimate

5 – 500 ft/day

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Roza Diversion Dam (See Appendix Table 1) at RM 128. Served by Roza canals.

Conceptual Operational Model

Shallow production wells would be used to recover water recently leaked to the shallow aquifer system by irrigation practices in the second half of the irrigation season. Recovered water would be discharged back into the irrigation system in leu of diversions from the Yakima River.

Estimated Costs and Cost Elements

Medium – Investigative costs, production wells, monitoring wells, pumps, and pipes. Project includes new power costs to replace gravity-fed diversion with groundwater withdrawals.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increased water supply to Roza, reduced diversions from the Yakima River, increased carry-over storage. Saved water could be used for storage at other locations or for instream flows.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow			X
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: Roza diversion at RM 128

Location of Benefits to Water Users: Roza water users and other junior water rights holders.

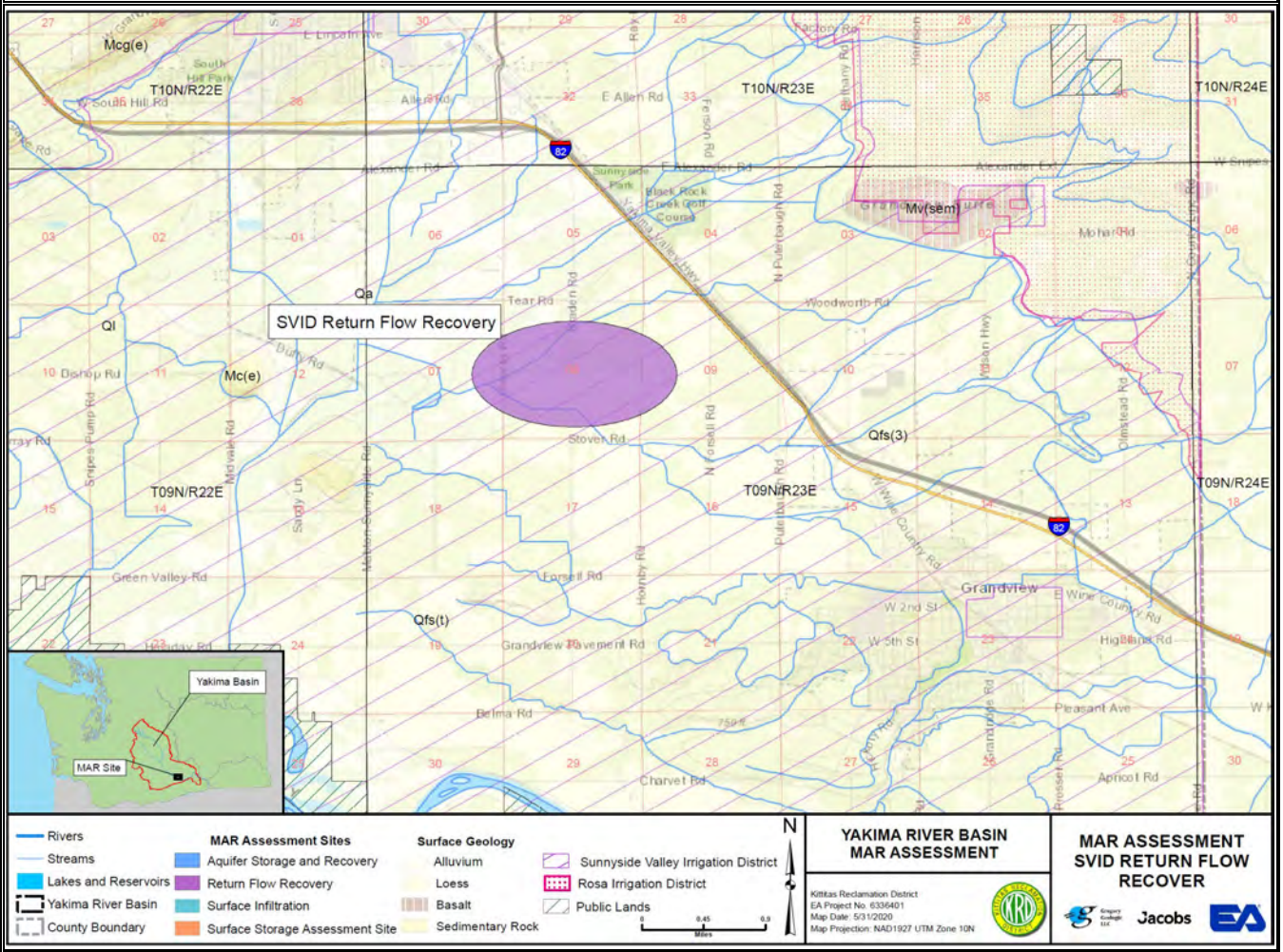
Integration with proposed Integrated Plan or other projects

Water savings and addition to carry-over storage could support all other water savings and habitat projects on the mainstem Yakima River downstream of the diversion.

Project Area Characteristics – Sunnyside Valley Irrigation District

Rank: 19

MAR Project Type: Return Flow Recovery



Location (TRS): Sunnyside Valley Irrigation District

Property Availability

Public and Private – Specific project locations have not been defined.

Site Surface Geology

Variable – Target alluvial deposits with large seasonal variation in groundwater levels near irrigation canals.

Project Area Subsurface Conditions

Alluvial sedimentary deposits

Depth to Water

Less than 50 feet

Hydraulic Conductivity Estimate

5 – 500 ft/day

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: SVID Diversion Dam (See Appendix Table 1) at RM 104. Served by SVID canals.

Conceptual Operational Model

Shallow production wells would be used to recover water recently leaked to the shallow aquifer system by irrigation practices in the second half of the irrigation season. Recovered water would be discharged back into the irrigation system in leu of diversions from the Yakima River.

Estimated Costs and Cost Elements

Medium – Investigative costs, production wells, monitoring wells, pumps, and pipes. Project includes new power costs to replace gravity-fed diversion with groundwater withdrawals.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increased water supply to SVID, reduced diversions from the Yakima River, increased carry-over storage. Saved water could be used for storage at other locations or for instream flows.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow			X
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: SVID diversion at RM 104

Location of Benefits to Water Users: SVID water users and other junior water rights holders.

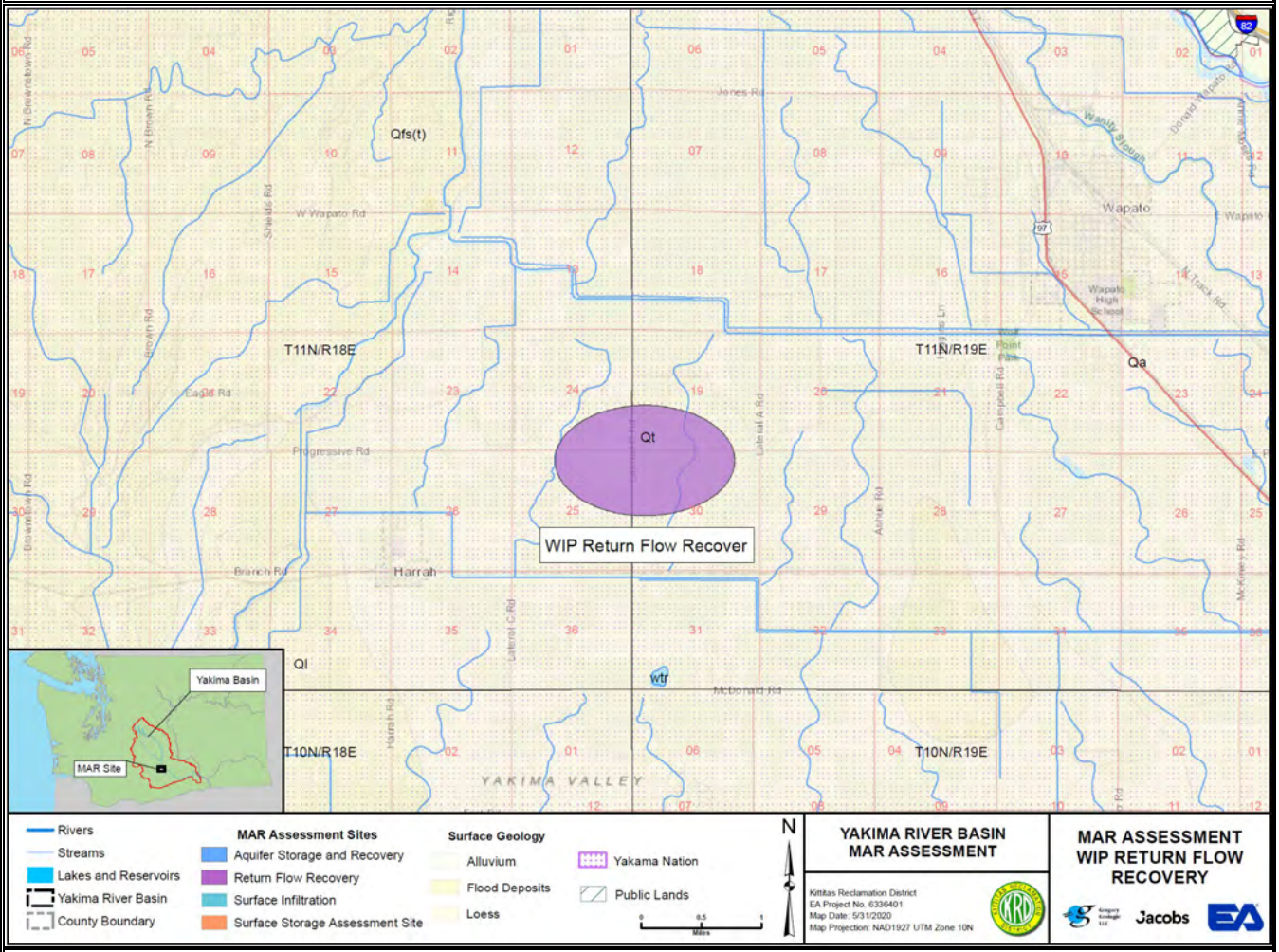
Integration with proposed Integrated Plan or other projects

Water savings and addition to carry-over storage could support all other water savings and habitat projects on the mainstem Yakima River downstream of the diversion.

Project Area Characteristics – Wapato Irrigation Project

Rank: 19

MAR Project Type: Return Flow Recovery



Location (TRS): Wapato Irrigation Project

Property Availability

Public and Private – Specific project locations have not been defined.

Site Surface Geology

Variable – Target alluvial deposits with large seasonal variation in groundwater levels near irrigation canals.

Project Area Subsurface Conditions

Alluvial sedimentary deposits

Depth to Water

Less than 50 feet

Hydraulic Conductivity Estimate

5 – 500 ft/day

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: WIP Diversion Dam (See Appendix Table 1) at RM 106.5. Served by WIP canals.

Conceptual Operational Model

Shallow production wells would be used to recover water recently leaked to the shallow aquifer system by irrigation practices in the second half of the irrigation season. Recovered water would be discharged back into the irrigation system in leu of diversions from the Yakima River.

Estimated Costs and Cost Elements

Medium – Investigative costs, production wells, monitoring wells, pumps, and pipes. Project includes new power costs to replace gravity-fed diversion with groundwater withdrawals.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increased water supply to WIP, reduced diversions from the Yakima River, increased carry-over storage. Saved water could be used for storage at other locations or for instream flows.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow			X
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: WIP diversion at RM 106.5.

Location of Benefits to Water Users: WIP water users and other junior water rights holders.

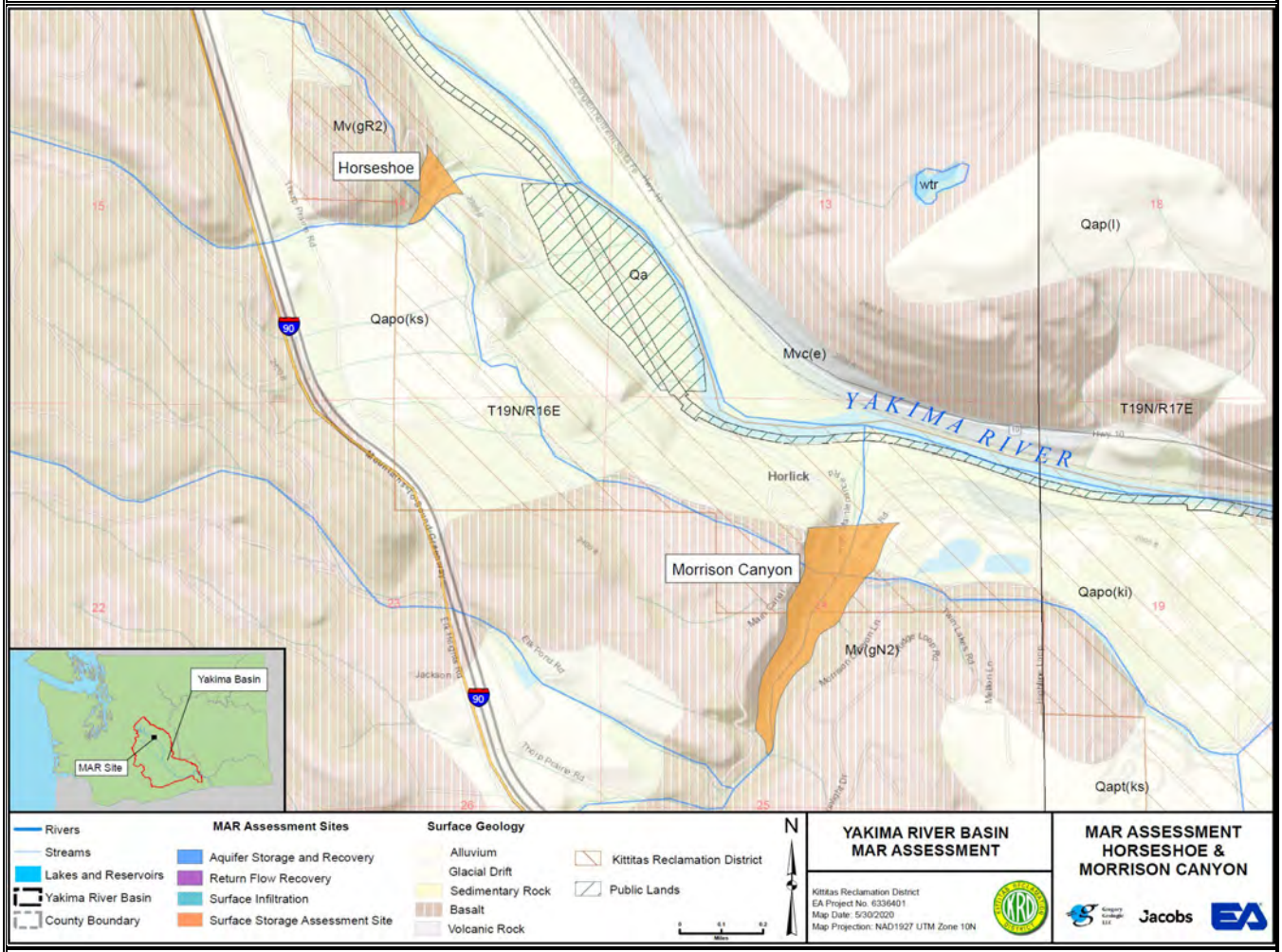
Integration with proposed Integrated Plan or other projects

Water savings and addition to carry-over storage could support all other water savings and habitat projects on the mainstem Yakima River downstream of the diversion.

Project Area Characteristics – Horseshoe & Morrison Canyon

Rank: Horseshoe - 19, Morrison Canyon - 19

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): Horseshoe - T19N, R16E, Section 14, Morrison Canyon - T19N, R16E, Section 24.

Property Availability

Private

Site Surface Geology

Basalt and Glacial Outwash

Project Area Subsurface Conditions

Outwash over sandstone and basalt. Basalt from surface to a depth of 200'

Depth to Water

Variable, 50 – 150'

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones, up to 500 ft/day in outwash (Ely et al, 2011)

Water Source and Availability

Limited tributary flow available.

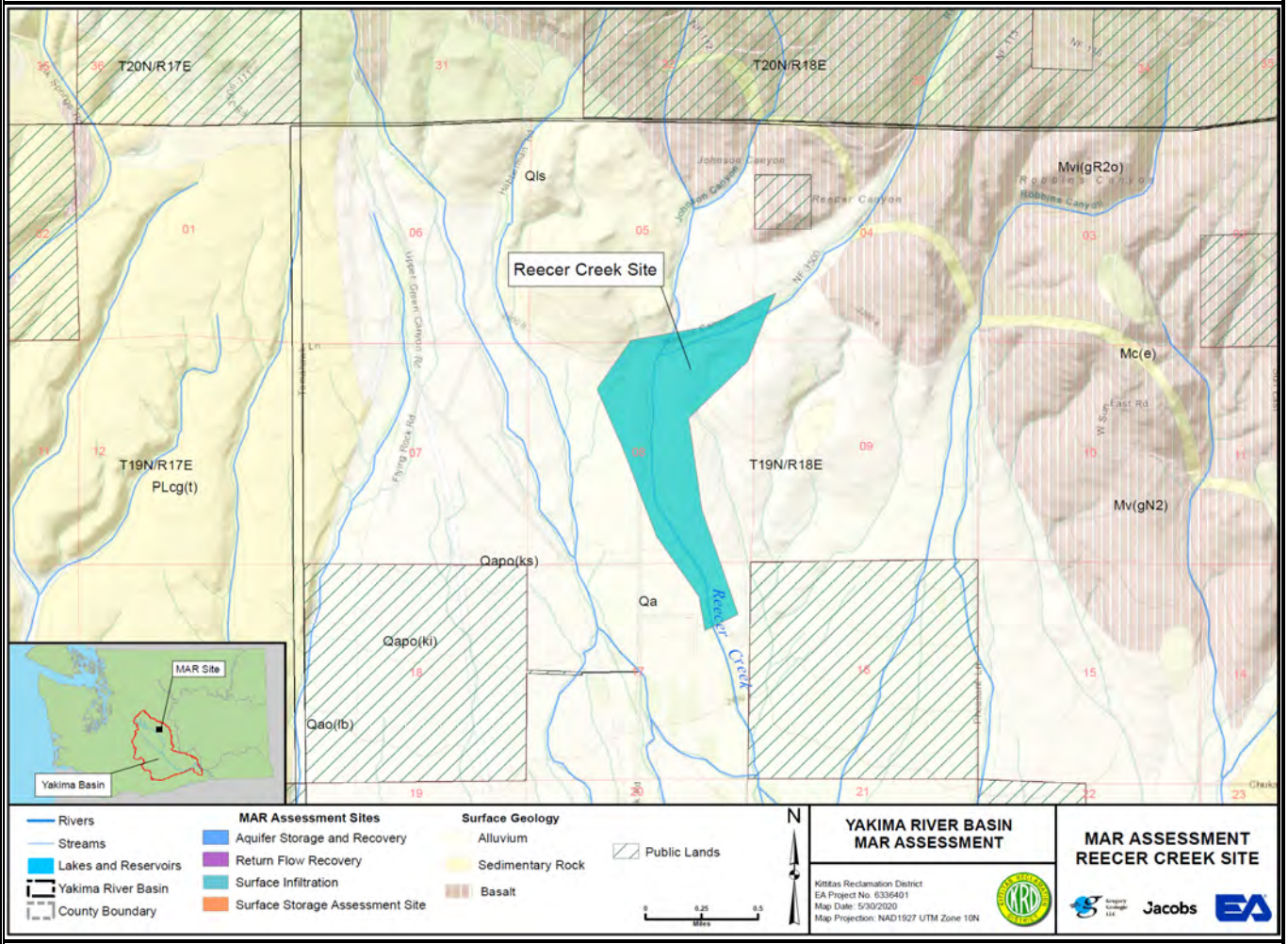
Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model			
Infiltration pond and/or subsurface galleries using flood flows and canal deliveries.			
Estimated Costs and Cost Elements			
Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.			
Water Quality Concerns			
None			
Benefits of Operation			
Benefits: Increase flows in Horseshoe Canyon and Morrison Canyon creeks, improve riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.			
Benefits	**Low**	**Medium**	**High**
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow		X	
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	
Location of Benefits of Operation			
Location of Yakima River Benefits: Horseshoe – RM 173, Morrison Canyon – RM 172			
Location of Benefits to Water Users: Local mitigation for Permit exempt and potentially junior right holder users.			
Integration with proposed Integrated Plan or other projects			
MAR project would integrate with proposed, in progress and completed fish screens and passage projects.			

Project Area Characteristics – Reecer Creek

Rank: 26

MAR Project Type: Surface Infiltration



Location (TRS): T19N R18E, Section 8.

Property Availability

Small private ranches.

Site Surface Geology

Quaternary Alluvium/Fan sequence.

Project Area Subsurface Conditions

Likely Ellensburg Fm. or Pleistocene Indian John at depth, generally quite clayey.

Depth to Water

Water at 3-400 feet, exhibit confined behavior.

Hydraulic Conductivity Estimate

Water Source and Availability

Flood Flows Peak 50% flood flow 30 cfs.

Flows from nearby Irrigation Canals: N/A. 2-3 miles uphill from North Branch Canal.

Conceptual Operational Model

Infiltration pond for flood flows into shallow subsurface.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Reecer Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Yakima RM 154.

Location of Benefits to Water Users: Reecer Creek ground water users, perhaps increased discharge to North Branch Canal.

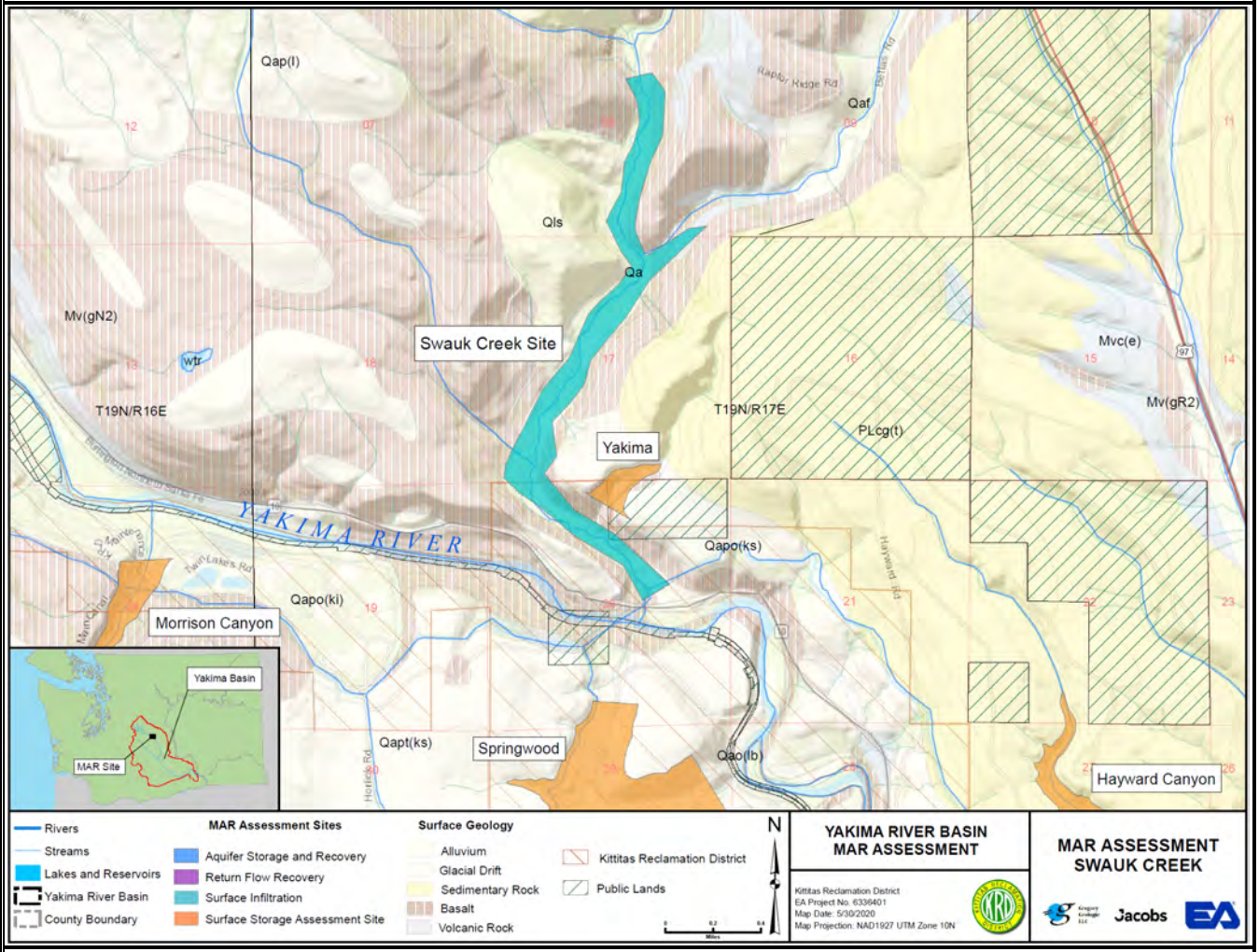
Integration with proposed Integrated Plan or other projects

No habitat projects in the immediate vicinity.

Project Area Characteristics – Swauk Creek

Rank: 27

MAR Project Type: Surface Infiltration



Location (TRS): T19N, R17E Sections 8,9,17.

Property Availability

Private land.

Site Surface Geology

Basalt and Quaternary Alluvium.

Project Area Subsurface Conditions

Basalt at 200'.

Depth to Water

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: Peak 50% flood flows 379 cfs.

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Infiltration pond, horizontal drain gallery or ASR.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mouth of Swauk Creek. Yakima RM 170.

Location of Benefits to Water Users: Downstream surface water users.

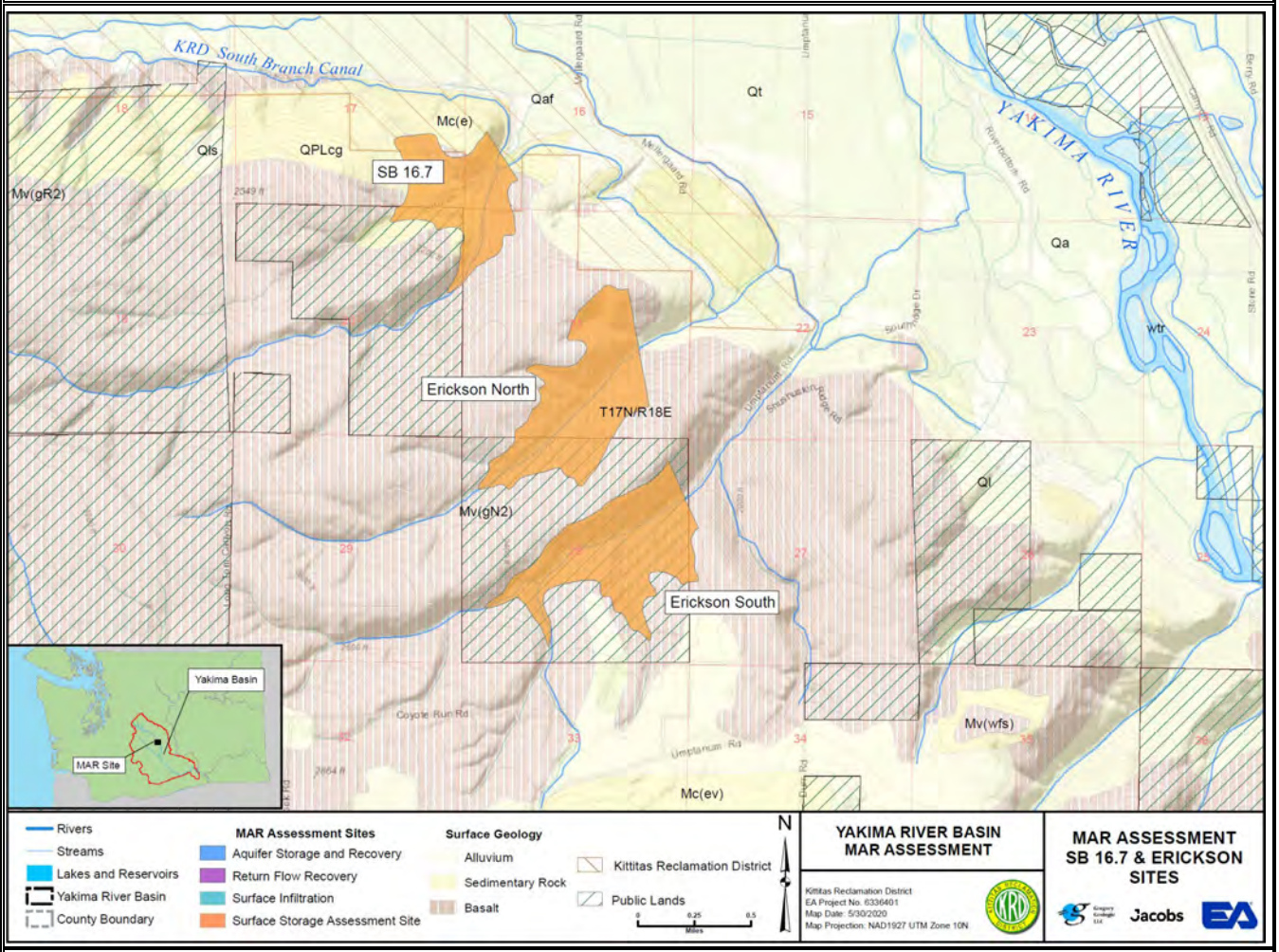
Integration with proposed Integrated Plan or other projects

In-progress and planned habitat projects in the immediate vicinity.

Project Area Characteristics – Erickson South

Rank: 43

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T17N, R18E, Sections 27 and 28

Property Availability

Mostly Public

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Basalt

Depth to Water

150 – 200 feet

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal at RM 202. KRD conserved water. Pumping above canal would be required.
Flood Flows: N/A

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells, pumps.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries. Delay runoff.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: RM 150

Location of Benefits to Water Users: Downstream of RM 150.

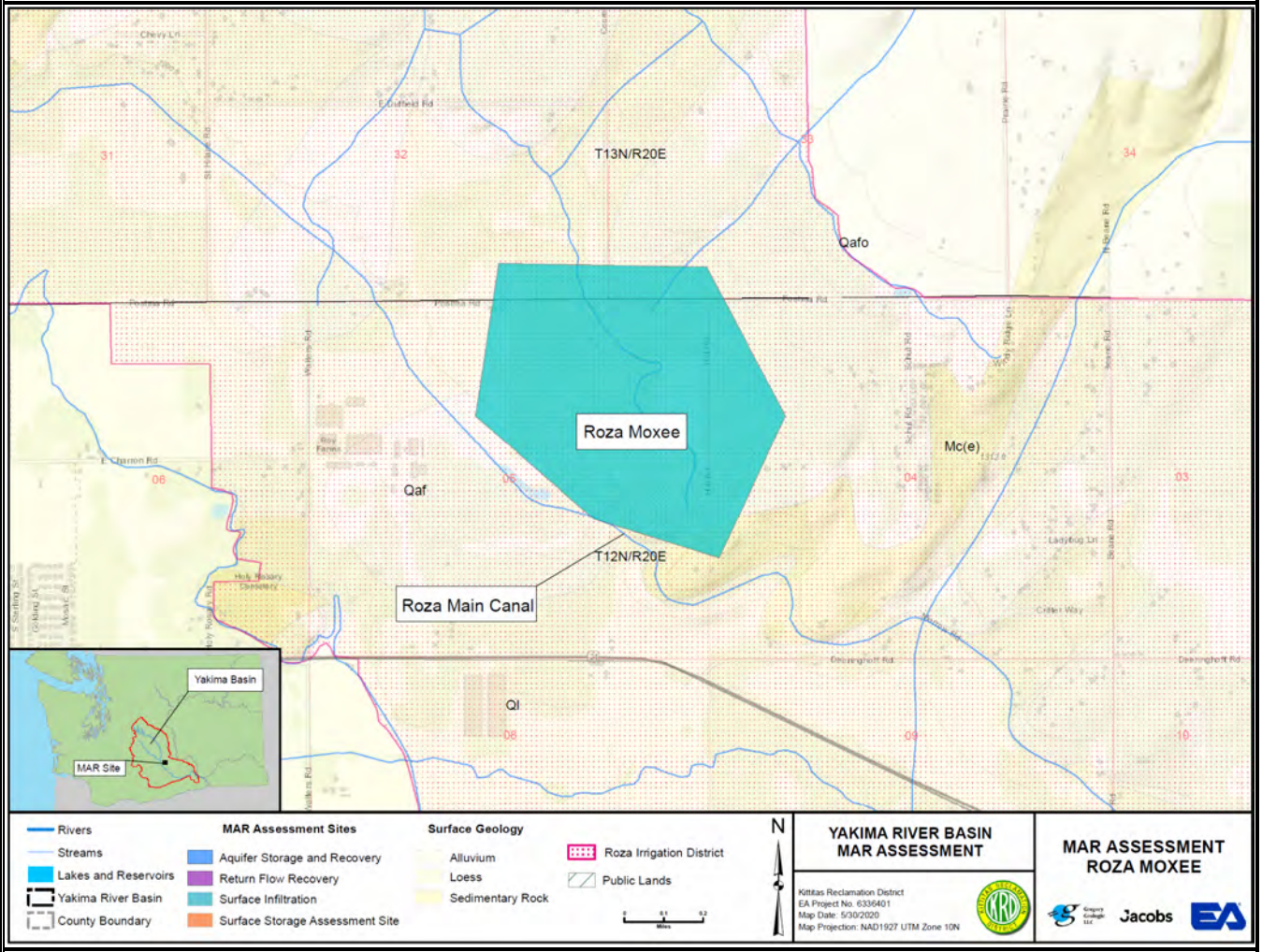
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Roza Moxee

Rank: 30

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T12N R20E Section 5.

Property Availability

Private Land.

Site Surface Geology

Thin Quaternary Alluvium, Alluvial Fan sediments.

Project Area Subsurface Conditions

Mixed sand and clay, Basalt at 1000'.

Depth to Water

Water at 20-50' below ground surface.

Hydraulic Conductivity Estimate

Hydraulic Conductivity highly variable.

Water Source and Availability

Flood Flows: Peak 50% flood flow 11 cfs.

Flows from nearby Irrigation Canals: Roza Diversion Dam, See Appendix Tables 3 & 4.

Conceptual Operational Model

Small storage/infiltration pond accepting water from Roza diversion or Washout Gulch flood flows.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

None.

Benefits of Operation

Benefits: Any storage and use of recovered water can reduce diversion from Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: MP 108 above Union Gap, and/or Roza Dam at RM 128.

Location of Benefits to Water Users: Ground Water users in Moxee City vicinity, Roza Canal irrigators.

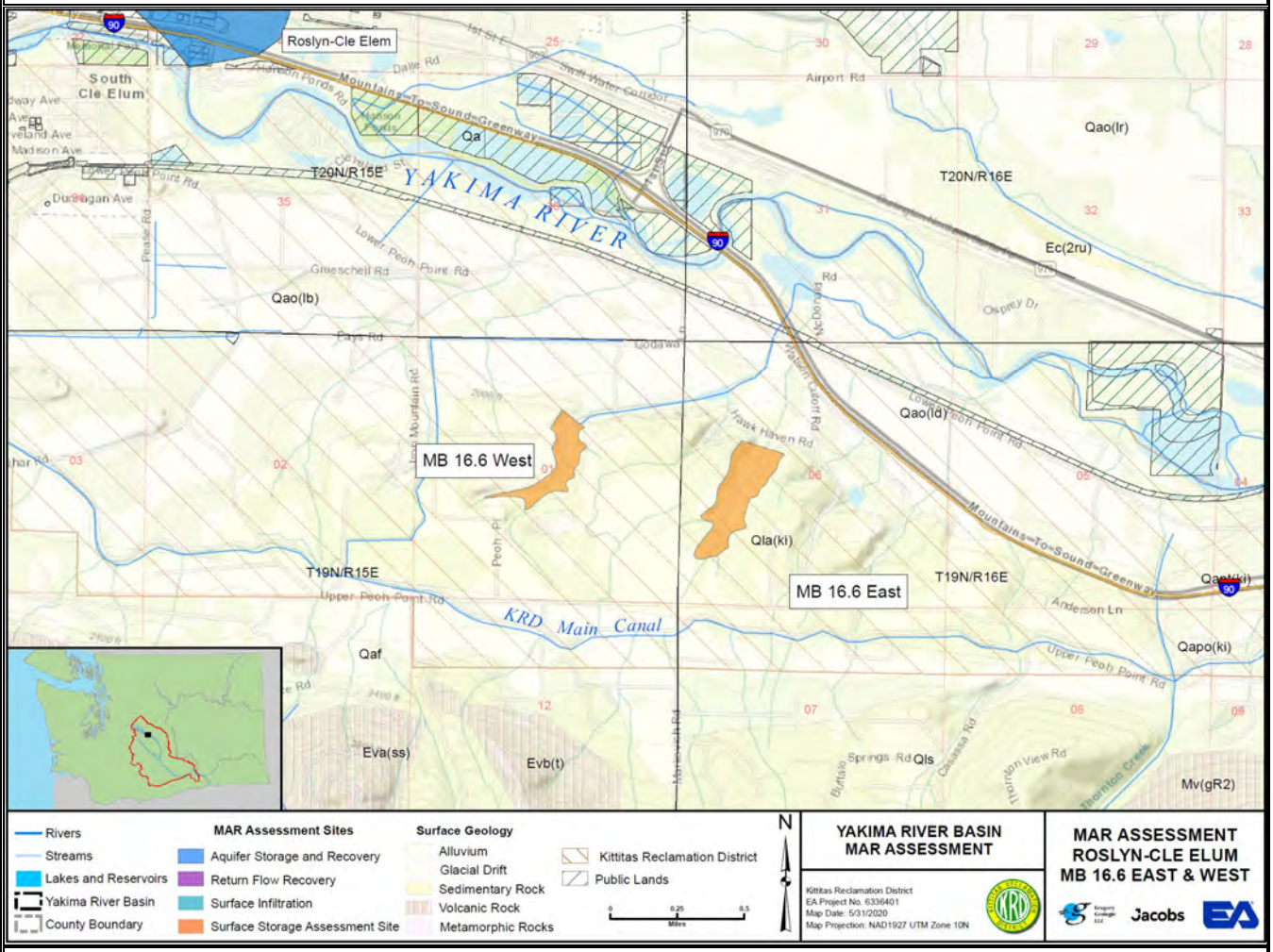
Integration with proposed Integrated Plan or other projects

Irrigation District investigating options.

Project Area Characteristics – MB 16.6 East and West

Rank: 30

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): East - T19N, R16E, Section 6, West - T19N, R15E, Section 1.

Property Availability

Private

Site Surface Geology

Lacustrine Deposits

Project Area Subsurface Conditions

Glacial Drift, clay, silt, sand and gravel

Depth to Water

100 – 200’

Hydraulic Conductivity Estimate

Low in lacustrine deposits

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1).

Conceptual Operational Model

Infiltration pond using KRD Main Canal for recharge.

Estimated Costs and Cost Elements

Low - Diversion structure, infiltration pond, piping, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Delay runoff, **i**ncrease flows in Yakima River, improves riparian habitat and cold water refugia. Mitigation of permit exempt and junior use.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow		X	
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals			X
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 178.5

Location of Benefits to Water Users: Potential for mitigation of permit exempt withdrawals in Roslyn structural basin.

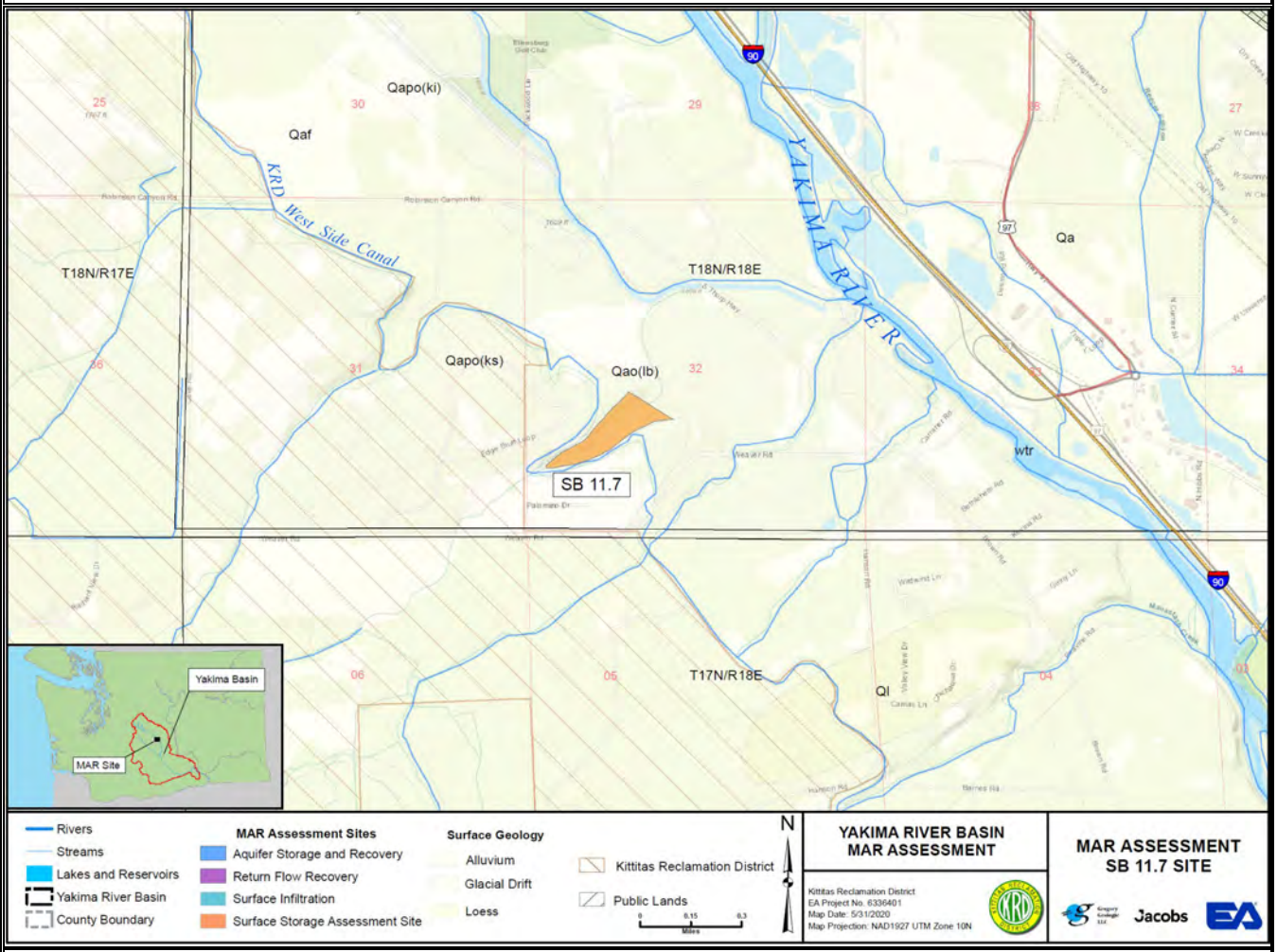
Integration with proposed Integrated Plan or other projects

Unknown

Project Area Characteristics – SB 11.7

Rank: 30

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T18N, R18E, Section 32.

Property Availability

Private

Site Surface Geology

Alpine Glacial Drift

Project Area Subsurface Conditions

Sand, silt, clay, gravel

Depth to Water

50 – 200’

Hydraulic Conductivity Estimate

Variable

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam. See Appendix Table 1. Served by KRD South Branch Canal.

Conceptual Operational Model

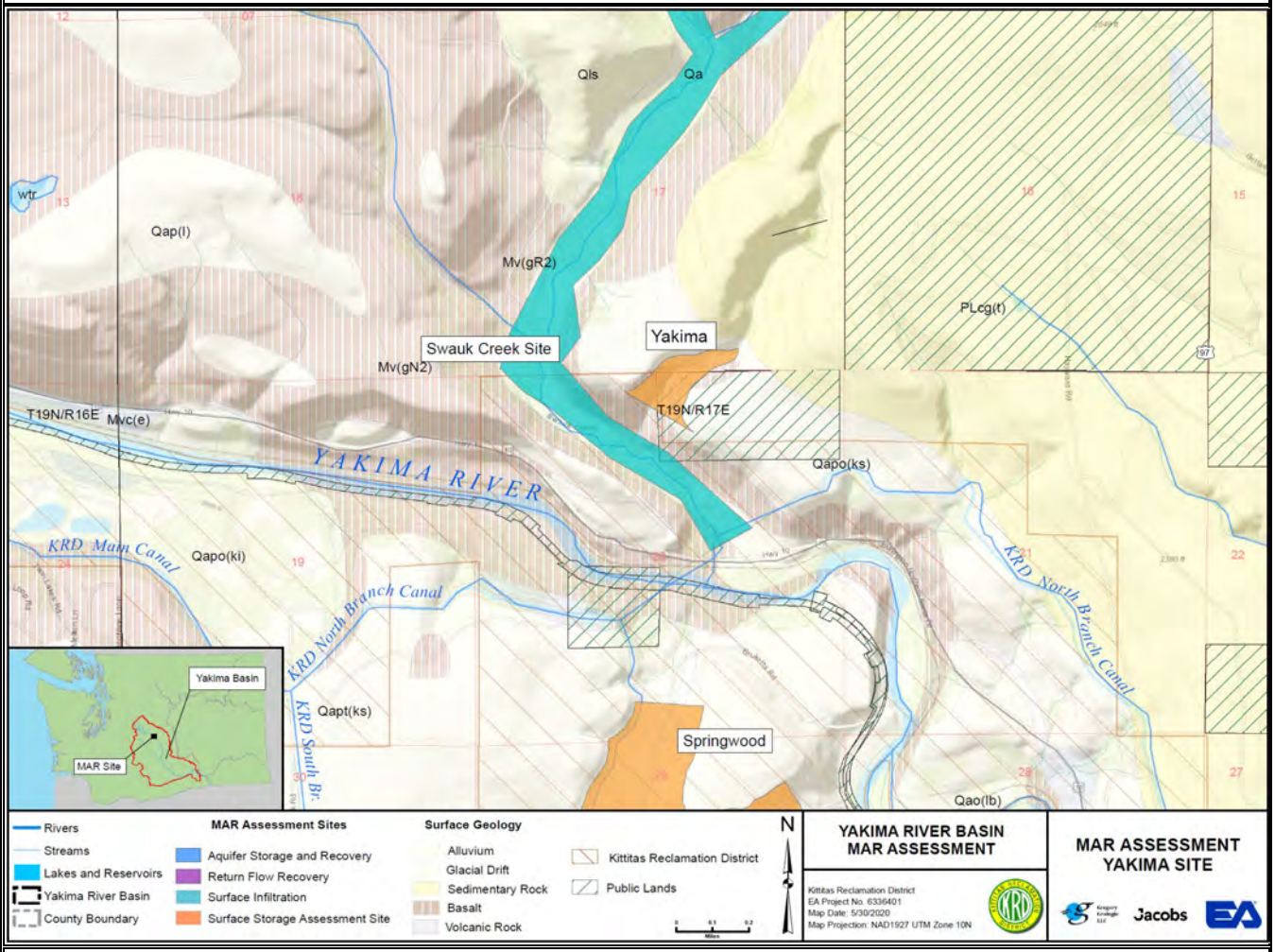
Infiltration pond and/or subsurface galleries using canal deliveries.

Estimated Costs and Cost Elements			
Low - Diversion structures, piping, infiltration ponds, stream gaging, monitoring wells.			
Water Quality Concerns			
None			
Benefits of Operation			
Benefits: Delays runoff in Yakima River, improves riparian habitat and floodplain habitat. Integrates with other on-going habitat and conservation projects.			
Benefits	**Low**	**Medium**	**High**
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X	X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		
Location of Benefits of Operation			
Location of Yakima River Benefits: RM 156			
Location of Benefits to Water Users: Groundwater users in vicinity			
Integration with proposed Integrated Plan or other projects			
No known habitat projects in the immediate vicinity.			

Project Area Characteristics – Yakima Site

Rank: 30

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T19N, R17E, Sections 17 and 20.

Property Availability

Public and Private

Site Surface Geology

Basalt, Outwash and Quaternary Alluvium.

Project Area Subsurface Conditions

Basalt at 200'.

Depth to Water

Unknown

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: Peak 50% flood flows 379 cfs.

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using flood flows and canal deliveries.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells. Need to pump up from canal.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		X
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Mouth of Swauk Creek. Yakima RM 170.

Location of Benefits to Water Users: Downstream surface water users.

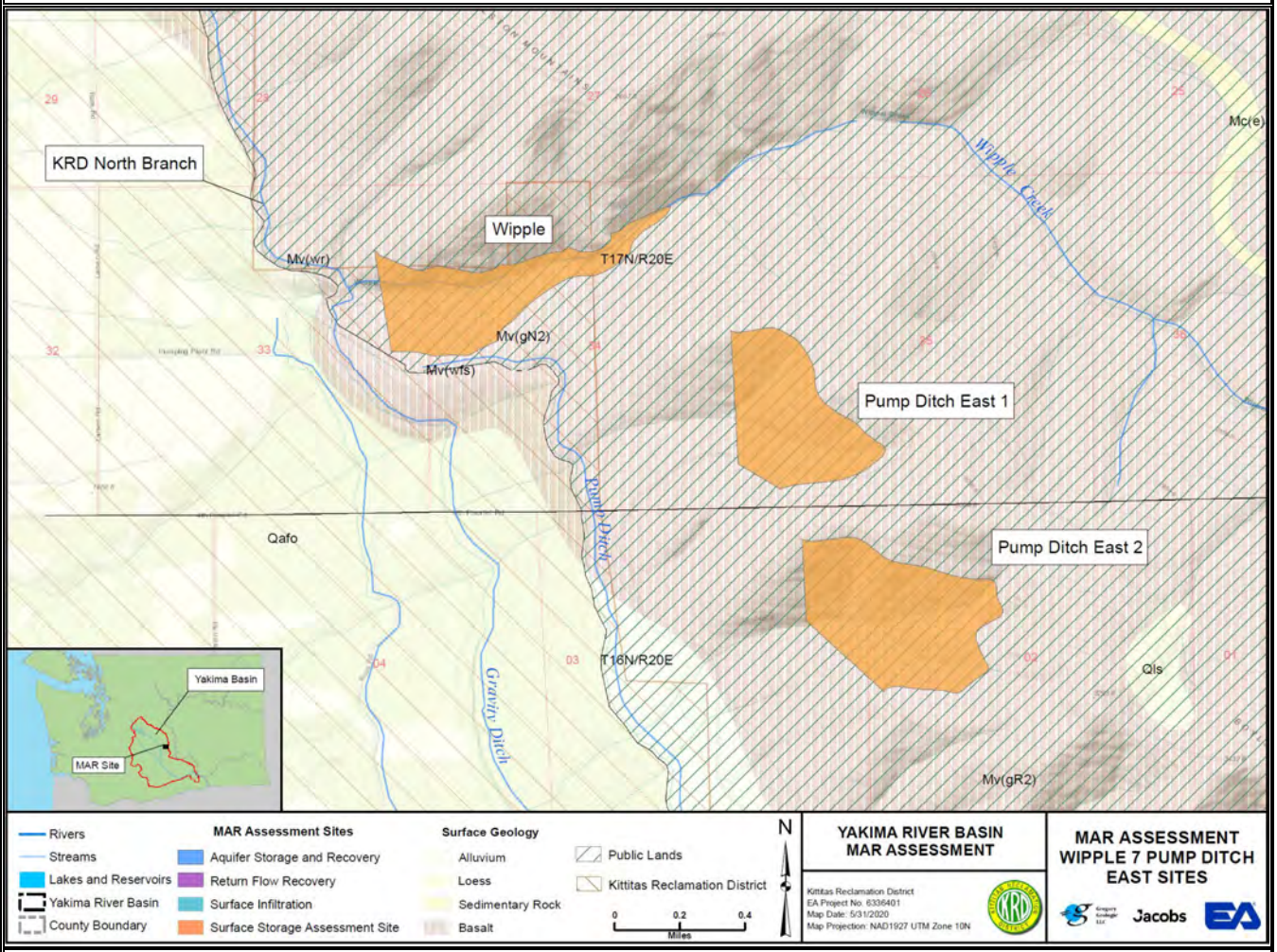
Integration with proposed Integrated Plan or other projects

In-progress and planned habitat projects in the immediate vicinity.

Project Area Characteristics – Wipple

Rank: 35

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T17N, R20E, Sections 33 and 34.

Property Availability

Private

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Basalt

Depth to Water

115’ in basalt

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: Minimal in Wipple Creek

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using canal deliveries.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells. Need to pump up from canal

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: RM 147

Location of Benefits to Water Users: KRD and groundwater users in Badger Pocket.

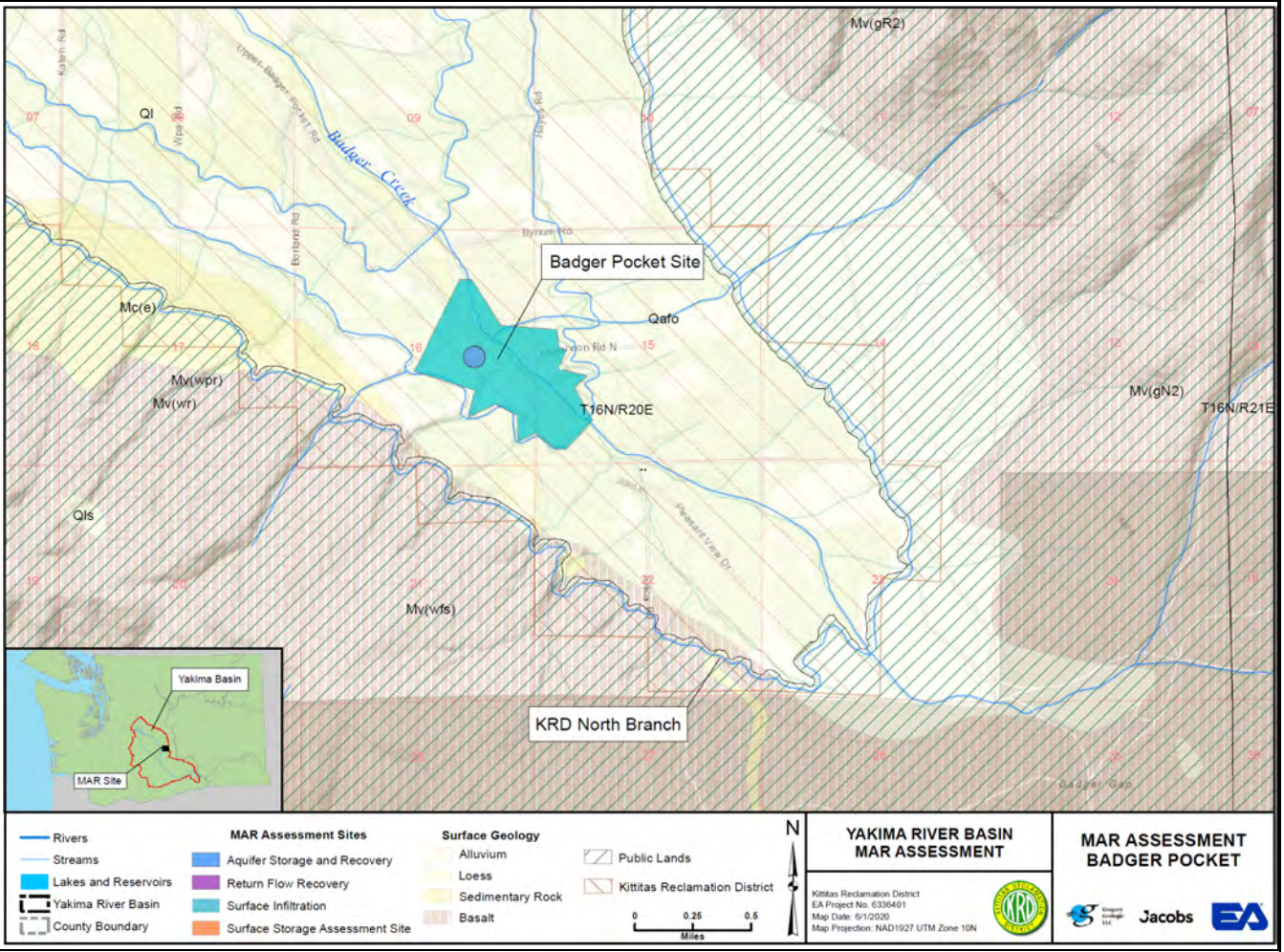
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Badger Pocket

Rank: 36

MAR Project Type: Surface Infiltration or ASR



Location (TRS): T16N R20E Sec 15 and 16

Property Availability

DNR Managed Section 16

Site Surface Geology

Variably cemented gravels and sand. Quaternary fan deposits and Ellensburg formation.

Project Area Subsurface Conditions

Grande Ronde Basalt.

Depth to Water

NWIS indicates 20-30' bgs or artesian. One-mile east, wells have 80' declining statics *USGS 465258120185801*.

Hydraulic Conductivity Estimate

Estimate relatively high in alluvial fan sediments and alluvium.

Water Source and Availability

Flood Flows: Peak 50% flood flow 25 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1). Served by KRD North Branch Canal.

Conceptual Operational Model

Surface infiltration into engineered drainage into alluvial fan. ASR Direct injection into Columbia River Basalt Wanapum formation using injection wells at 80-150', Recovery possible. Recovery of canal leakage.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration facility, ASR wells, monitoring wells.

Water Quality Concerns

Must meet GWQS in aquifer.

Benefits of Operation

Benefits: Saturation of shallow fan sediments: Increased availability for local ground water users, leakage to Yakima River above Umtanum.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia		X	
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: At the mouth of the canyon RM 148.

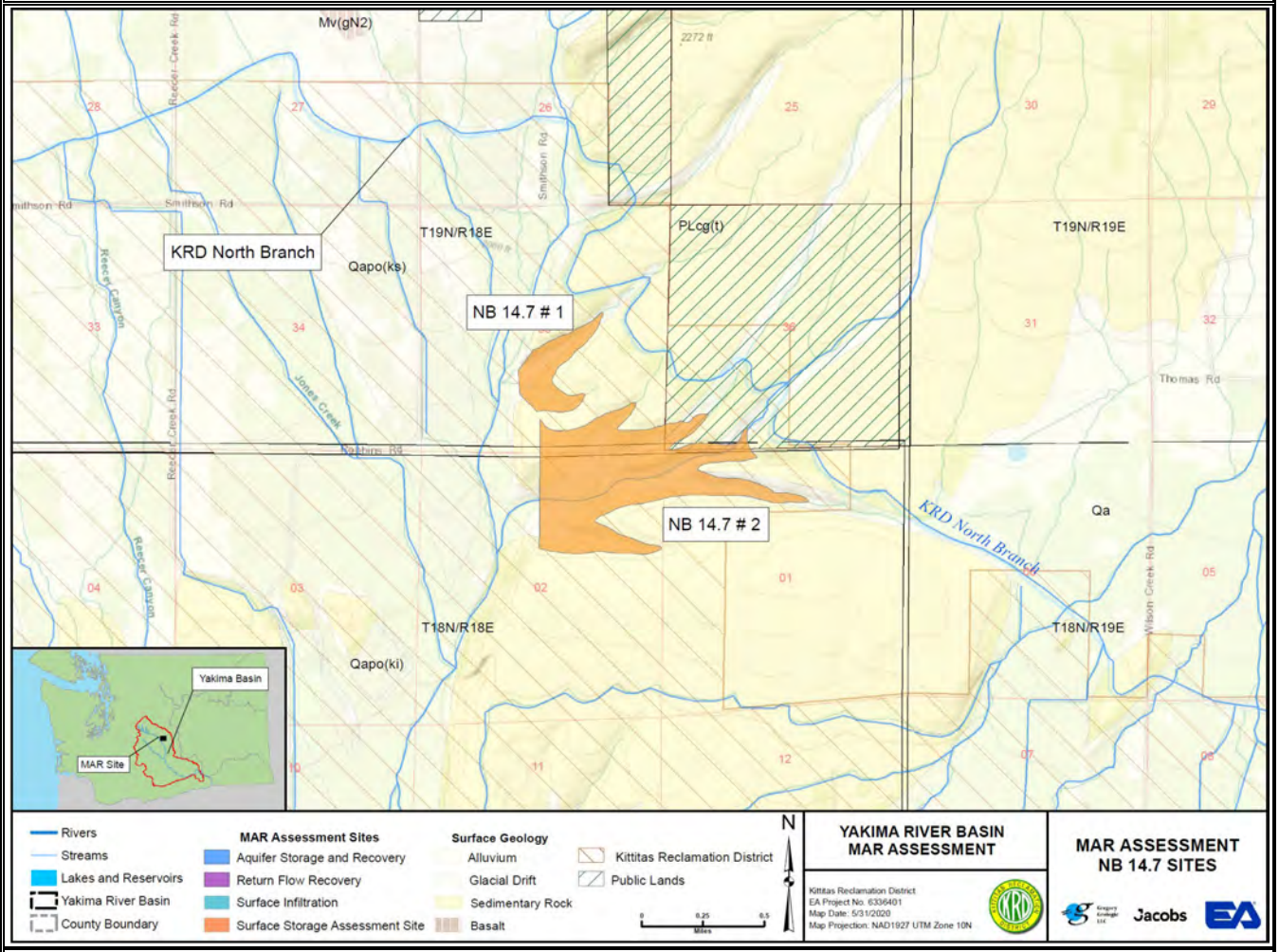
Location of Benefits to Water Users: KRD below Badger Pocket.

Integration with proposed Integrated Plan or other projects

Project Area Characteristics – NB 14.7 #1 and #2

Rank: 36

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): NB 14.7 #1 - T19N, R18E, Section 35, NB 14.7 #2 - T18N, R18E, Sections 1 and 2.

Property Availability

Mostly private land, NE portion of #2 is public land.

Site Surface Geology

Thin Quaternary alluvium overlying Thorp Gravel

Project Area Subsurface Conditions

Thorp formation with water bearing sands at approximately 113', Basalt below 120' with water bearing unit at 240'

Depth to Water

110-150', Static Water Level in basalt 40'

Hydraulic Conductivity Estimate

Highly variable

Water Source and Availability

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by KRD Canal, North Branch.

Flood Flows: limited

Conceptual Operational Model

Surface infiltration into engineered drainage into alluvial fan. ASR direct injection into Columbia River Basalt using injection wells at 120-150', recovery possible. Recovery of canal leakage.

Estimated Costs and Cost Elements

Low – Medium. Diversion structures, piping, infiltration ponds, stream gaging, production, and monitoring wells.

Water Quality Concerns

None with SAR, compliance with state Groundwater Quality Standards with ASR.

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to Currier Creek, a tributary to the Yakima River. Capture of canal leakage could save water at diversion.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: Currier Creek discharges to the Yakima River at RM 154

Location of Benefits to Water Users: Ground water users in Kittitas area, KRD users downgradient if ASR project developed.

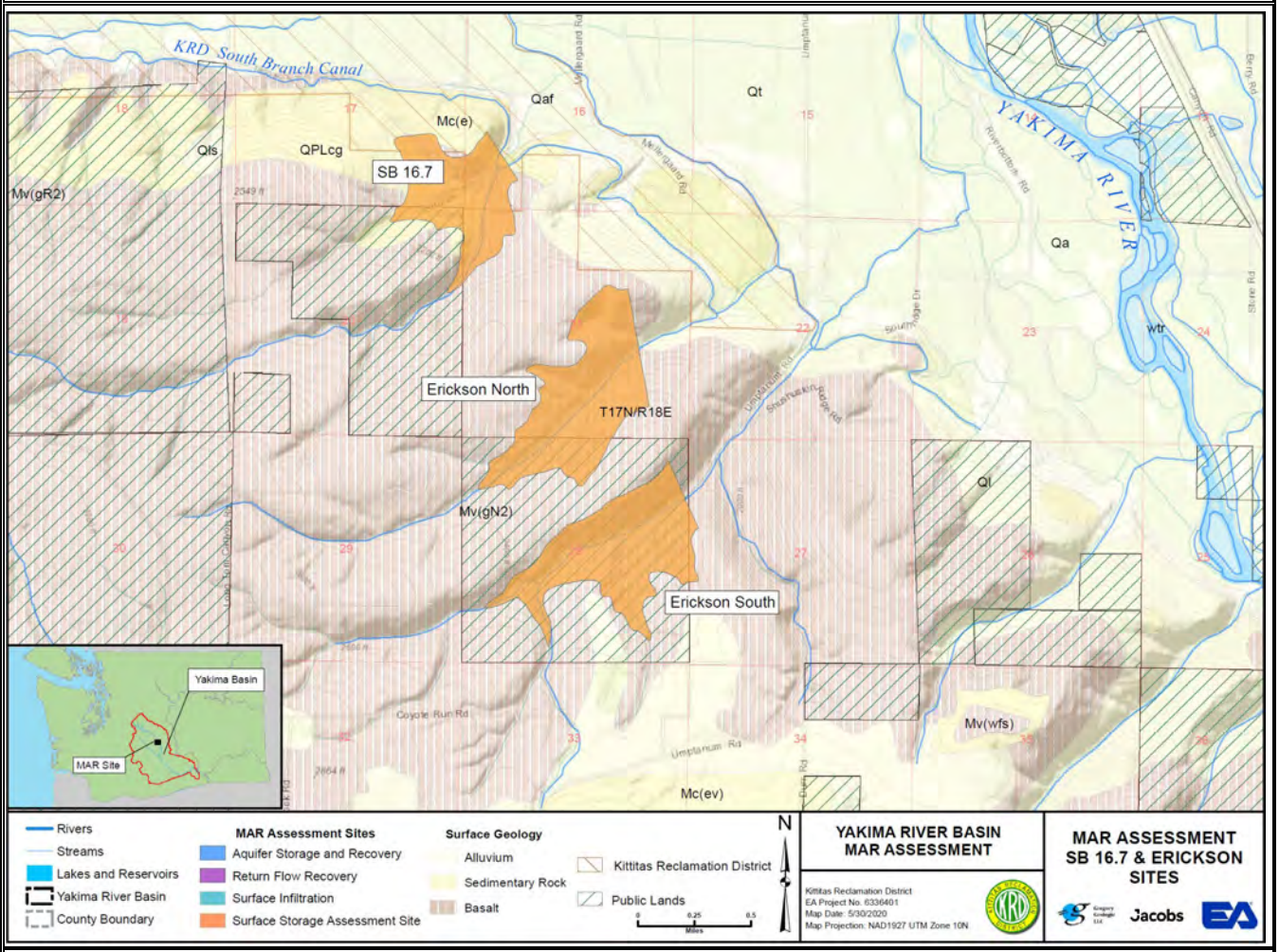
Integration with proposed Integrated Plan or other projects

This site is one of the surface storage assessment sites which could be used in conjunction with an ASR well. Relatively steep slopes and low permeable Thorp Gravels on site are not conducive for SAR facility. NB 14.7 #1 was the highest-ranking surface storage site in Jacobs, 2017.

Project Area Characteristics – SB 16.7

Rank: 36

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T17N, R18E, Sections 16, 17, 20 and 21.

Property Availability

Mostly Private, some public on upper end

Site Surface Geology

Basalt and sedimentary deposits

Project Area Subsurface Conditions

Basalt 50 – 100 feet

Depth to Water

150 – 200 feet

Hydraulic Conductivity Estimate

Variable, 4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal at RM 202. KRD conserved water. Pumping above canal would be required.
Flood Flows: very small tributary.

Conceptual Operational Model
Surface infiltration into engineered drainage into sedimentary rocks or basalt.
Estimated Costs and Cost Elements
Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells, pumps.
Water Quality Concerns
None
Benefits of Operation
Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries. Delay runoff.

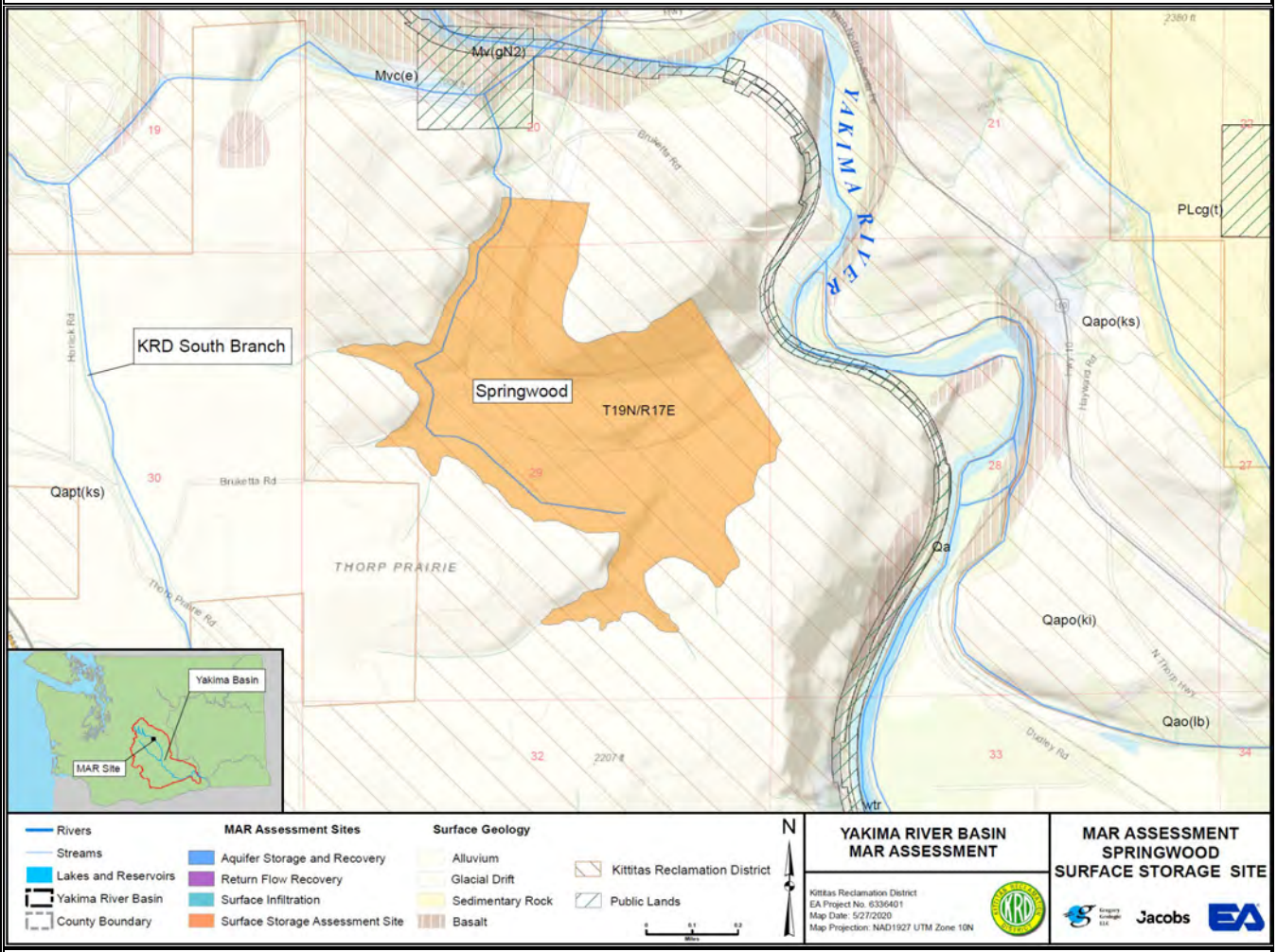
Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation
Location of Yakima River Benefits: RM 150
Location of Benefits to Water Users: Downstream of RM 150.
Integration with proposed Integrated Plan or other projects
No known habitat projects in the immediate vicinity.

Project Area Characteristics – Springwood

Rank: 36

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T19N, R17E, Sections 20, 28 and 29.

Property Availability

Private

Site Surface Geology

Alpine Glacial Outwash

Project Area Subsurface Conditions

Glacial Outwash over basalt

Depth to Water

Unknown

Hydraulic Conductivity Estimate

Outwash 5 – 500 ft/day

Water Source and Availability

Flood Flows: N/A

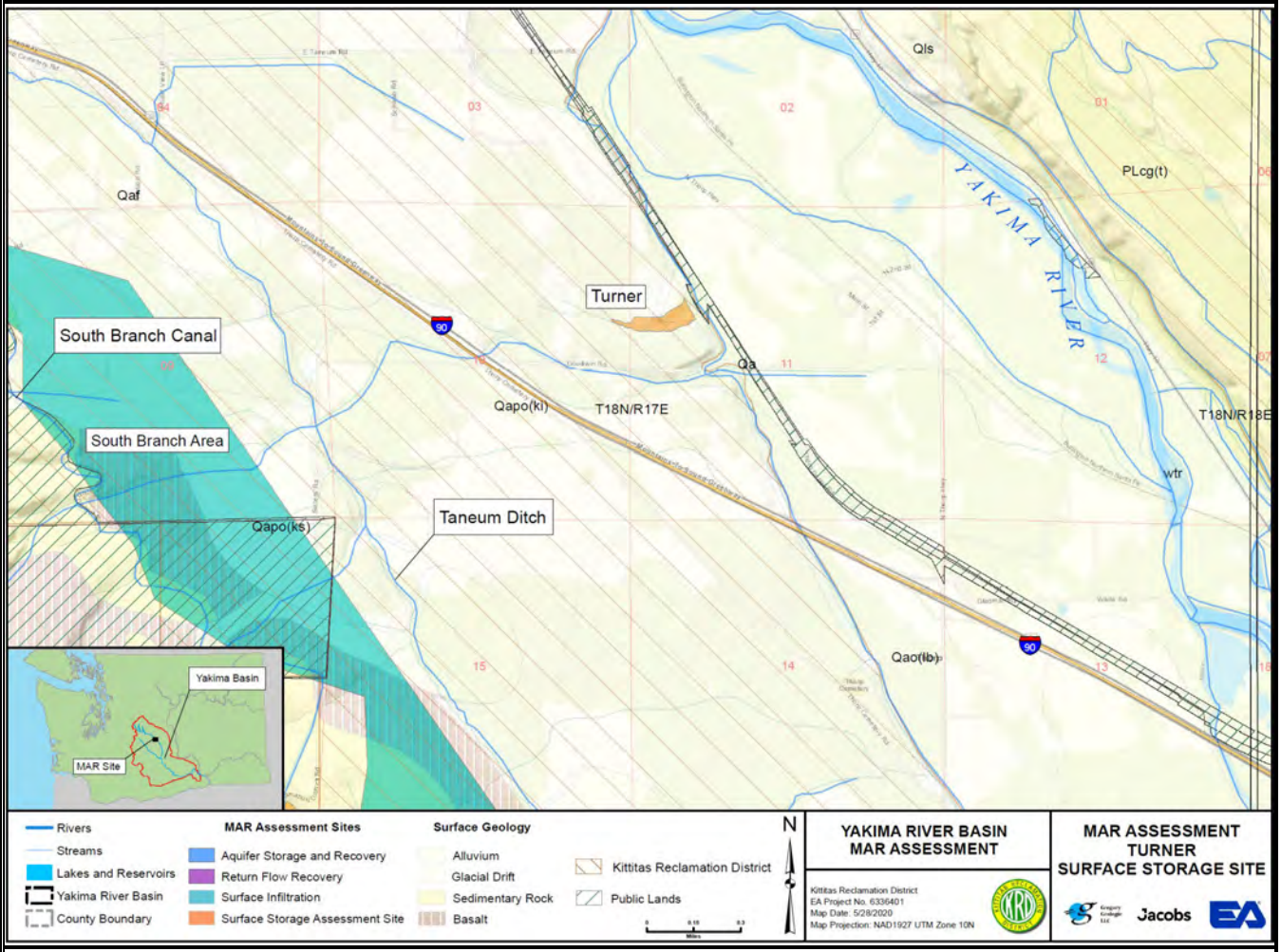
Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model			
Infiltration pond and/or subsurface galleries using canal deliveries.			
Estimated Costs and Cost Elements			
Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.			
Water Quality Concerns			
None			
Benefits of Operation			
Benefits: Delay runoff, Increase baseflow discharge to Yakima River.			
Benefits	**Low**	**Medium**	**High**
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow			X
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		
Location of Benefits of Operation			
Location of Yakima River Benefits: RM 168			
Location of Benefits to Water Users: Downstream surface water users.			
Integration with proposed Integrated Plan or other projects			
No known habitat projects in the immediate vicinity.			

Project Area Characteristics – Turner

Rank: 36

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T18N, R17E, Sections 10 and 11.

Property Availability

Private

Site Surface Geology

Alpine Glacial Drift

Project Area Subsurface Conditions

Coarse sand and gravel

Depth to Water

65 – 100’

Hydraulic Conductivity Estimate

5 – 500 ft/day in coarse sediments

Water Source and Availability

Flood Flows: Small drainages.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.

Conceptual Operational Model

Install low-tech surface recharge facilities for recharge. Could intercept and return South Branch Canal leakage. Horizontal drains to collectors, small impoundments, and pumping stations.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Any storage and use of recovered water can reduce diversion from Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: RM 156

Location of Benefits to Water Users: KRD South Branch canal water users.

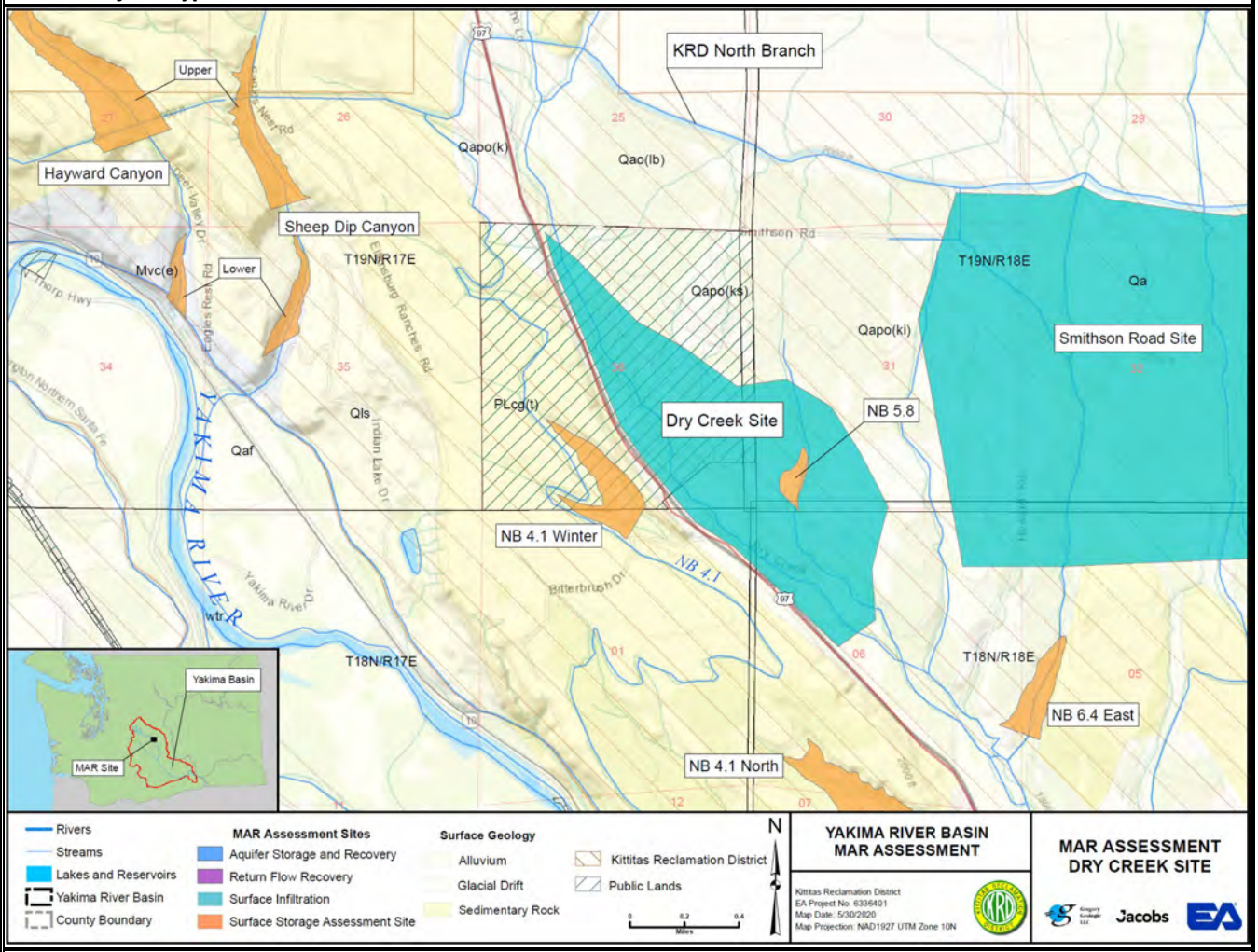
Integration with proposed Integrated Plan or other projects

There are no know fish or habitat projects in the vicinity of this project.

Project Area Characteristics – Dry Creek

Rank: 42

MAR Project Type: Surface Infiltration



Location (TRS): T18N, R17E Section 1, T18N, R18E Section 6, T19N, R17E Section 36, T18N, R18E Section 31.

Property Availability

Section 36 DNR land, remainder private.

Site Surface Geology

Quaternary Alluvium, 30-60 feet thick, Thorp Gravel, Alpine Glacial Drift.

Project Area Subsurface Conditions

Kittitas Drift, Indian John unit; sands and gravels below about 300 ft.

Depth to Water

Depth to water Drift wells at 30', wells in lower sands and gravels have heads at 250 NWIS well 470642120394901 indicates Ellensburg Formation 30' below ground surface.

Hydraulic Conductivity Estimate

Variable., high values in alluvium.

Water Source and Availability

Flood Flows: Peak 50% flood flow 57 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam (EASW), See Appendix Table 1. Note- Served by KRD, North Branch Canal.

Conceptual Operational Model
Infiltration pond into Quaternary Alluvium.
Estimated Costs and Cost Elements
Low - Diversion structures, piping, recharge basin, stream gaging, monitoring wells.
Water Quality Concerns
None
Benefits of Operation
Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

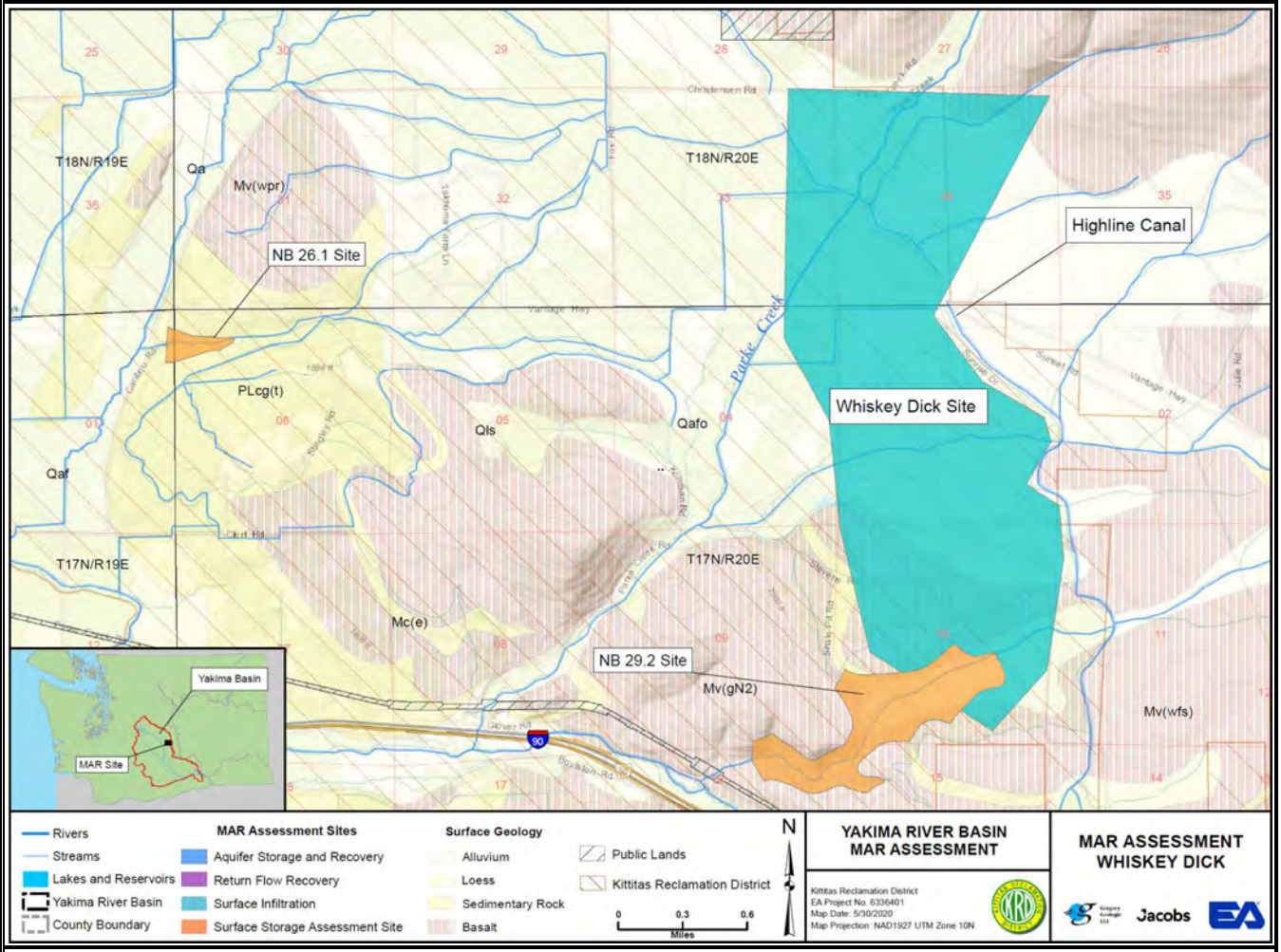
Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation
Location of Yakima River Benefits: Generally below MP 157.
Location of Benefits to Water Users: Lower Dry Creek Groundwater users.
Integration with proposed Integrated Plan or other projects
No known habitat or fish projects in progress.

Project Area Characteristics – Whiskey Dick Creek

Rank: 42

MAR Project Type: Shallow Aquifer Recharge or ASR



Location (TRS): T17N, R20E, Sections 3, 4, 10 and 11 and T18N, R20E, Sections 33 and 34.

Property Availability

Private Land

Site Surface Geology

Basalt, likely Grande Ronde.

Project Area Subsurface Conditions

Basalt

Depth to Water

Local steep groundwater declines.

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: Peak 50% 69 cfs

Flows from nearby Irrigation Canals: Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

ASR or Recharge water using KRD water.

Estimated Costs and Cost Elements

Low for SAR, Medium for ASR. Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None, compliance with Groundwater Quality Standards

Benefits of Operation

Benefits: Increase later-season baseflow discharge to Parke Creek, increase recharge to local aquifers.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: Canyon mouth, RM 148.

Location of Benefits to Water Users: Ground water users in Kittitas area. KRD users downgradient if ASR project developed.

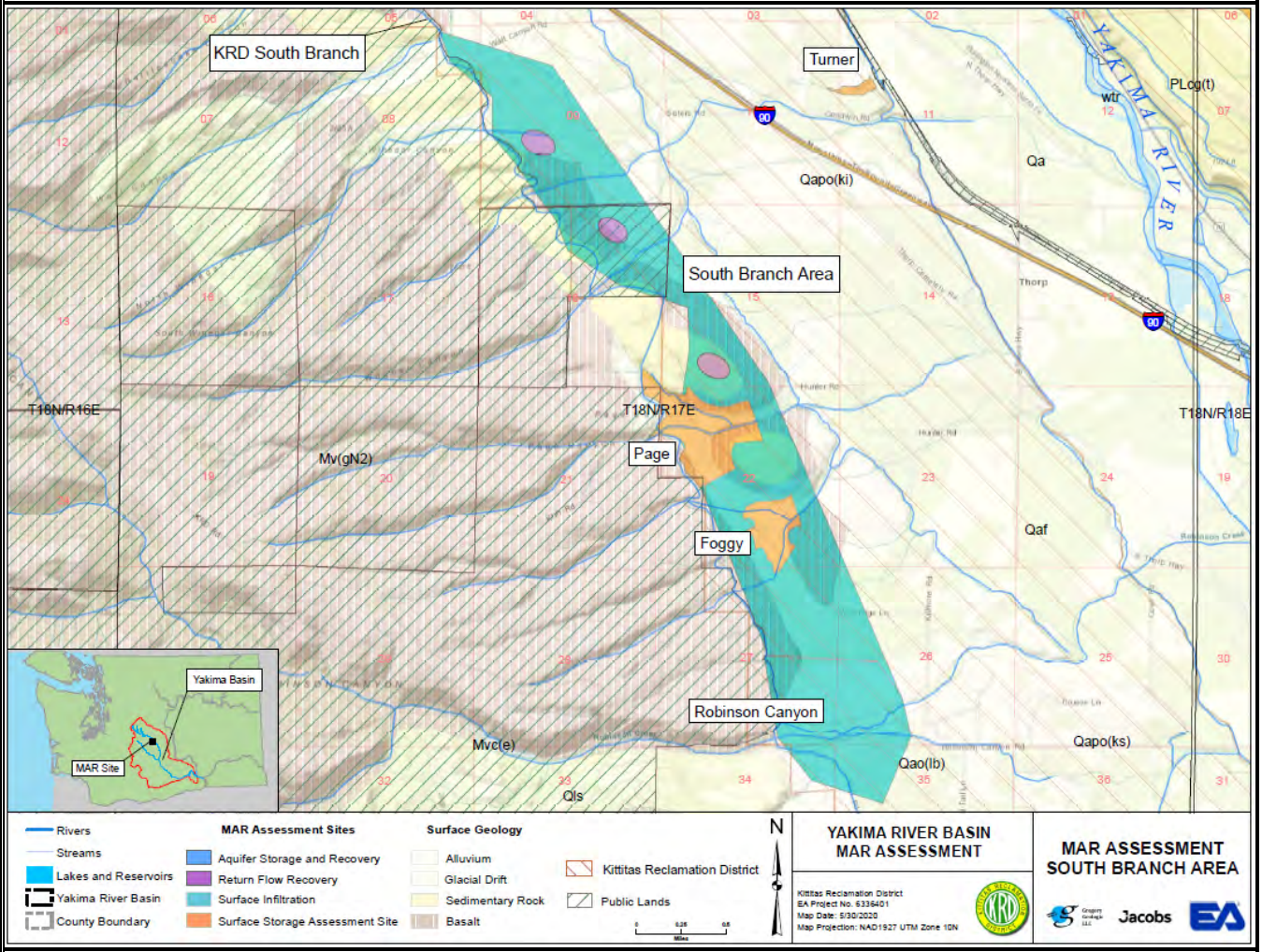
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – South Branch Area

Rank: SAR – 19, RFR - 42

MAR Project Type: Shallow Aquifer Recharge and Return Flow Recovery



Location (TRS): T18N R17E Sections 8, 9, 15, 16, 22, 23, 26, and 27.

Property Availability

Mostly Private land, some DNR.

Site Surface Geology

Quaternary Alluvium, Thorp Gravel, Basalt.

Project Area Subsurface Conditions

Quaternary alluvium of varying thickness over sediment and Grande Ronde Basalt.

Depth to Water

40’ in shallow units to up to 200’ in basalt.

Hydraulic Conductivity Estimate

Highly variable.

Water Source and Availability

Flood Flows: Small drainages.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.

Conceptual Operational Model

Install facilities to intercept, store, and return South Branch Canal leakage. Horizontal drains to collectors, small impoundments and pumping stations.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

None.

Benefits of Operation

Benefits: Any storage and use of recovered water can reduce diversion from Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: KRD diversion at Easton, RM 202.

Location of Benefits to Water Users: KRD South Branch canal water users.

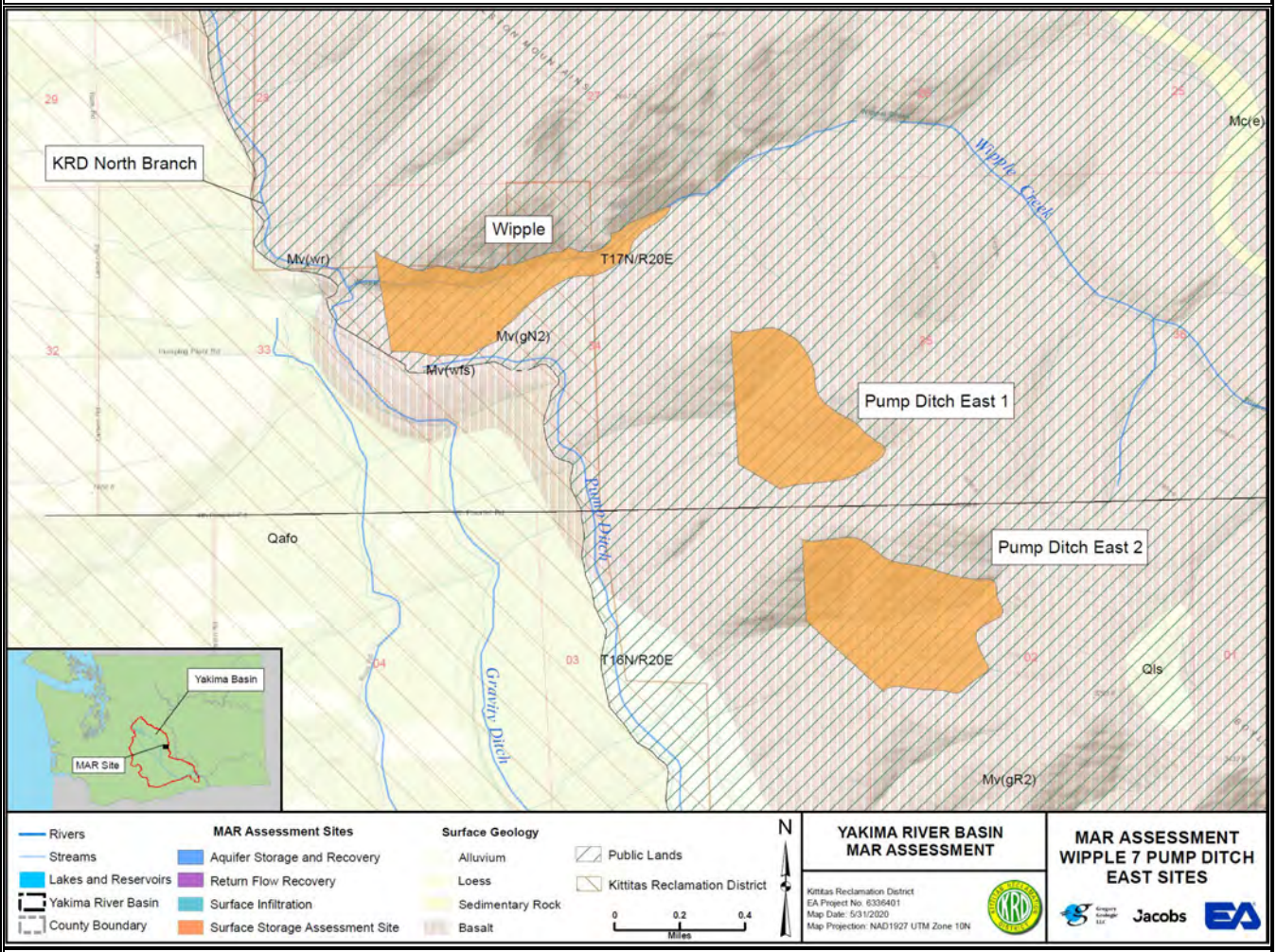
Integration with proposed Integrated Plan or other projects

There are no know fish or habitat projects in the vicinity of this project.

Project Area Characteristics – Pump Ditch East 1 and 2

Rank: 42

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): Pump Ditch East 1 - T17N, R20E, Sections 34 and 35, Pump Ditch East 2 - T16N, R20E, Sections 2 and 3.

Property Availability

Private

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Basalt

Depth to Water

115’ in basalt

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using canal deliveries.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells. Need to pump up from canal

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: RM 147

Location of Benefits to Water Users: KRD and groundwater users in Badger Pocket.

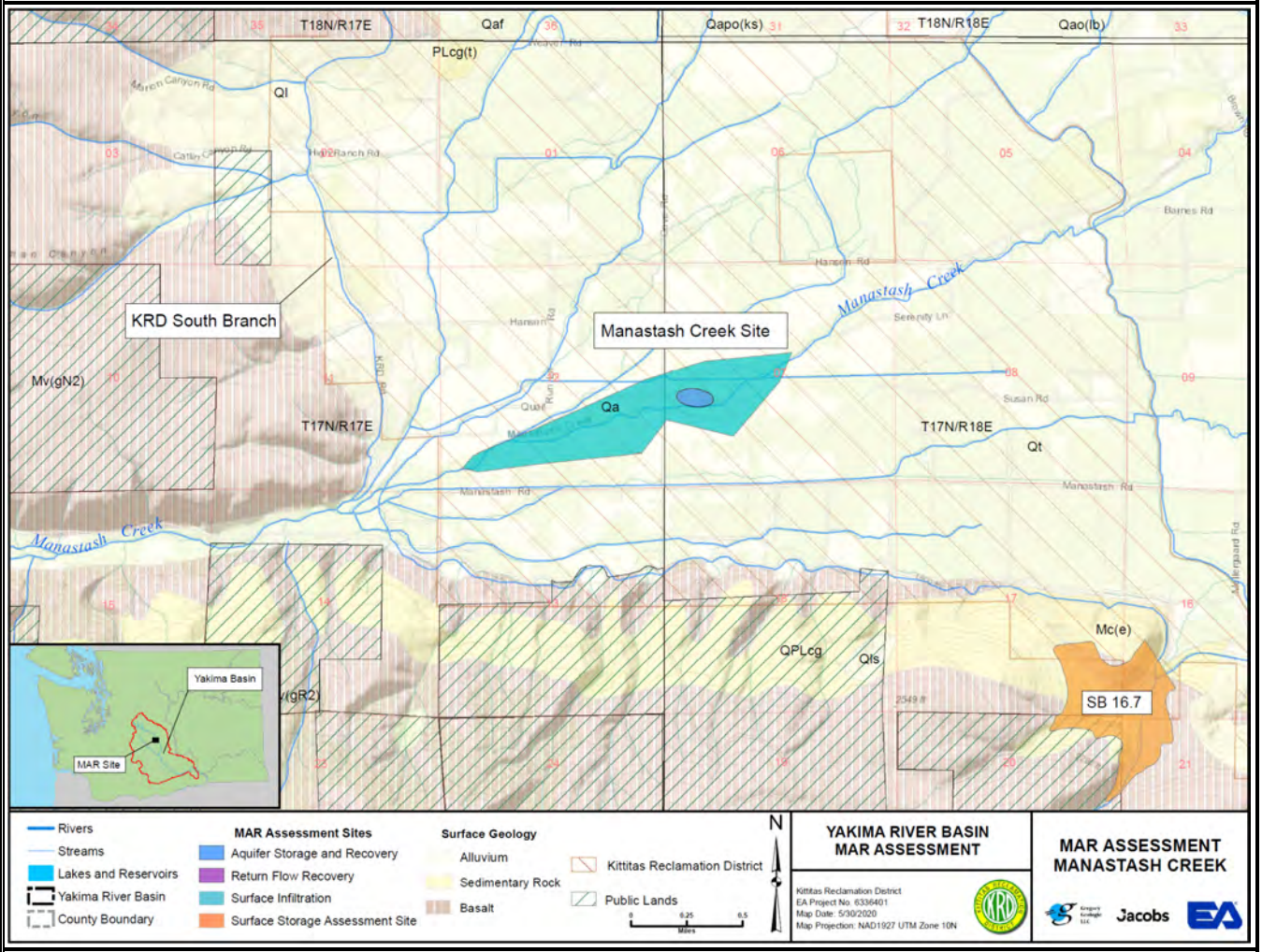
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Manastash Creek

Rank: ASR - 89, SAR - 47

MAR Project Type: Aquifer Storage and Recovery and Shallow Aquifer Recharge



Location (TRS): T17N R17E Section 12, T17N R18E Section 7.

Property Availability

Private.

Site Surface Geology

Quaternary Alluvium.

Project Area Subsurface Conditions

Deeper wells into Basalt, intercalated with Ellensburg Formation.

Depth to Water

Shallow wells artesian to shallow (10-20') statics, Basalt hosted deep wells 80-100' statics.

Hydraulic Conductivity Estimate

Hydraulic Conductivity estimate highly dependent well to well.

Water Source and Availability

Flood Flows: Peak 50% Flood Flows estimate 1290 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Note- Served by KRD South Branch Canal. Downhill from South Branch canal, uphill from West Side canal.

Conceptual Operational Model

Infiltration pond or ASR wells into basalt.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

Compliance with GWQS.

Benefits of Operation

Benefits: Increase baseflow in lower Manastash Creek and downstream water users.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: Yakima RM 154.

Location of Benefits to Water Users: Ground water users on east side of Yakima River below Manastash Creek, potential capture or use in West Side Canal.

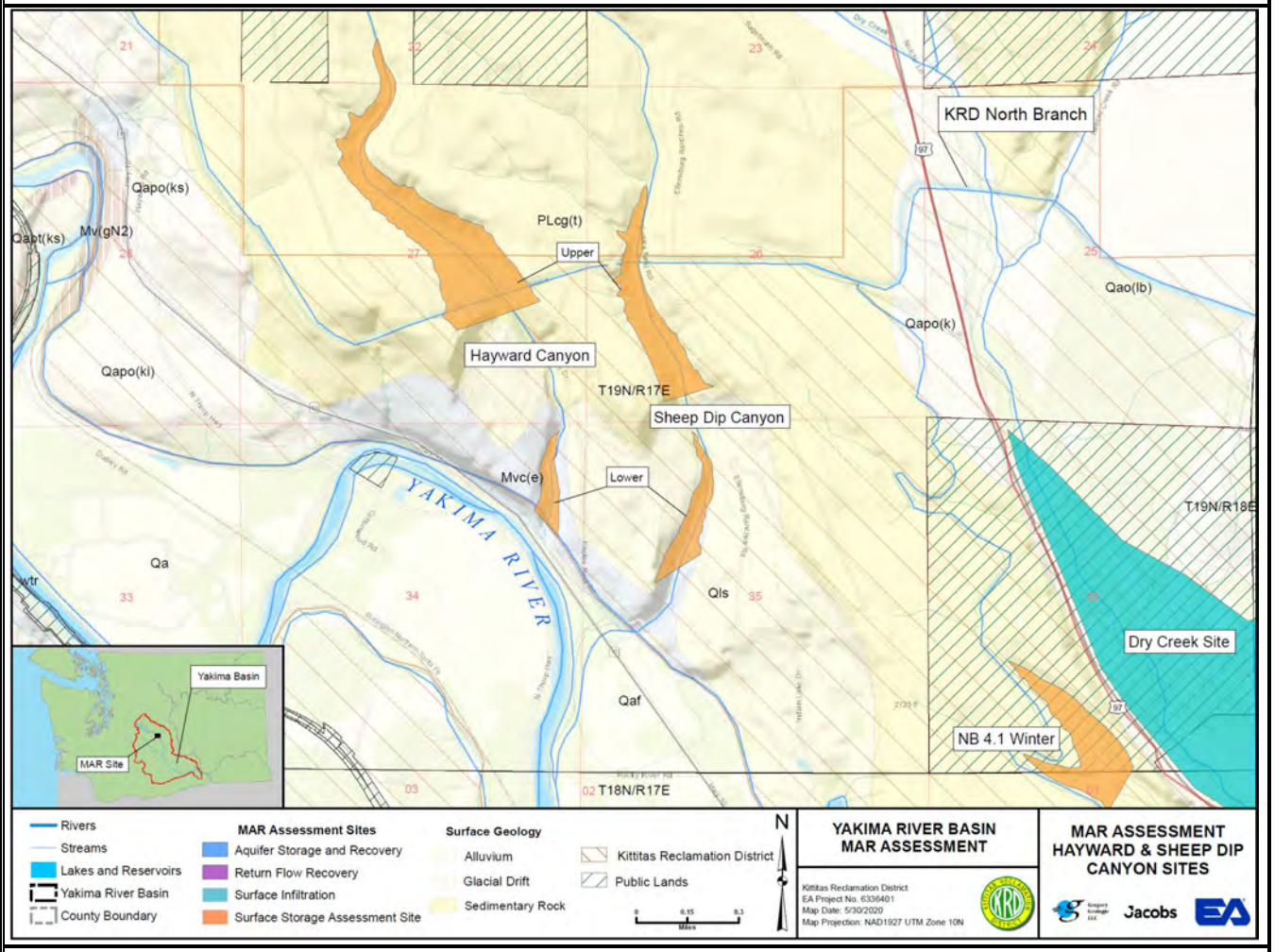
Integration with proposed Integrated Plan or other projects

Compliments conservation efforts and habitat projects on Manastash Creek.

Project Area Characteristics – Hayward Canyon Upper & Lower

Rank: Upper Hayward Canyon – 47, Lower Hayward Canyon - 61

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): Upper - T19N, R17E, Sections 22 and 27, Lower - T19N, R17E, Section 34.

Property Availability

Private

Site Surface Geology

Upper – Thorp Gravels, Lower - Volcaniclastic rocks of the Ellensburg Formation

Project Area Subsurface Conditions

Thorp Gravels, volcaniclastic rocks of the Ellensburg Formation, basalt at depth

Depth to Water

Variable 100 – 400 feet

Hydraulic Conductivity Estimate

Variable, likely relatively low in most shallow units

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.
Flood Flows: N/A

Conceptual Operational Model

Infiltration ponds of KRD water into shallow aquifer. Low permeability of Thorp Gravel at Upper site makes SAR infeasible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Delayed runoff

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 164

Location of Benefits to Water Users: Downstream of RM 164

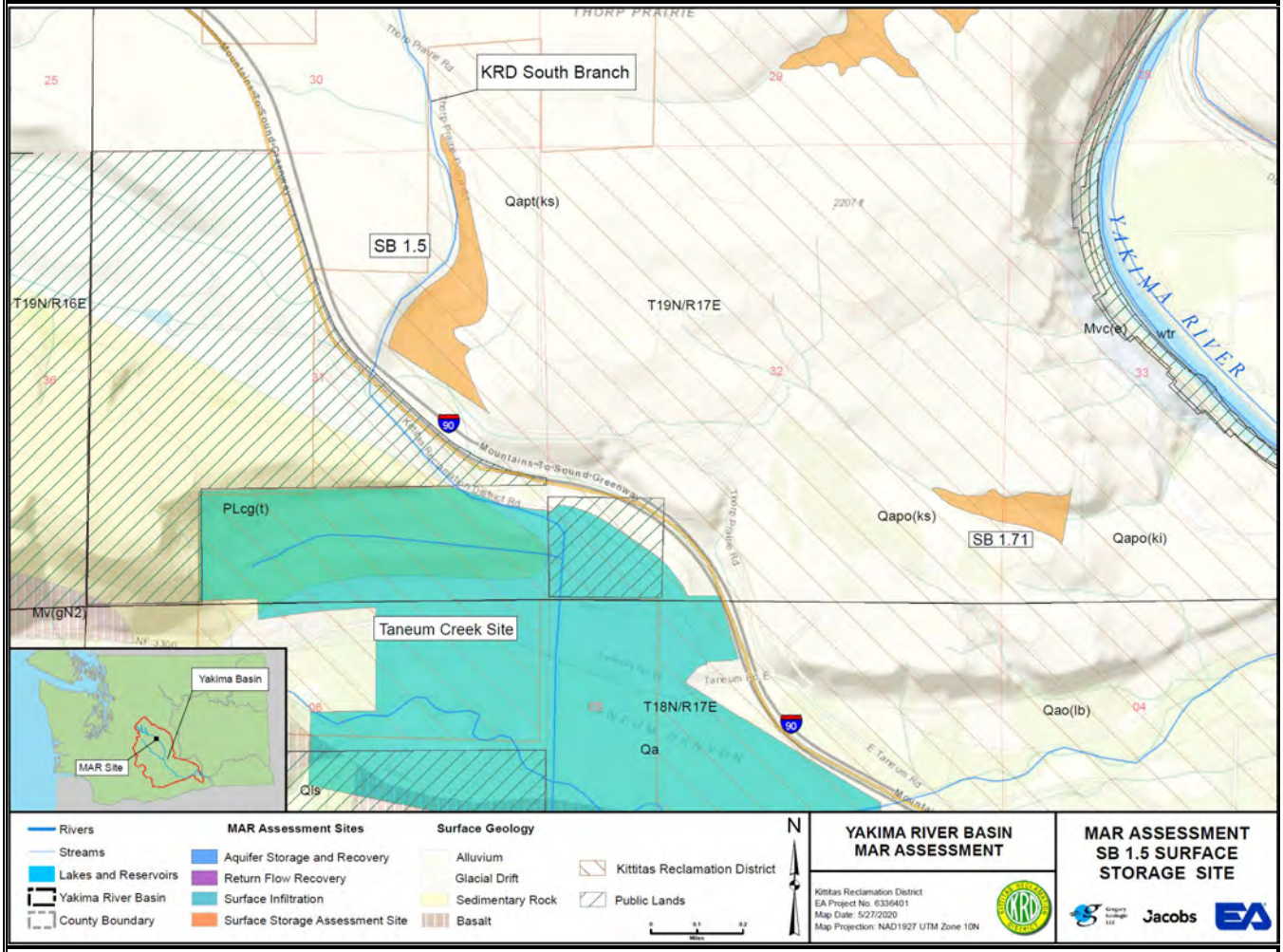
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – SB 1.5

Rank: 47

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): Upper - T19N, R17E, Sections 30 and 31.

Property Availability

Private

Site Surface Geology

Alpine Glacial Drift

Project Area Subsurface Conditions

Glacial drift, abundant clay

Depth to Water

Unknown

Hydraulic Conductivity Estimate

Unknown, likely relatively low

Water Source and Availability

Flood Flows: N/A

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using canal deliveries.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits:

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 169

Location of Benefits to Water Users: Downstream surface water users.

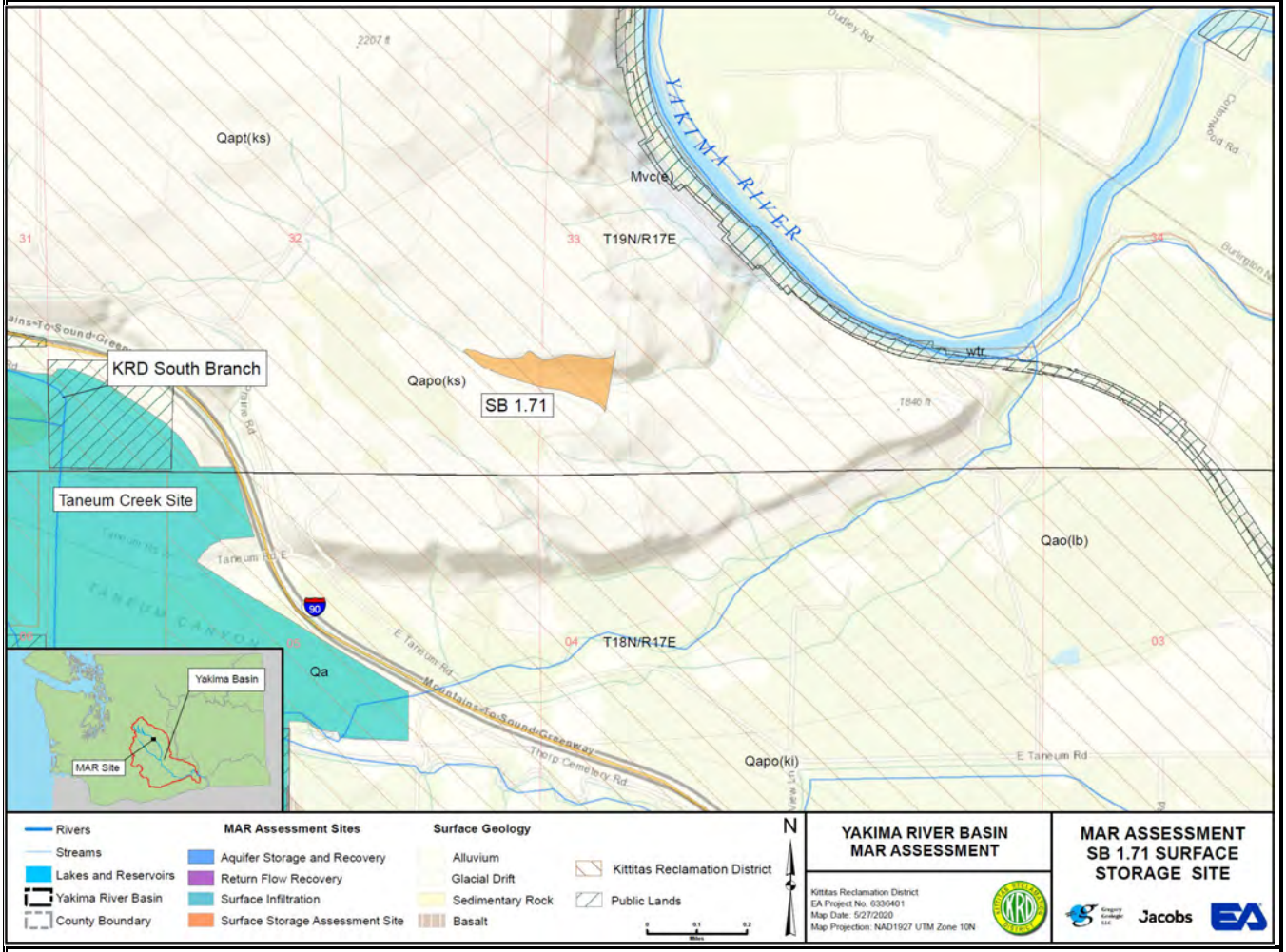
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – SB 1.71

Rank: 47

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T19N, R17E, Sections 32 and 33.

Property Availability

Private

Site Surface Geology

Alpine Glacial Drift

Project Area Subsurface Conditions

Glacial drift, abundant clay

Depth to Water

Unknown

Hydraulic Conductivity Estimate

Unknown, likely relatively low

Water Source and Availability

Flood Flows: N/A

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Infiltration pond and/or subsurface galleries using canal deliveries.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits:

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 165

Location of Benefits to Water Users: Downstream surface water users.

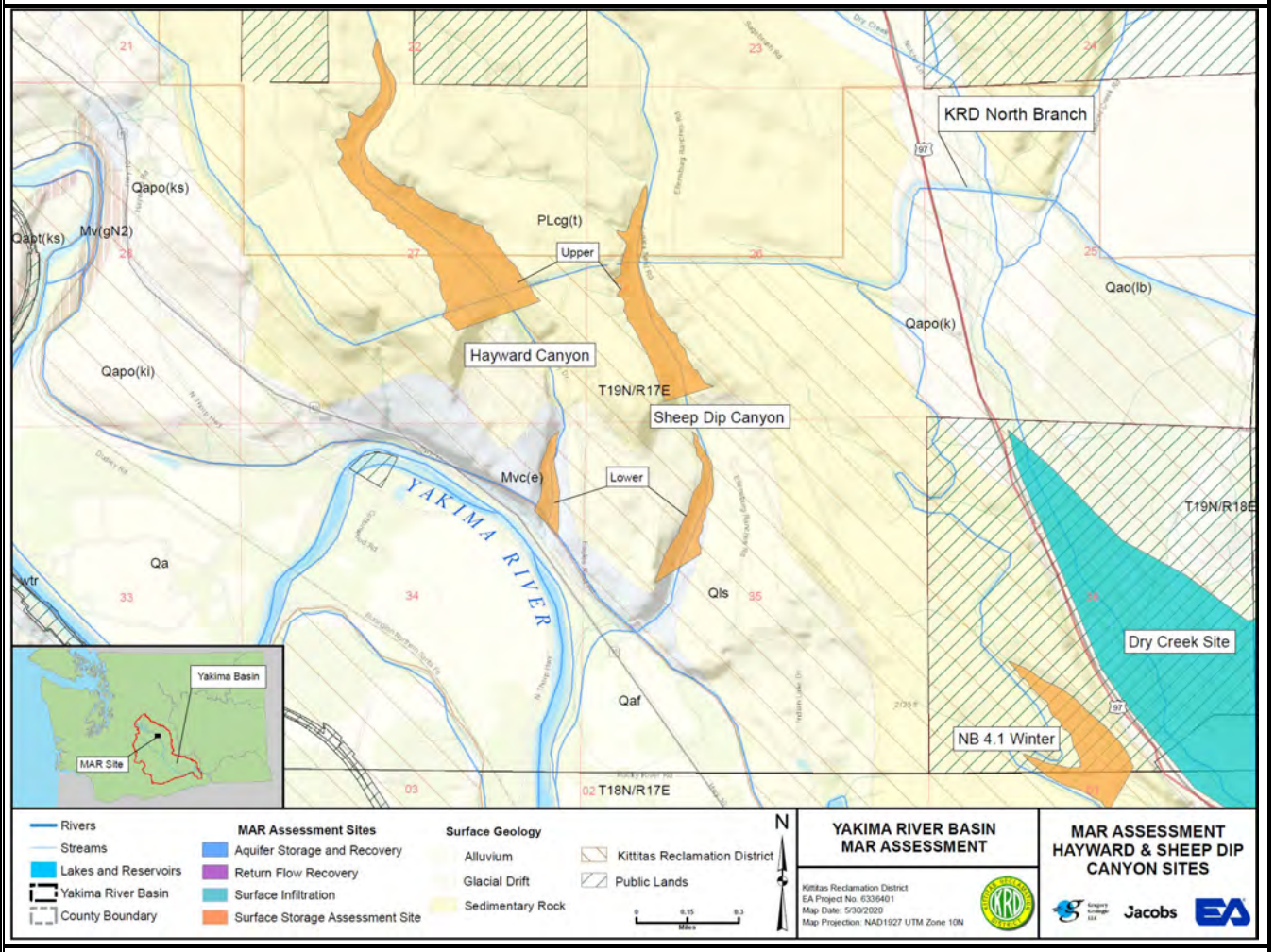
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Sheep Dip Canyon Upper & Lower

Rank: Upper Sheep Dip Canyon – 47, Lower Sheep Dip Canyon - 61

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): Upper - T19N, R17E, Section 26, Lower - T19N, R17E, Section 35.

Property Availability

Private

Site Surface Geology

Upper – Thorp Gravels, Lower - Volcaniclastic rocks of the Ellensburg Formation

Project Area Subsurface Conditions

Thorp Gravels, volcaniclastic rocks of the Ellensburg Formation, basalt at depth

Depth to Water

Variable 100 – 400 feet

Hydraulic Conductivity Estimate

Variable, likely relatively low in most shallow units

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.
Flood Flows: N/A

Conceptual Operational Model

Infiltration ponds of KRD water into shallow aquifer. Low permeability of Thorp Gravel at Upper site makes SAR infeasible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Delayed runoff

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 162

Location of Benefits to Water Users: Downstream of RM 162

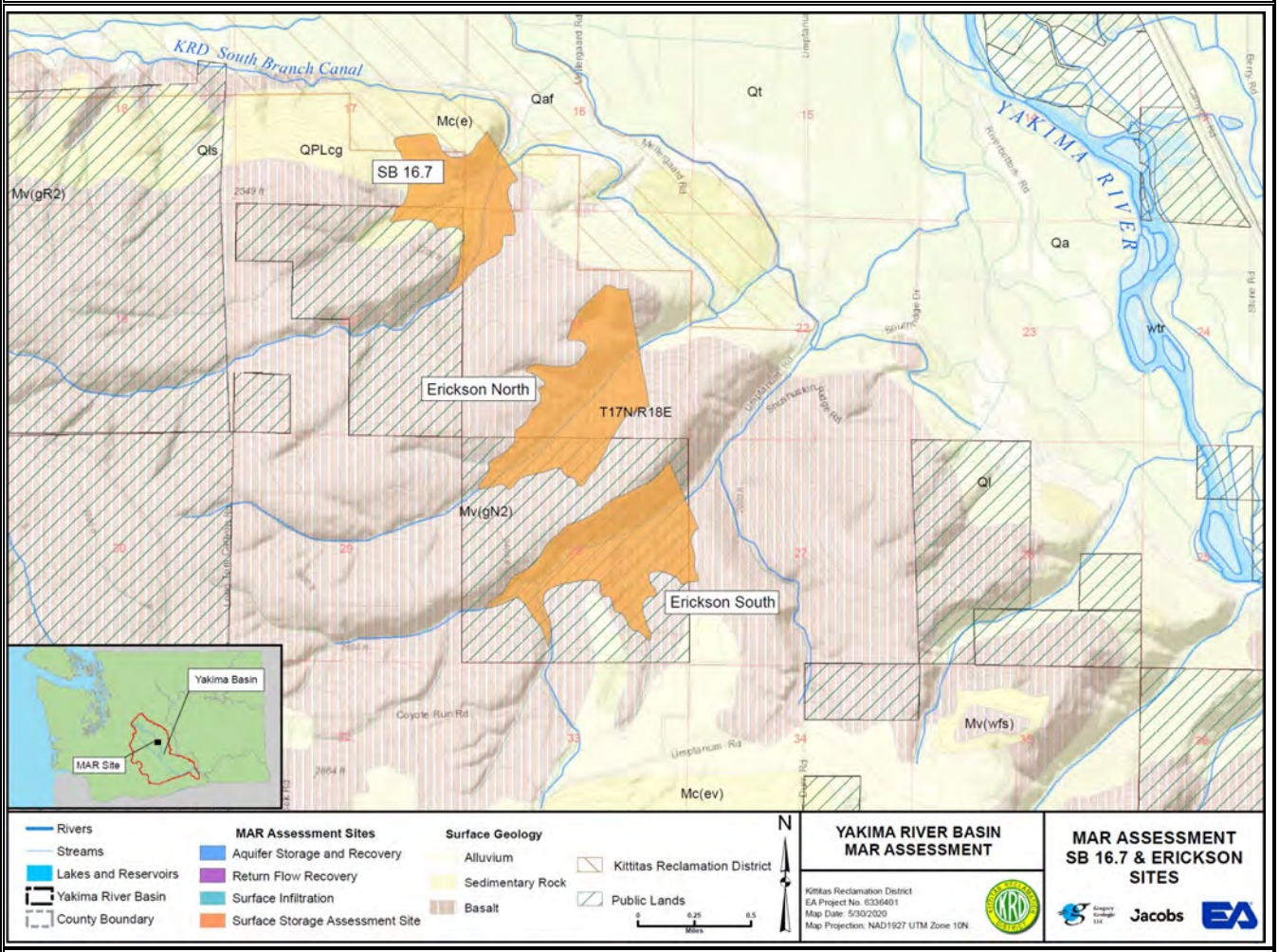
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Erickson North

Rank: 52

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T17N, R18E, Sections 21 and 28

Property Availability

Public and Private in southern portion

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Basalt

Depth to Water

150 – 200 feet

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal at RM 202. KRD conserved water. Pumping above canal would be required.
Flood Flows: N/A

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells, pumps.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries. Delay runoff.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: RM 150

Location of Benefits to Water Users: Downstream of RM 150.

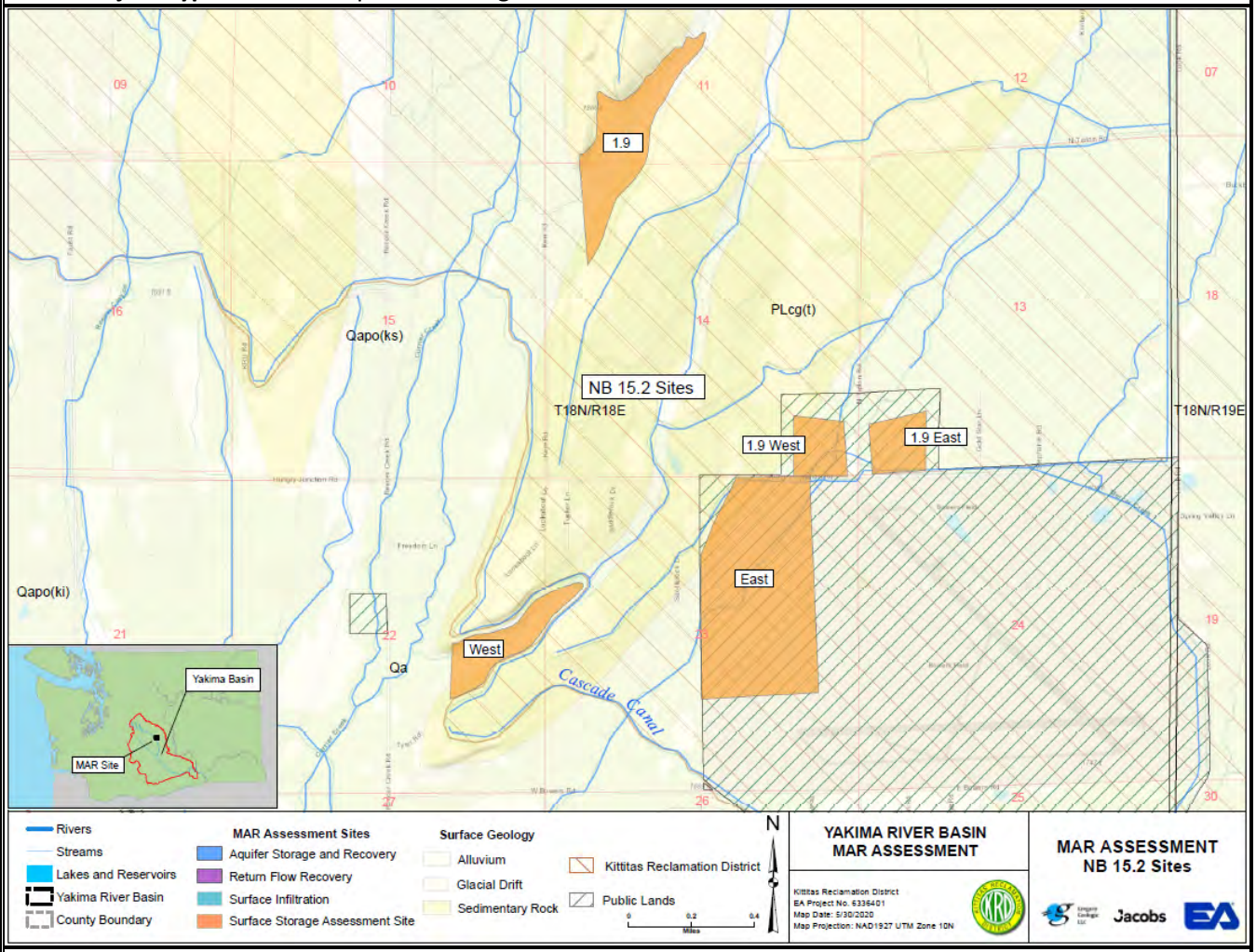
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – NB 15.2 Sites

Rank: NB 15.**2**-1.9 - 52, NB 15.2 West - 72, NB 15.2-1.9 East - 14, 1.9 NB 15.2-1.9 West - 14, 1.9 NB 15.2 East - 14

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T18N, R18E, Sections 11, 13, 14, 22, and 23.

Property Availability

Private and Public land (sites 1.9 West, 1.9 East and East are located on Bowers Field).

Site Surface Geology

Thorp Gravel and Quaternary Alluvium, recent outwash from Naneum Canyon.

Project Area Subsurface Conditions

Alluvium 30-100 feet thick, quite coarse, overlying basalt or Thorp-like cemented sands.
Few wells, but groundwater seems shallow (30') in creek channel.

Depth to Water

Shallow, variable with irrigation season.

Hydraulic Conductivity Estimate

Highly variable.

Water Source and Availability

Flood Flows: Naneum Creek, Flood Flows Peak 50% flood 391 cfs, Wilson Creek 387 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.

Conceptual Operational Model

Infiltration ponds of flood flows into shallow aquifer and alluvial fan sediments at NB 16 South. In this case, likely very low tech to enhance existing percolation operations. Low permeability of Thorp Gravel at NB 15.2 1.9 and West sites makes SAR less feasible. Other sites on alluvium and public land. Need to be compatible with airport operations.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards.

Benefits of Operation

Benefits: Enhanced late season ground water in Naneum/Wilson Creek drainages.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: KRD diversion at Easton, RM 202. Baseflow at RM 154

Location of Benefits to Water Users: KRD North Branch canal water users.

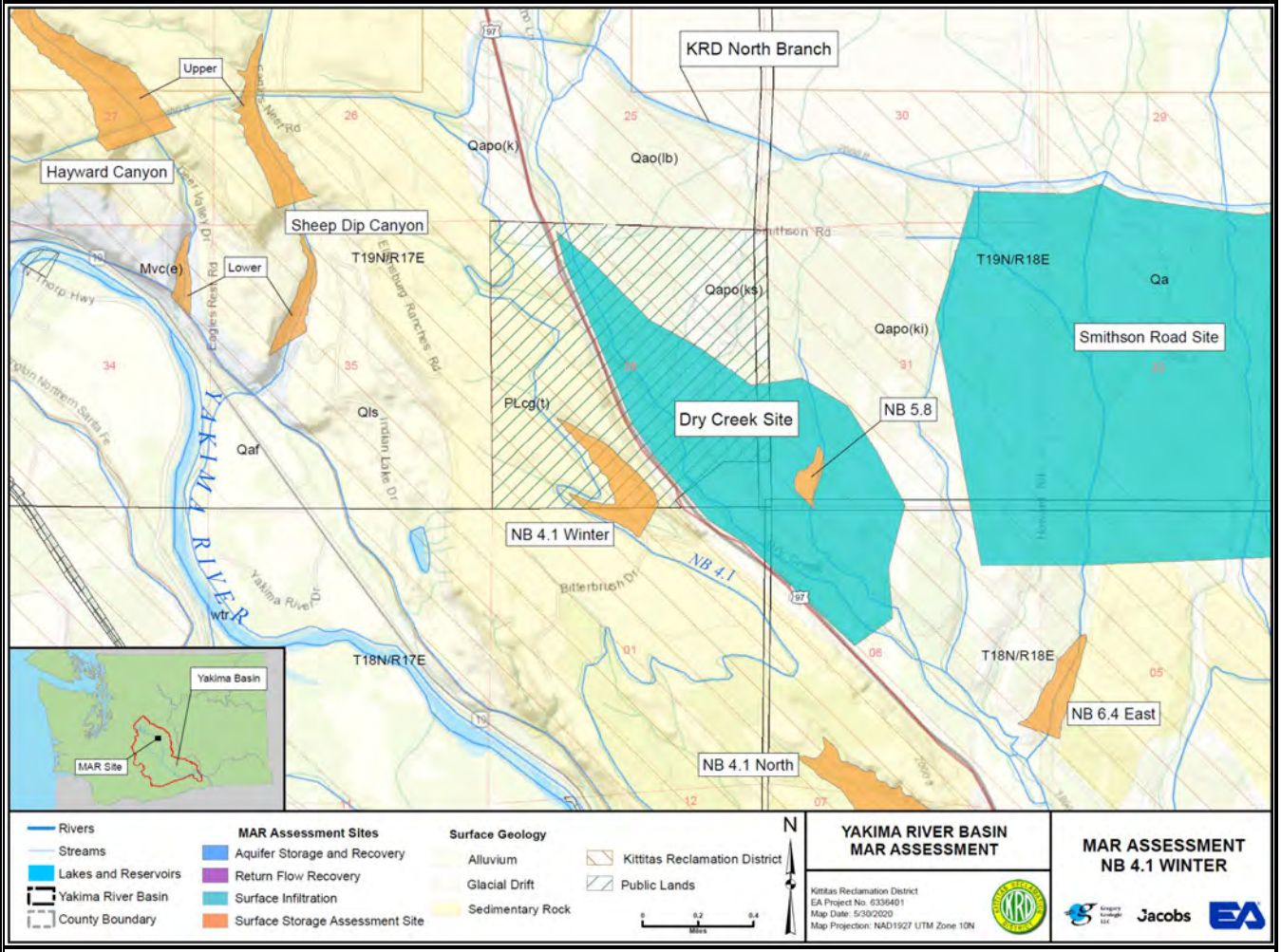
Integration with proposed Integrated Plan or other projects

These sites are five of the surface storage assessment sites (Jacobs, 2017) which could be used in conjunction with a SAR facility.

Project Area Characteristics – NB 4.1 Winter

Rank: 52

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T18N, R18E, Section 1 and T19N, R18E, Section 36.

Property Availability

Mostly Public, Private on the southern portion.

Site Surface Geology

Thorp Gravel

Project Area Subsurface Conditions

Sand, clay, gravel

Depth to Water

50 – 100 ‘

Hydraulic Conductivity Estimate

Highly variable, likely very low

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1). Served by KRD North Branch Canal.

Conceptual Operational Model

Surface infiltration into engineered recharge facility.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None.

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to Dry Creek and the Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Water recovered or released from storage could be discharged to the Dry Creek drainage, which discharges to the Yakima River at RM 158.

Location of Benefits to Water Users: Ground water users in the Dry Creek area.

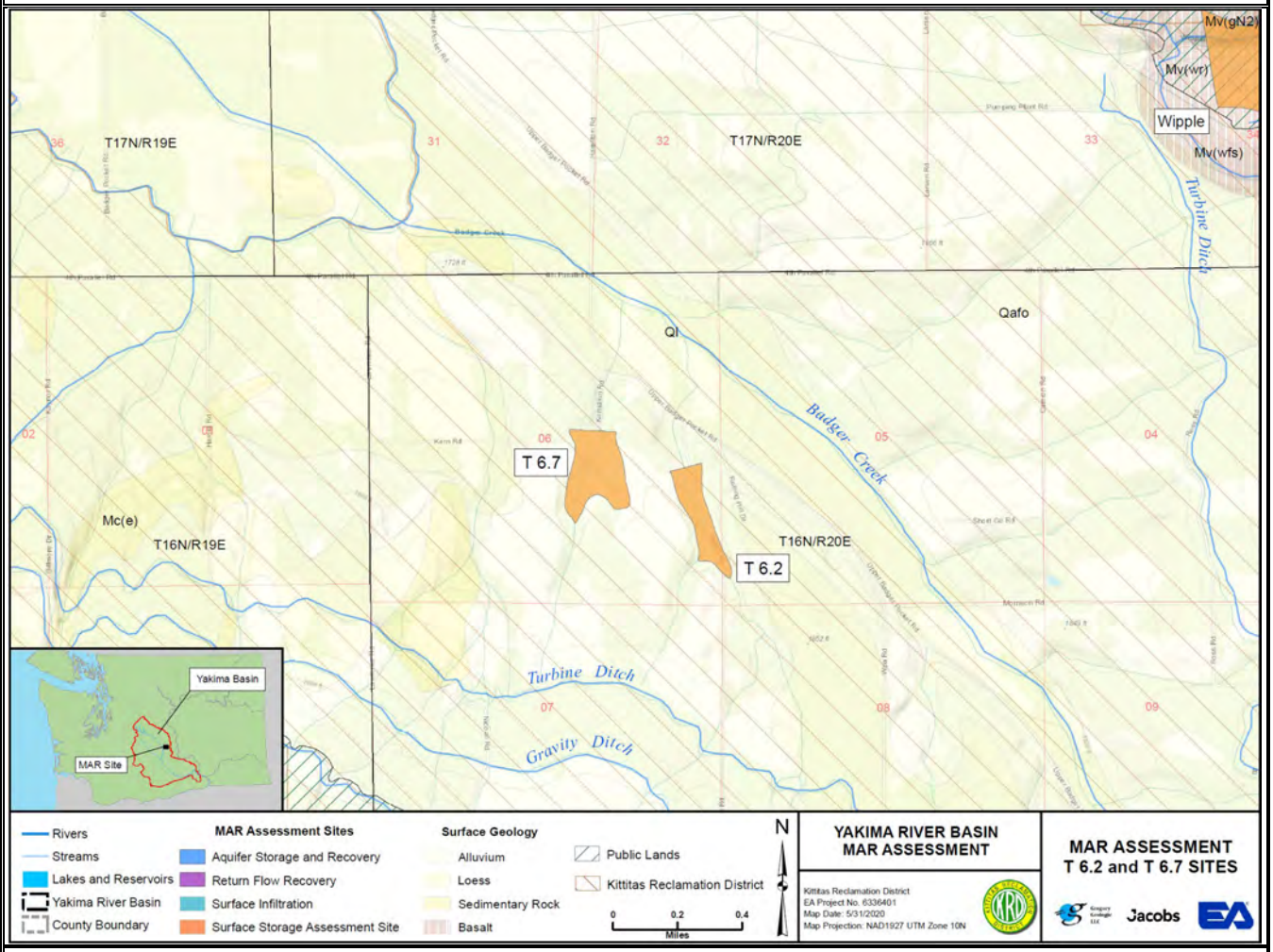
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – T 6.2 and T 6.7

Rank: 52

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T 6.2 - T16N, R20E, Sections 5 and 6, T 6.7 - T16N, R20E, Section 6.

Property Availability

Private

Site Surface Geology

Quaternary alluvial fan deposits

Project Area Subsurface Conditions

Thick alluvial deposits of clay, sand and gravel

Depth to Water

30 – 100 feet

Hydraulic Conductivity Estimate

Variable

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal to Turbine ditch. KRD conserved water.

Flood Flows: Minor flows in Badger Creek.

Conceptual Operational Model

Infiltration ponds of flood flows into shallow aquifer and alluvial fan sediments at. Likely very low tech to enhance existing percolation operations.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping/pumping to site, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

Tail end of irrigation canal.

Benefits of Operation

Benefits: Increase baseflow discharge to KRD canals, Yakima River and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: RM 147

Location of Benefits to Water Users: Groundwater users in Badger Pocket

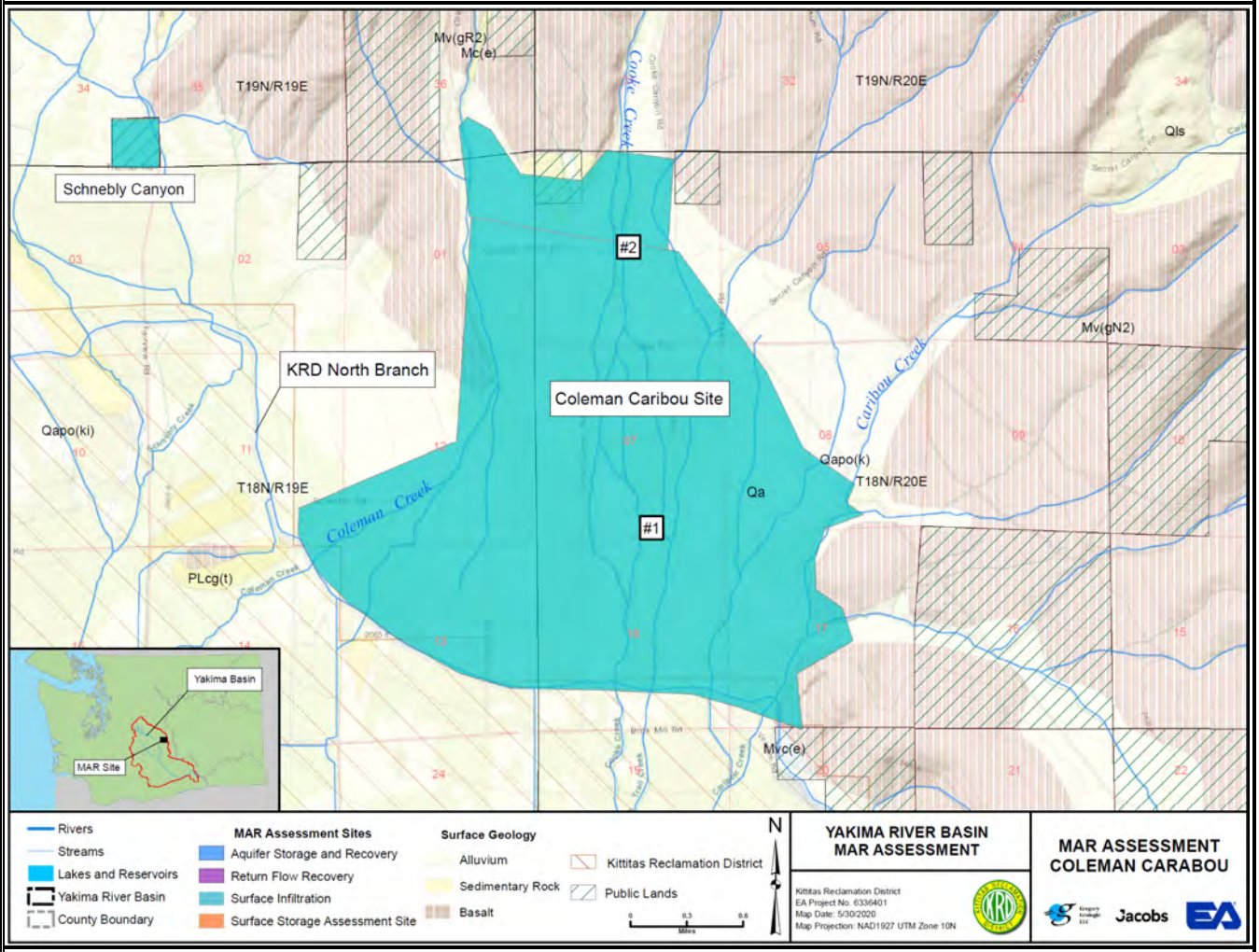
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Coleman-Caribou

Rank: 57

MAR Project Type: Surface Infiltration



Location (TRS): T18N R19E Sections 12, 13. , Also T18N R20E Sections 7, 8, 17,18.

Property Availability

Mostly Private land.

Site Surface Geology

Quaternary Alluvium, Alluvial Fan sediments.

Project Area Subsurface Conditions

Alluvium of varying thickness above basalt.

Depth to Water

Basalt at variable depth, generally about 200’ below ground surface, some shallow groundwater, but regional statics roughly 40’-50’.

Hydraulic Conductivity Estimate

Variable.

Water Source and Availability

Flood Flows: Peak 50% flood flows from Coleman, Caribou, and Cooke Creeks total 285 cfs.

Flows from nearby Irrigation Canals: N/A.

Conceptual Operational Model

Flood flow recharge basins.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X	X	
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: KRD Diversion at Easton. Recharge to Kittitas Basin above Yakima RM 146.

Location of Benefits to Water Users: Canal users downstream of Cooke Creek. Groundwater users in the Kittitas vicinity.

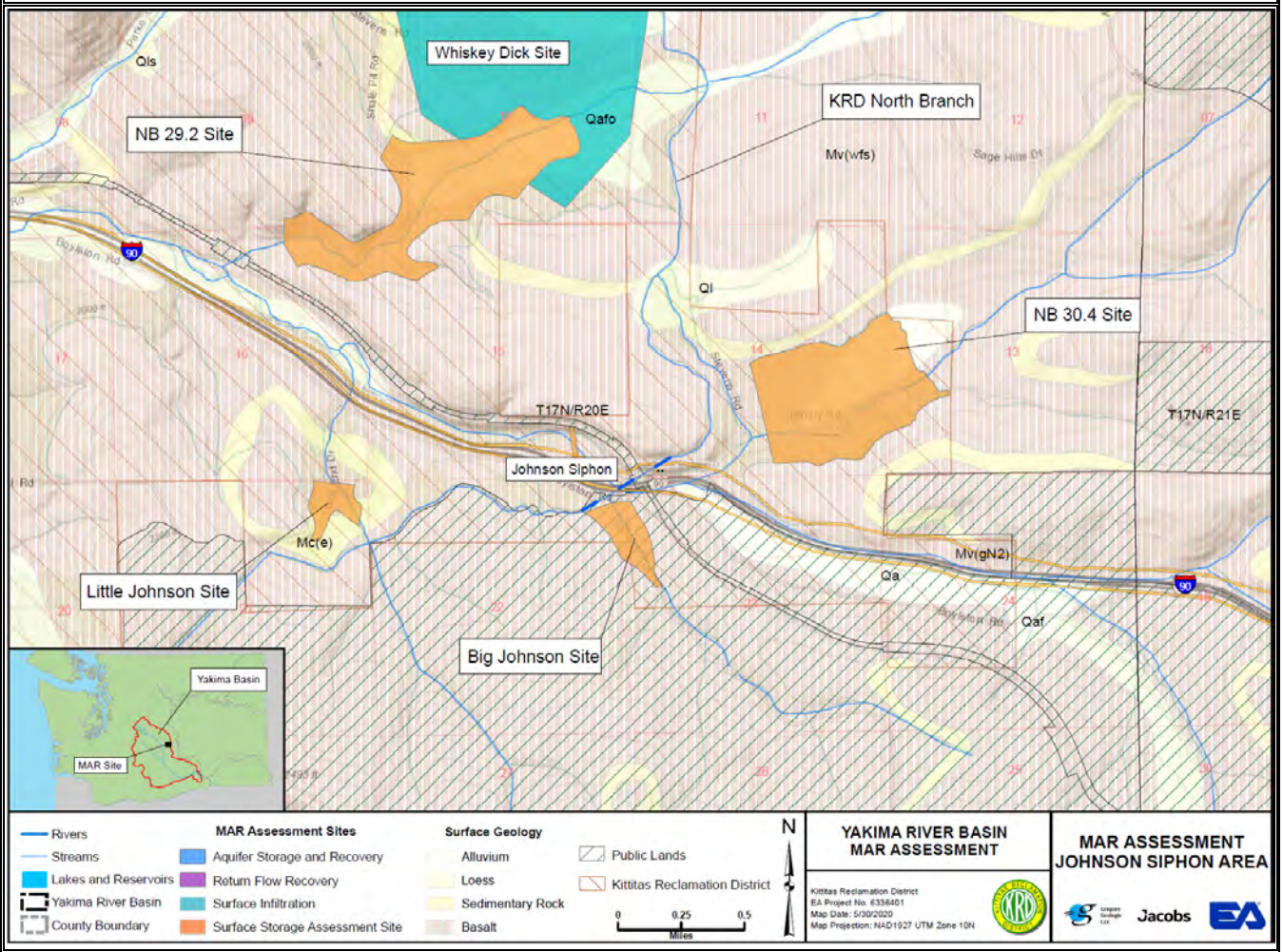
Integration with proposed Integrated Plan or other projects

Active Coho supplementation, fish and habitat projects in process.

Project Area Characteristics – NB 30.4

Rank: 57

MAR Project Type: Surface Infiltration or ASR



Location (TRS): T17N, R20E, Sections 13 and 14.

Property Availability

Private Land

Site Surface Geology

Thin Quaternary alluvial fan deposits overlying Miocene Grande Ronde Basalt Mv(gN2)

Project Area Subsurface Conditions

Alluvium and Basalt at surface

Depth to Water

230, Static Water Level in basalt 162'.

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by KRD Canal, North Branch.

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt. ASR direct injection into Columbia River Basalt using shallow injection wells, recovery possible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, stream gaging, infiltration facilities, ASR wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to the KRD North Branch canal or Park Creek, a tributary to the Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout			X
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Water recovered or released from storage could be discharged to the KRD North Branch Canal which discharges to the Yakima River at RM 146 or Park Creek, which discharges to the Yakima River at RM 147.4.

Location of Benefits to Water Users: Ground water users in Kittitas area, KRD users downgradient if ASR project developed.

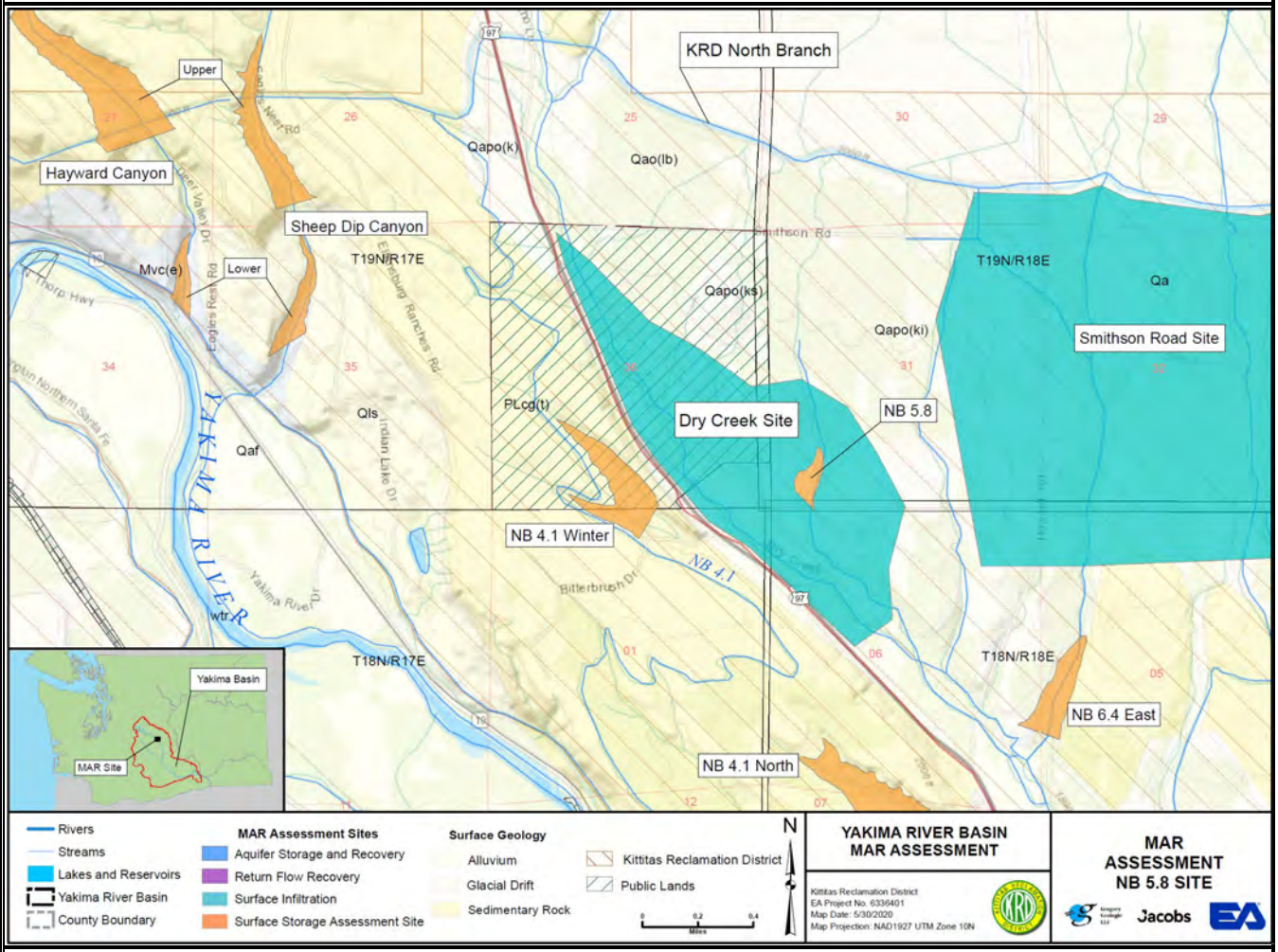
Integration with proposed Integrated Plan or other projects

This site is one of the surface storage assessment sites which could be used in conjunction with an ASR well. There are two residences on site. This site is one of the sites evaluated for surface storage in Jacobs, 2017.

Project Area Characteristics – NB 5.8

Rank: 57

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T19N, R18E, Section 31.

Property Availability

Private

Site Surface Geology

Alpine Glacial Drift, Alluvium

Project Area Subsurface Conditions

Kittitas Drift, Indian John unit; sands and gravels below about 300 ft.

Depth to Water

Depth to water Drift wells at 30', wells in lower sands and gravels have heads at 250. NWIS well 470642120394901 indicates Ellensburg Formation 30' below ground surface.

Hydraulic Conductivity Estimate

Variable., high values in alluvium.

Water Source and Availability

Flood Flows: Peak 50% flood flow 57 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam (EASW), See Appendix Table 1. Note- Served by KRD, North Branch Canal.

Conceptual Operational Model

Infiltration pond into Quaternary Alluvium.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, recharge basin, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout		X	
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: Generally below MP 157.

Location of Benefits to Water Users: Lower Dry Creek Groundwater users.

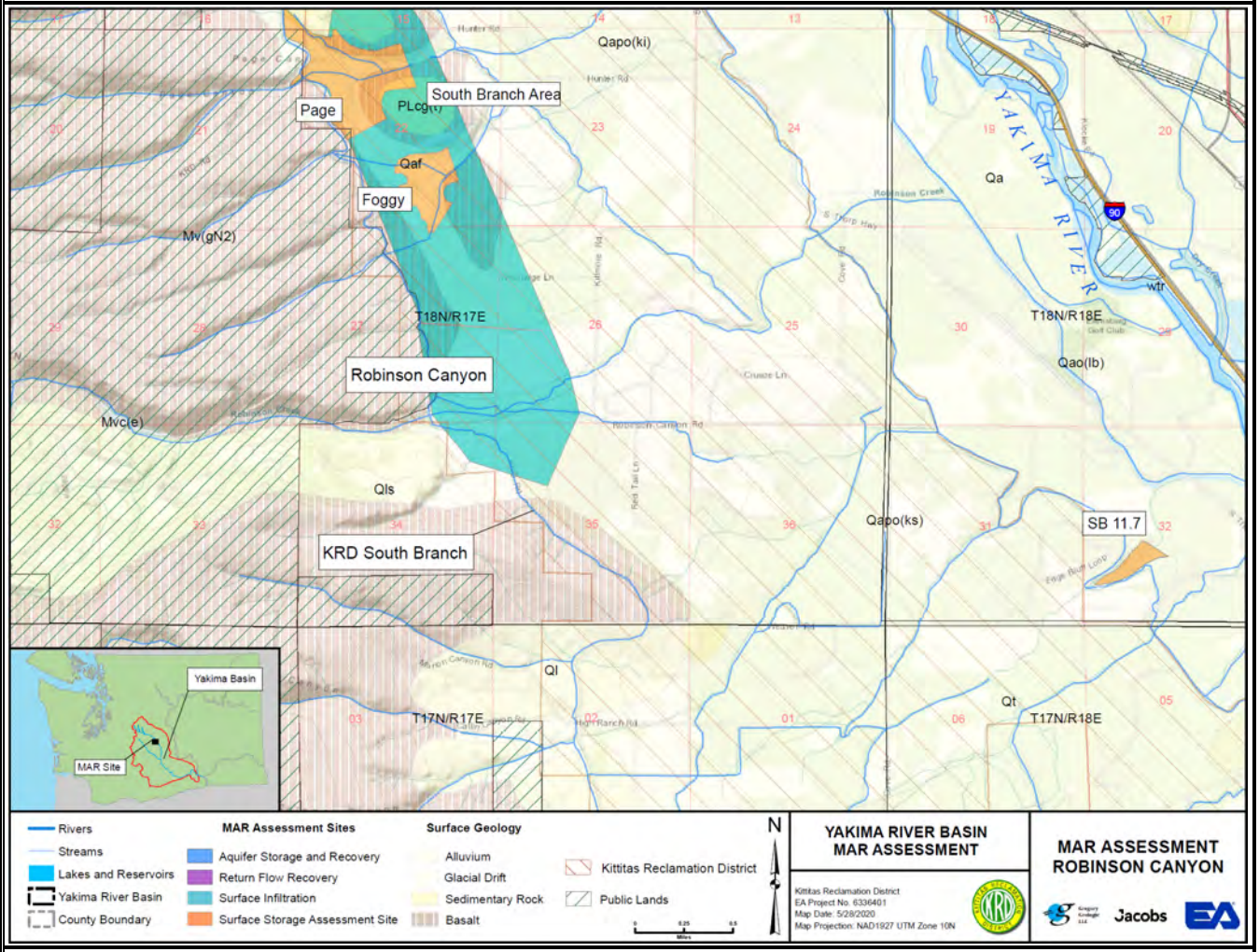
Integration with proposed Integrated Plan or other projects

No known habitat or fish projects in progress.

Project Area Characteristics – Robinson Canyon

Rank: 61

MAR Project Type: Surface Infiltration



Location (TRS): T18N, R17E, Sections 26 and 27.

Property Availability

Private land, intensive cultivation.

Site Surface Geology

Thin Quaternary Alluvium

Project Area Subsurface Conditions

Columbia River Basalt/Ellensburg Formation.

Depth to Water

120', 50'statics.

Hydraulic Conductivity Estimate

Very local hydraulic conductivity variation.

Water Source and Availability

Flood Flows: Peak 50% Flood estimate 77 cfs.

Flows from nearby Irrigation Canals: Easton Diversion Dam. See Appendix Table 1. Served by KRD South Branch Canal.

Conceptual Operational Model

Infiltration pond, potential for surface infiltration, likely infiltration wells.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase flows in Robinson Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation

Location of Yakima River Benefits: Yakima RM 158

Location of Benefits to Water Users: Increase in groundwater availability and sub irrigation in West Branch canal vicinity, capture and infiltrate South Branch canal leakage.

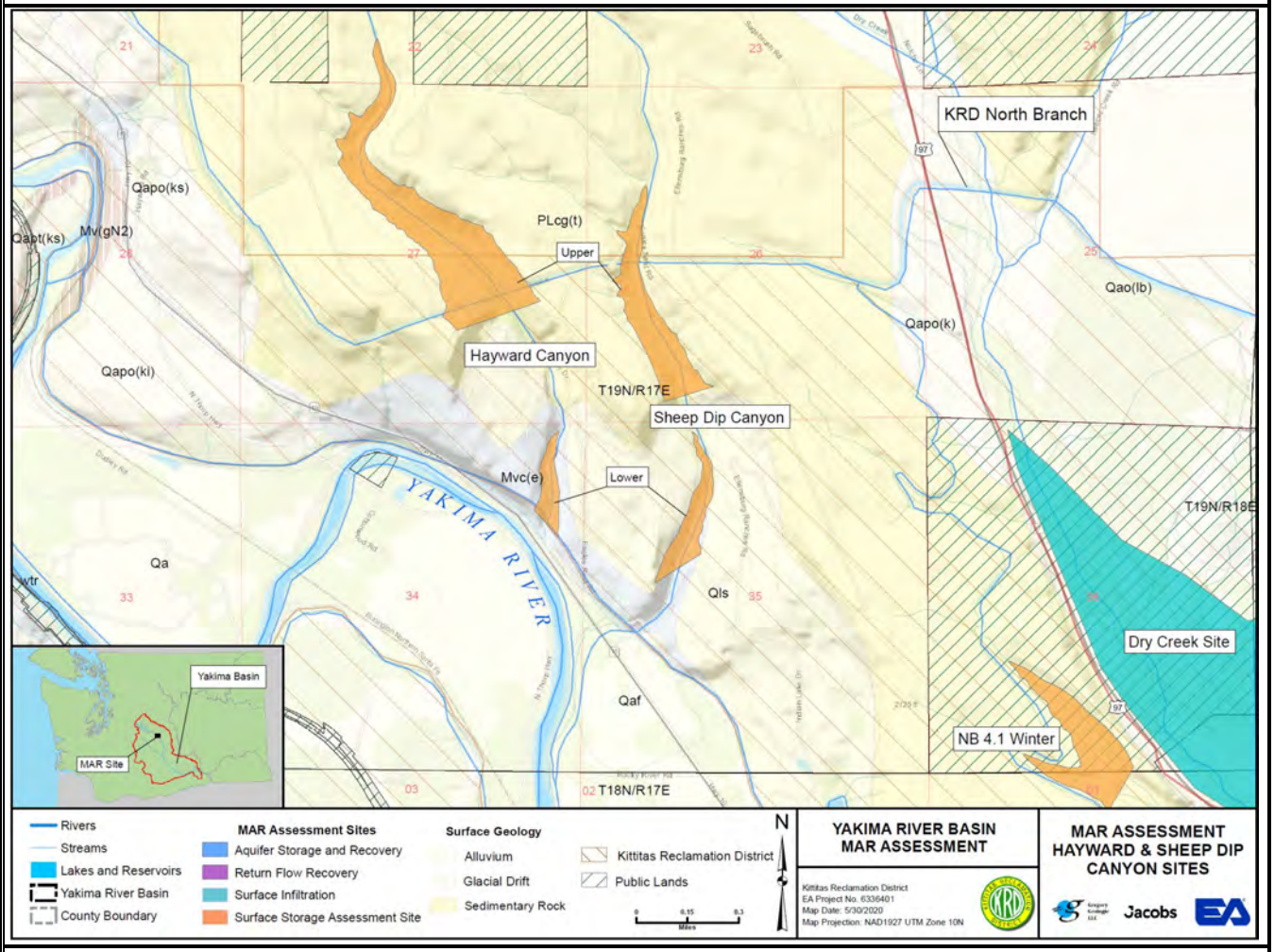
Integration with proposed Integrated Plan or other projects

No habitat projects in the immediate vicinity.

Project Area Characteristics – Hayward Canyon Upper & Lower

Rank: Upper Hayward Canyon – 47, Lower Hayward Canyon - 61

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): Upper - T19N, R17E, Sections 22 and 27, Lower - T19N, R17E, Section 34.

Property Availability

Private

Site Surface Geology

Upper – Thorp Gravels, Lower - Volcaniclastic rocks of the Ellensburg Formation

Project Area Subsurface Conditions

Thorp Gravels, volcaniclastic rocks of the Ellensburg Formation, basalt at depth

Depth to Water

Variable 100 – 400 feet

Hydraulic Conductivity Estimate

Variable, likely relatively low in most shallow units

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.
Flood Flows: N/A

Conceptual Operational Model

Infiltration ponds of KRD water into shallow aquifer. Low permeability of Thorp Gravel at Upper site makes SAR infeasible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Delayed runoff

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 164

Location of Benefits to Water Users: Downstream of RM 164

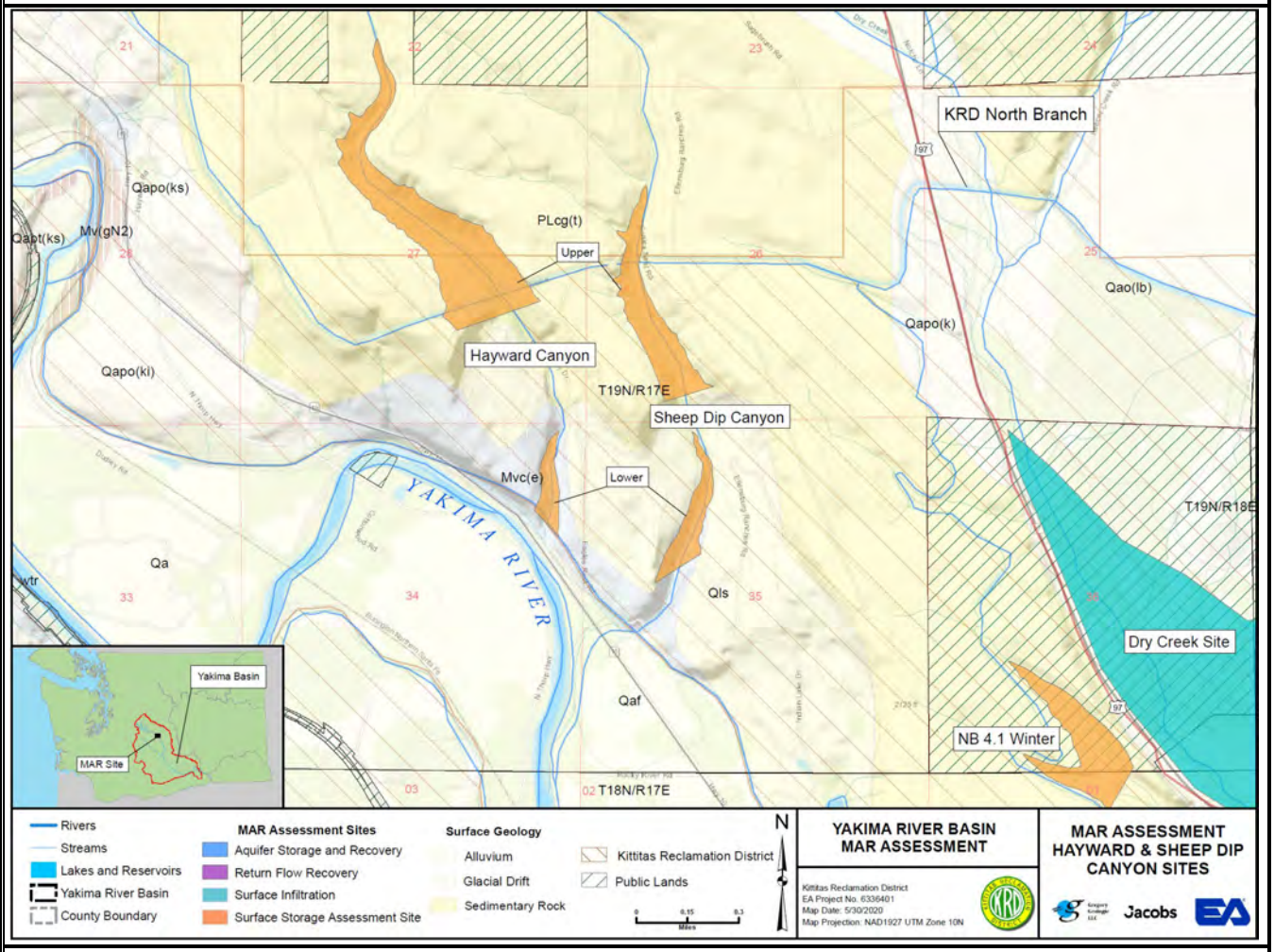
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Sheep Dip Canyon Upper & Lower

Rank: Upper Sheep Dip Canyon – 47, Lower Sheep Dip Canyon - 61

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): Upper - T19N, R17E, Section 26, Lower - T19N, R17E, Section 35.

Property Availability

Private

Site Surface Geology

Upper – Thorp Gravels, Lower - Volcaniclastic rocks of the Ellensburg Formation

Project Area Subsurface Conditions

Thorp Gravels, volcaniclastic rocks of the Ellensburg Formation, basalt at depth

Depth to Water

Variable 100 – 400 feet

Hydraulic Conductivity Estimate

Variable, likely relatively low in most shallow units

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.
Flood Flows: N/A

Conceptual Operational Model

Infiltration ponds of KRD water into shallow aquifer. Low permeability of Thorp Gravel at Upper site makes SAR infeasible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Delayed runoff

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 162

Location of Benefits to Water Users: Downstream of RM 162

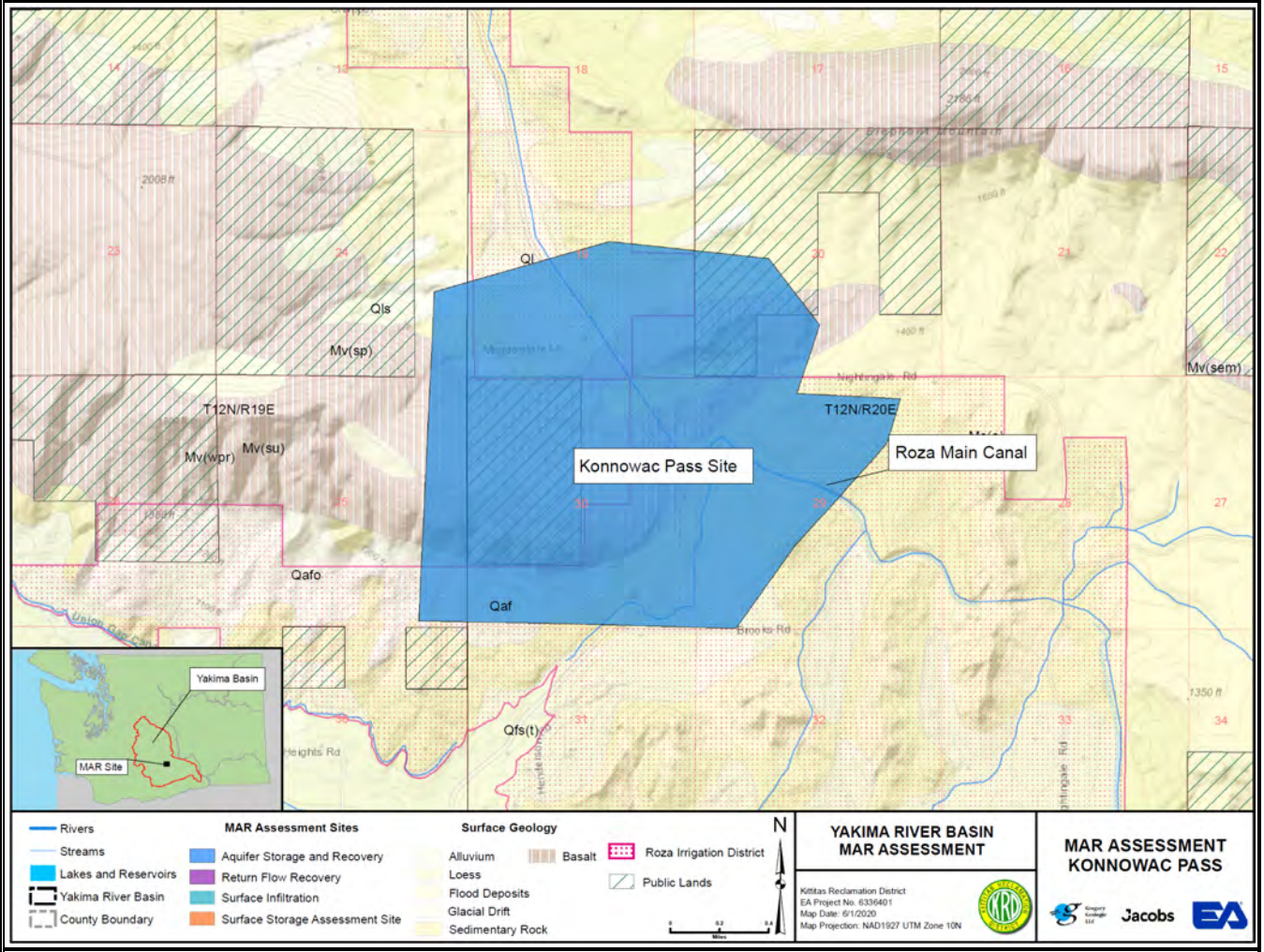
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Konnowac Pass

Rank: 64

MAR Project Type: Aquifer Storage and Recovery



Location (TRS): T12N, R20E, Sections 19,20,29,30.

Property Availability

Some BLM parcels mixed in private.

Site Surface Geology

Variable thickness (up to 100') Quaternary Alluvium/Colluvium, outcrops of Pomona member, Saddle Mts Basalt

Project Area Subsurface Conditions

Basalt below approx. 100 feet (variable) Ql/Qa.

Depth to Water

Depth to water variable-generally >300'. Significant faulting and folding in this location, significant potential for open space in basalt.

Hydraulic Conductivity Estimate

Large valley/fracture system at top of ridge.

Water Source and Availability

Flood Flows: N/A.

Flows from nearby Irrigation Canals: Roza Dam Diversion, See Appendix Tables 3 & 4.

Conceptual Operational Model

ASR into Pomona member/into open space fractures in structural basin.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, recharge wells, monitoring wells. Requires 240' lift from the Roza Canal.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA			X
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Roza Diversion. Yakima RM 128.

Location of Benefits to Water Users: Roza Irrigation District Roza Canal water users.

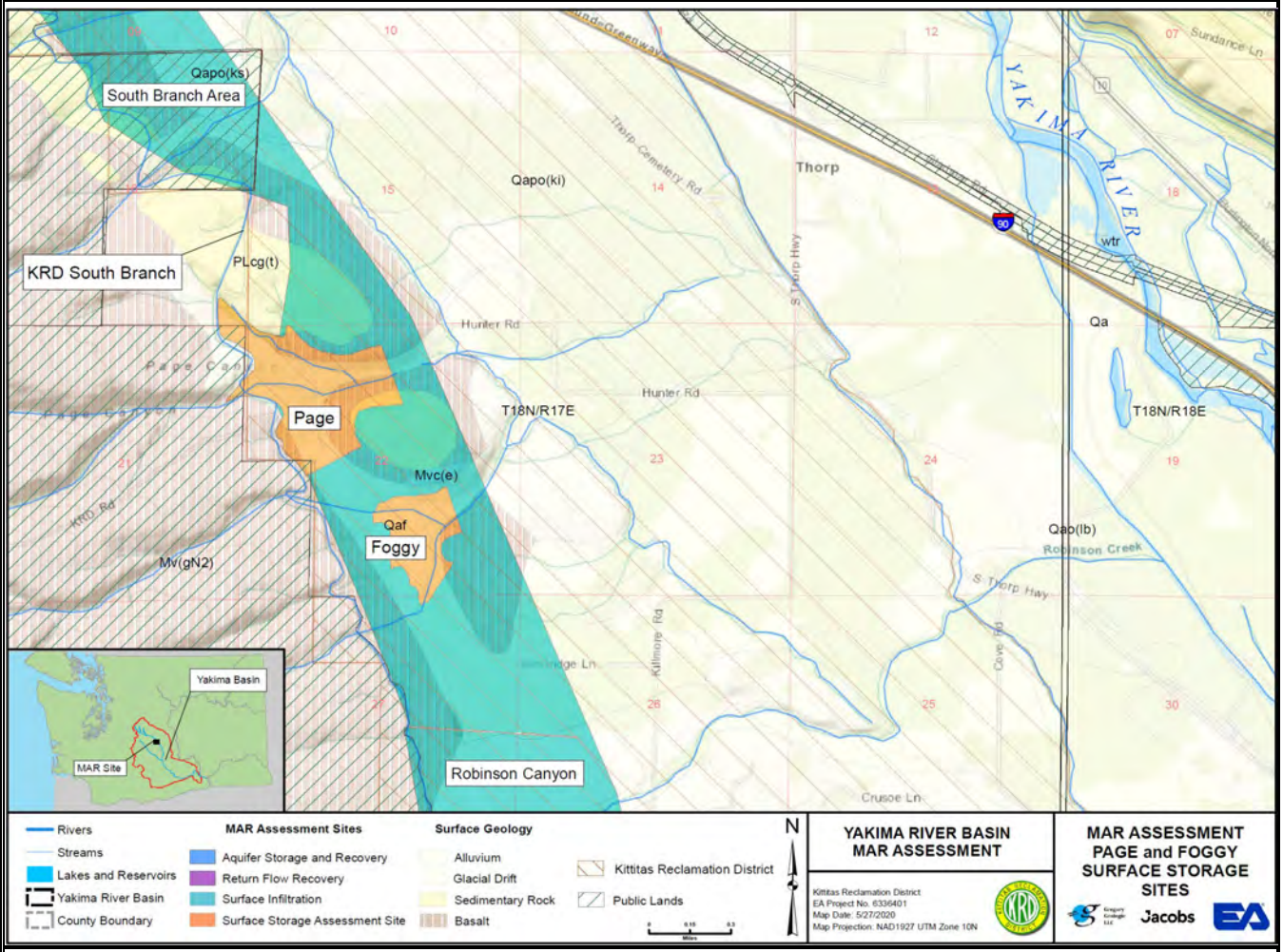
Integration with proposed Integrated Plan or other projects

No known habitat or fish projects in progress.

Project Area Characteristics – Page and Foggy

Rank: Page: 64, Foggy: 64

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): Page - T18N, R17E, Sections 15, 16, 21 and 22, Foggy - T18N, R17E, Sections 22 and 27.

Property Availability

Private

Site Surface Geology

Quaternary Alluvium with basalt outcrops.

Project Area Subsurface Conditions

Quaternary alluvium of varying thickness over sediment and Grande Ronde Basalt.

Depth to Water

40’ in shallow units to up to 200’ in basalt.

Hydraulic Conductivity Estimate

Highly variable.

Water Source and Availability

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by the KRD South Branch canal. Recovery of leakage and discharge from South Branch Canal.
Flood Flows: Small drainages.

Conceptual Operational Model
Install facilities to intercept, store, and return South Branch Canal leakage. Horizontal drains to collectors, small impoundments and pumping stations.
Estimated Costs and Cost Elements
Low - Diversion structures, piping, recharge basin, recharge wells, monitoring wells.
Water Quality Concerns
None
Benefits of Operation
Benefits: Any storage and use of recovered water can delay runoff and reduce diversion from Yakima River.

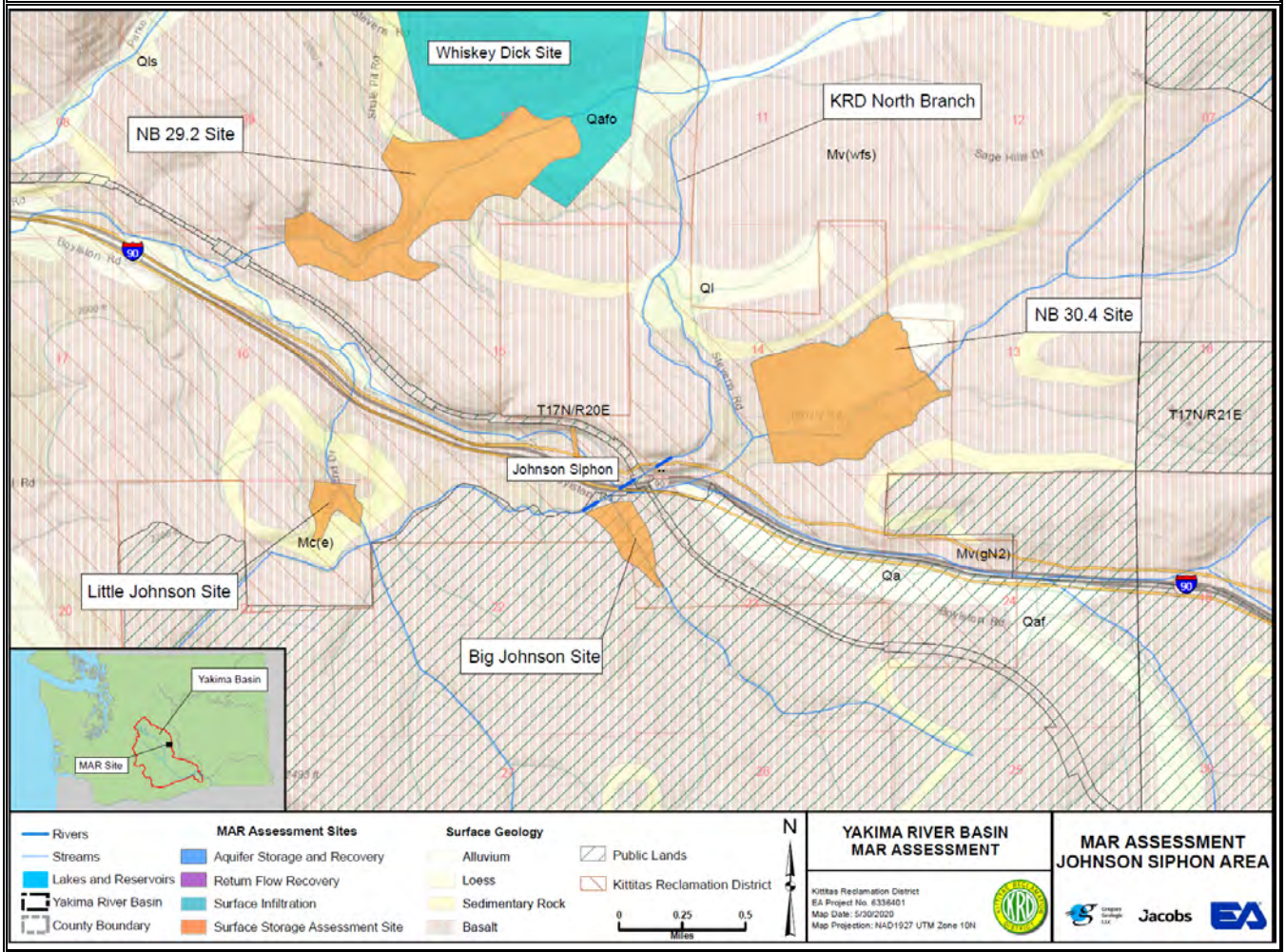
Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use			X

Location of Benefits of Operation
Location of Yakima River Benefits: KRD diversion at Easton, RM 202.
Location of Benefits to Water Users: KRD South Branch canal water users.
Integration with proposed Integrated Plan or other projects
There are no know fish or habitat projects in the vicinity of this project.

Project Area Characteristics – Johnson Siphon

Rank: 64

MAR Project Type: Surface Infiltration or ASR



Location (TRS): T17N, R20E, Sections 22 and 23.

Property Availability

Federal, US Army Corps of Engineers

Site Surface Geology

Miocene Grande Ronde Basalt Mv(gN2)

Project Area Subsurface Conditions

Basalt at surface

Depth to Water

175, Static Water Level in basalt 158’

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by KRD Canal, North Branch.

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt. ASR direct injection into Columbia River Basalt using shallow injection wells, recovery possible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, stream gaging, infiltration facilities, ASR wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to the KRD North Branch canal or Park Creek, a tributary to the Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Water recovered or released from storage could be discharged to the KRD North Branch Canal which discharges to the Yakima River at RM 146 or Park Creek, which discharges to the Yakima River at RM 147.4.

Location of Benefits to Water Users: Ground water users in Kittitas area, KRD users downgradient if ASR project developed.

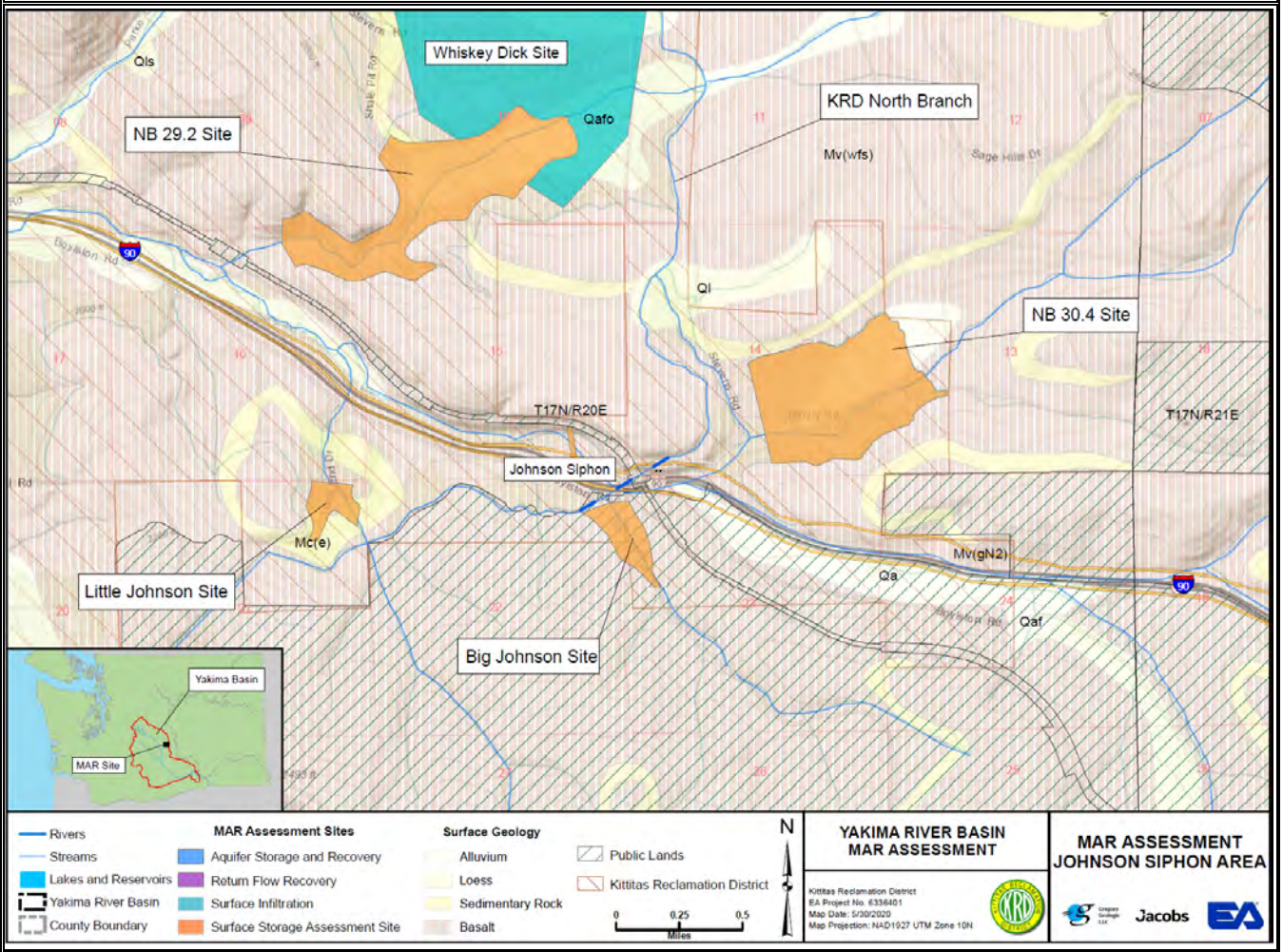
Integration with proposed Integrated Plan or other projects

This site is one of the surface storage assessment sites which could be used in conjunction with an ASR well. There are two residences on site. This site is one of the sites evaluated for surface storage in Jacobs, 2017.

Project Area Characteristics – Little Johnson

Rank: 64

MAR Project Type: Surface Infiltration or ASR



Location (TRS): T17N, R20E, Section 21.

Property Availability

Private Land

Site Surface Geology

Miocene Grande Ronde Basalt Mv(gN2)

Project Area Subsurface Conditions

Basalt at surface

Depth to Water

175, Static Water Level in basalt 158’

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by KRD Canal, North Branch.

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt. ASR direct injection into Columbia River Basalt using shallow injection wells, recovery possible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, stream gaging, infiltration facilities, ASR wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to the KRD North Branch canal or Park Creek, a tributary to the Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Water recovered or released from storage could be discharged to the KRD North Branch Canal which discharges to the Yakima River at RM 146 or Park Creek, which discharges to the Yakima River at RM 147.4.

Location of Benefits to Water Users: Ground water users in Kittitas area, KRD users downgradient if ASR project developed.

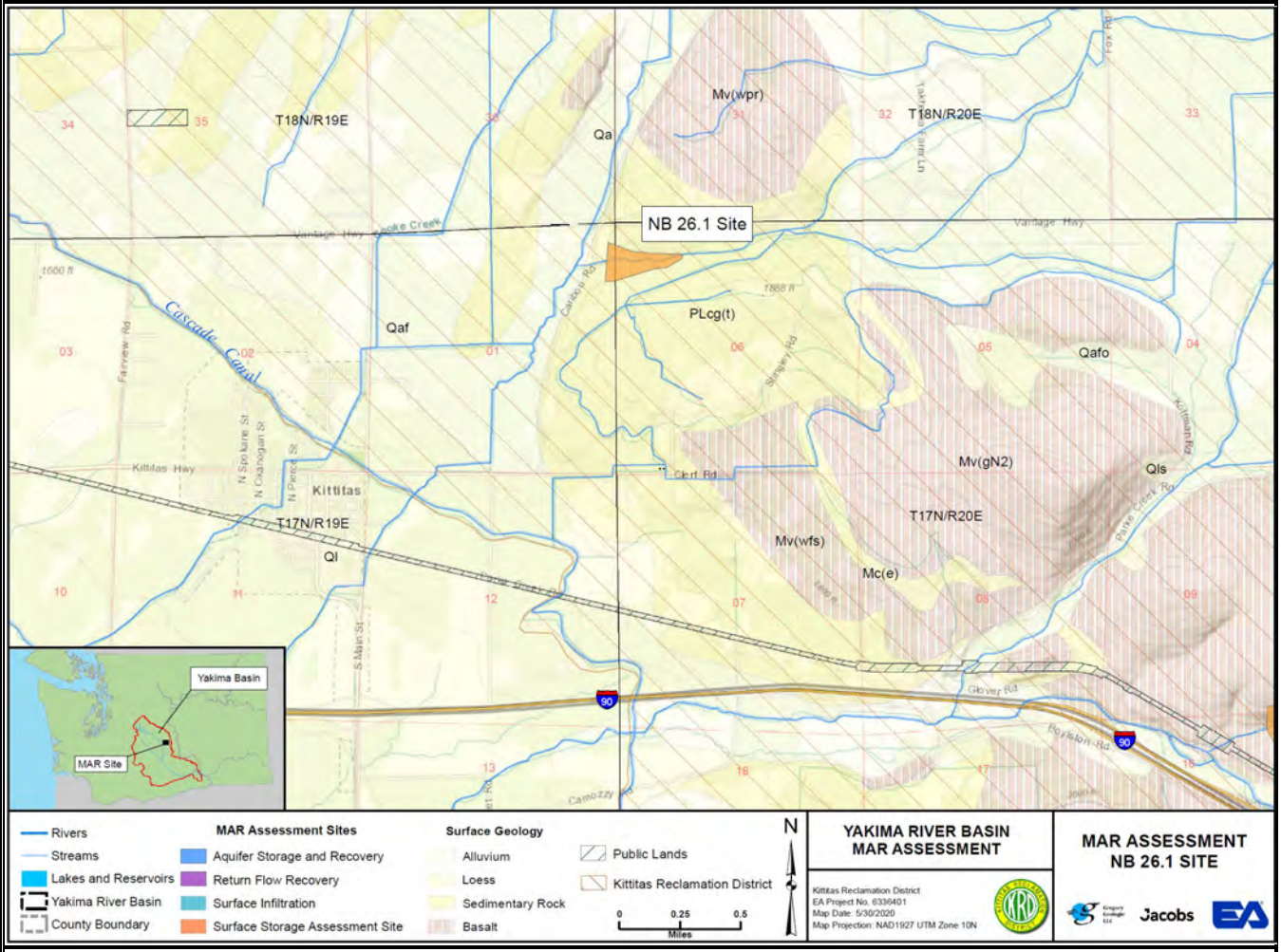
Integration with proposed Integrated Plan or other projects

This site is one of the surface storage assessment sites which could be used in conjunction with an ASR well. There are two residences on site. This site is one of the sites evaluated for surface storage in Jacobs, 2017.

Project Area Characteristics – NB 26.1

Rank: 64

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): T17N, R19E, Section 1 and, T17N, R20E, Section 6.

Property Availability

Private

Site Surface Geology

Thorp Gravel

Project Area Subsurface Conditions

Clay, sand and gravel, Basalt around 150 feet below ground surface.

Depth to Water

50 – 100’

Hydraulic Conductivity Estimate

Variable

Water Source and Availability

Flood Flows: Peak 50% 69 cfs

Flows from nearby Irrigation Canals: Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

Surface infiltration using KRD water

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase later-season baseflow discharge to Parke Creek, increase recharge to local aquifers.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Canyon mouth, RM 148.

Location of Benefits to Water Users: Ground water users in Kittitas area.

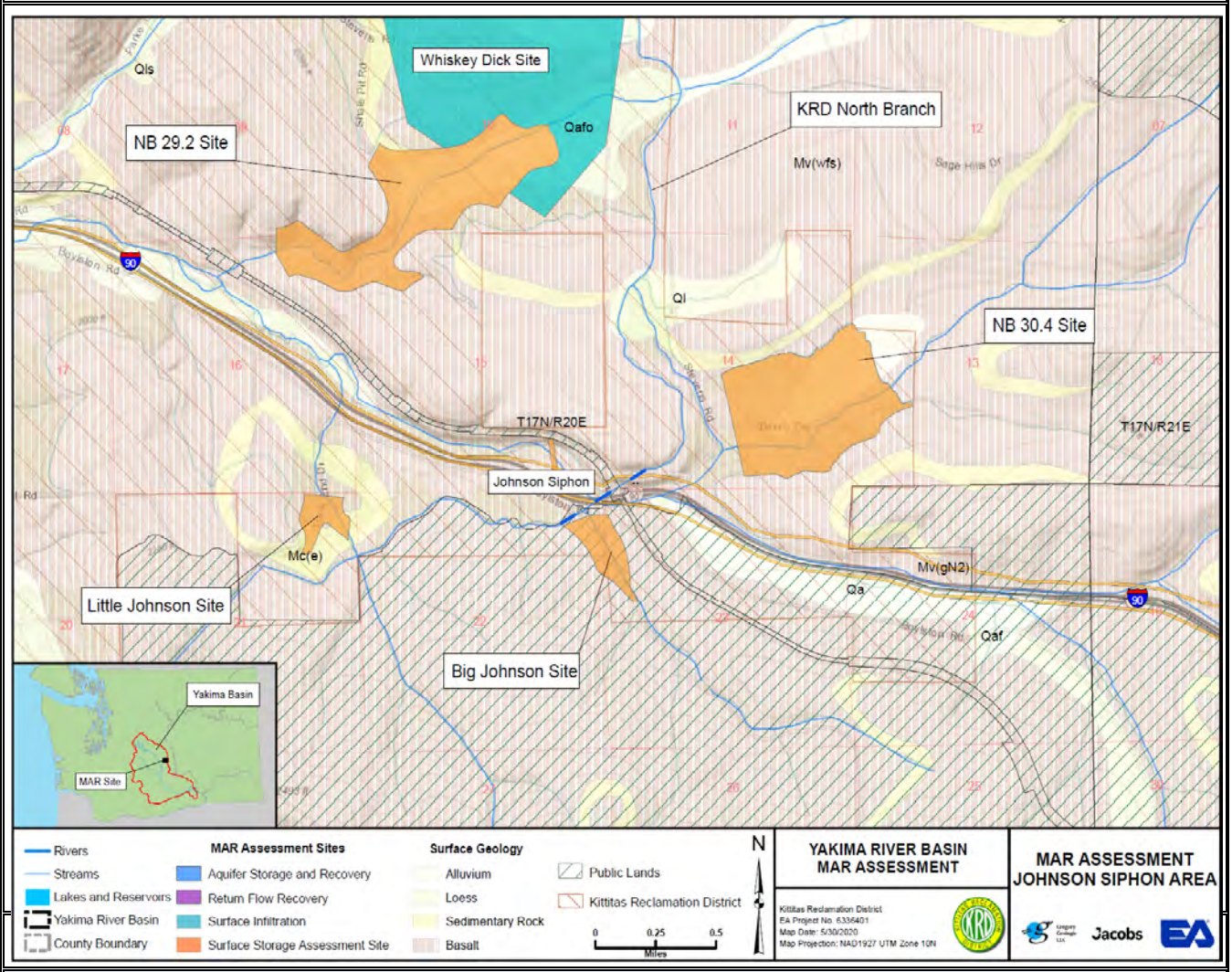
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – NB 29.2

Rank: 64

MAR Project Type: Surface Infiltration or ASR



Property Availability

Mostly Private Land, Washington State DNR owns the SW portion of the site

Site Surface Geology

Thin Quaternary alluvial fan deposits overlying Miocene Grande Ronde Basalt Mv(gN2).

Project Area Subsurface Conditions

Alluvium and Basalt at surface.

Depth to Water

100, Static Water Level in basalt 95’

Hydraulic Conductivity Estimate

Estimate relatively high in alluvial fan sediments and alluvium.

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam (see Appendix Table 1). Served by KRD North Branch Canal.

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt. ASR direct injection into Columbia River Basalt using shallow injection wells, recovery possible.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, infiltration facility, ASR wells, monitoring wells.

Water Quality Concerns

Must meet GWQS in aquifer.

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to the KRD North Branch canal or Park Creek, a tributary to the Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia			X
Improves riparian and/or floodplain habitat			X
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Water recovered or released from storage could be discharged to the KRD North Branch Canal which discharges to the Yakima River at RM 146 or Park Creek, which discharges to the Yakima River at RM 147.4.

Location of Benefits to Water Users: Ground water users in Kittitas area, KRD users downgradient if ASR project developed.

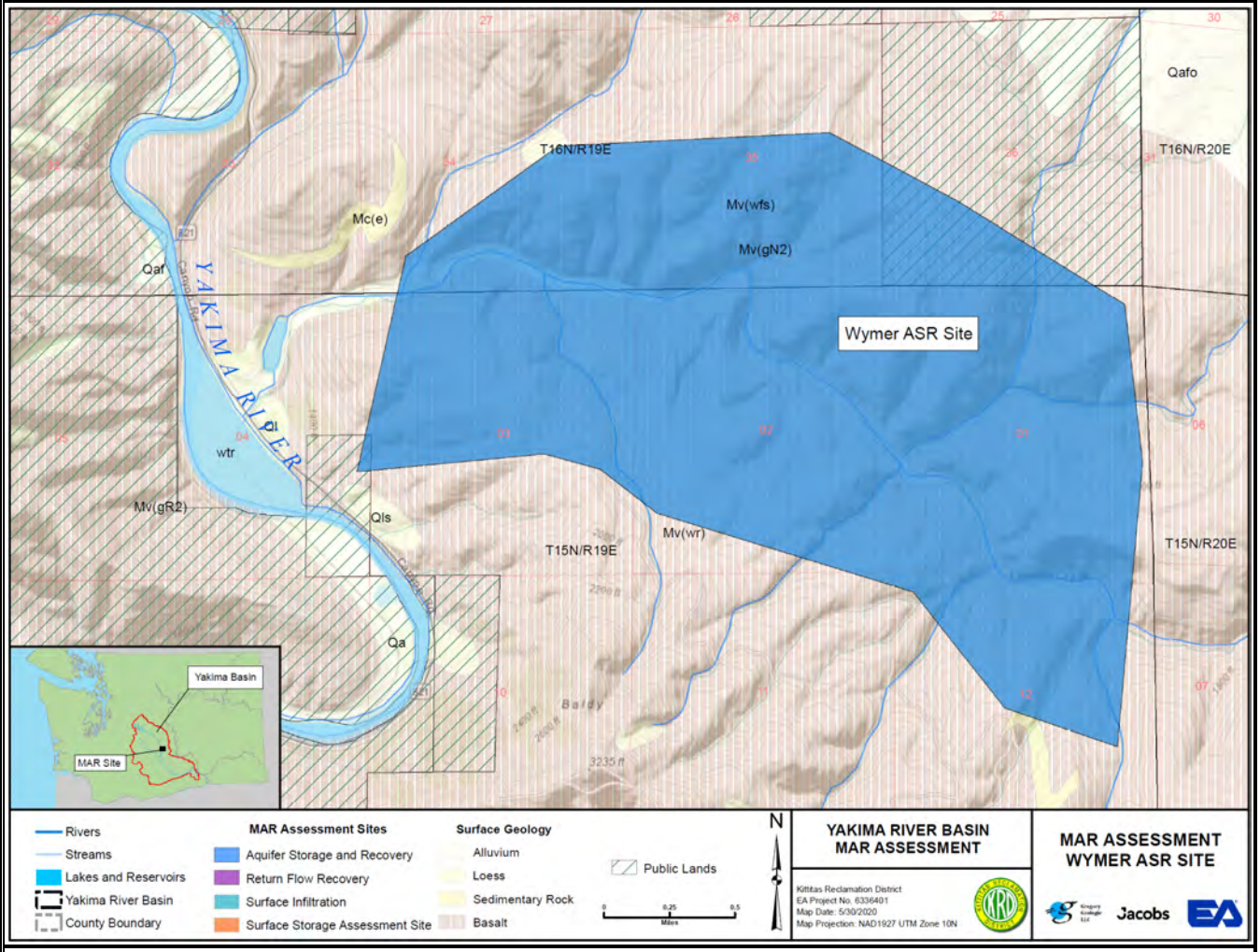
Integration with proposed Integrated Plan or other projects

This site is one of the surface storage assessment sites which could be used in conjunction with an ASR well.

Project Area Characteristics – Wymer ASR

Rank: 71

MAR Project Type: Aquifer Storage & Recovery



Location (TRS): Centers on T. 16 N R 19 E Sections 34, 35, 36; T 15N R 19 E Sections 1, 2, 3.

Property Availability

Largely Private, some BLM Some DNR.

Site Surface Geology

Grande Ronde below Wanapum Basalt. Sole Well log from T.15 N. R. 19 E Section 4 indicates Basalt flows and interflow conditions. See Wymer investigation documentation.

Project Area Subsurface Conditions

Basalt at surface

Depth to Water

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: Median 2-year peak flood 154 cfs.

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal. KRD conserved water.

Conceptual Operational Model

ASR of water to supplement Wymer surface storage.

Estimated Costs and Cost Elements

High - Diversion structures, piping, pumping, tunneling, stream gaging, production wells, monitoring wells. Terrain very steep, investigation effort and cost very high.

Water Quality Concerns

Unknown

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Roza diversion. Yakima RM 128.

Location of Benefits to Water Users: Roza diversion.

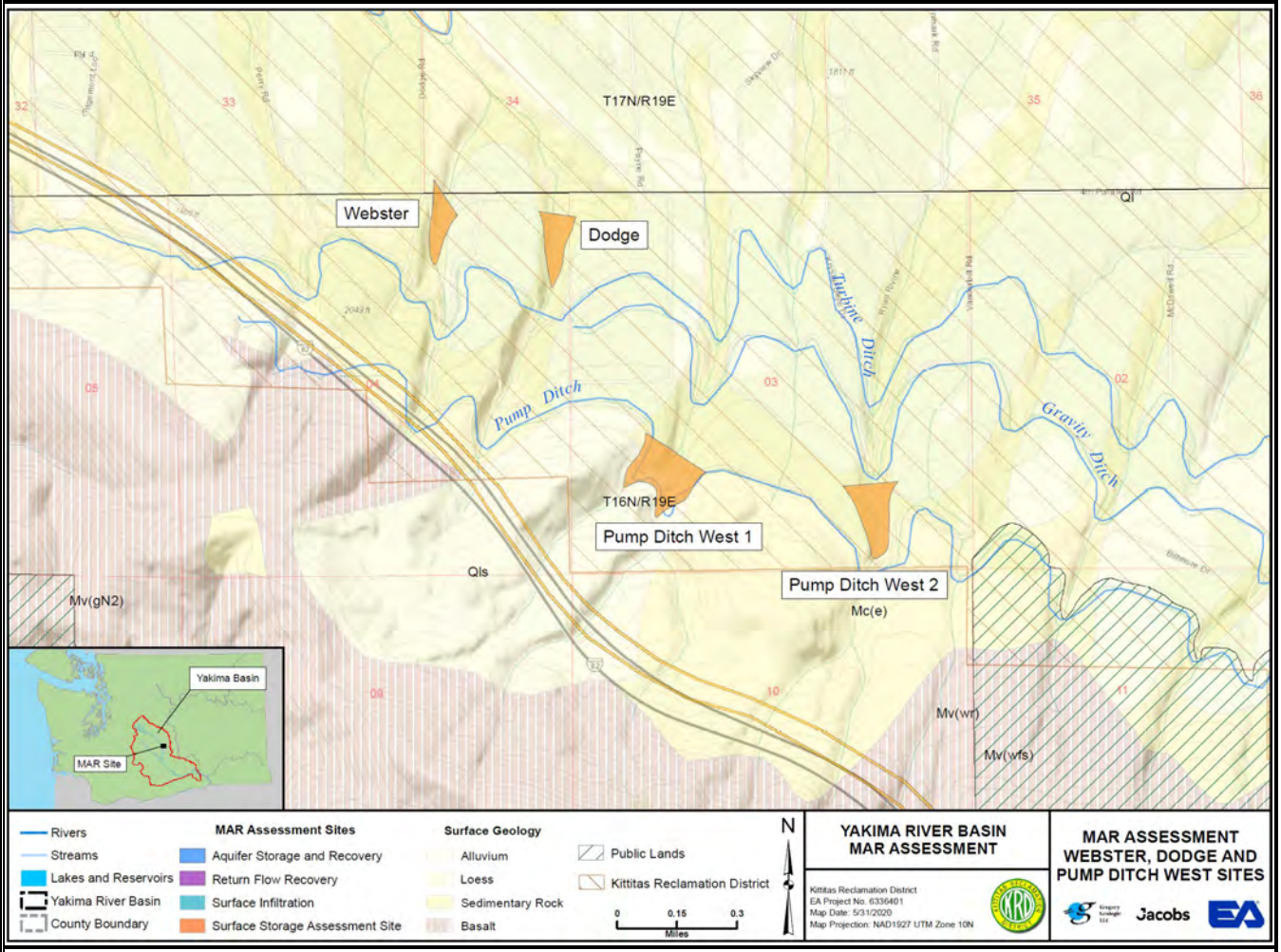
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Pump Ditch West 1 and 2

Rank: 71

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): T16N, R19E, Section 3.

Property Availability

Private

Site Surface Geology

Loess and sandstone and clay of the Ellensburg Formation

Project Area Subsurface Conditions

Sandstone and clay

Depth to Water

150 – 250 ‘

Hydraulic Conductivity Estimate

~ 0.5 ft/day (Ely et al, 2011)

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal to Pump Ditch. KRD conserved water.
Flood Flows: N/A

Conceptual Operational Model
Infiltration pond and/or subsurface galleries using flood flows and canal deliveries.
Estimated Costs and Cost Elements
Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells
Water Quality Concerns
Tail end of irrigation canal
Benefits of Operation
Benefits: Increase baseflow discharge to KRD canals, Yakima River and nearby tributaries.

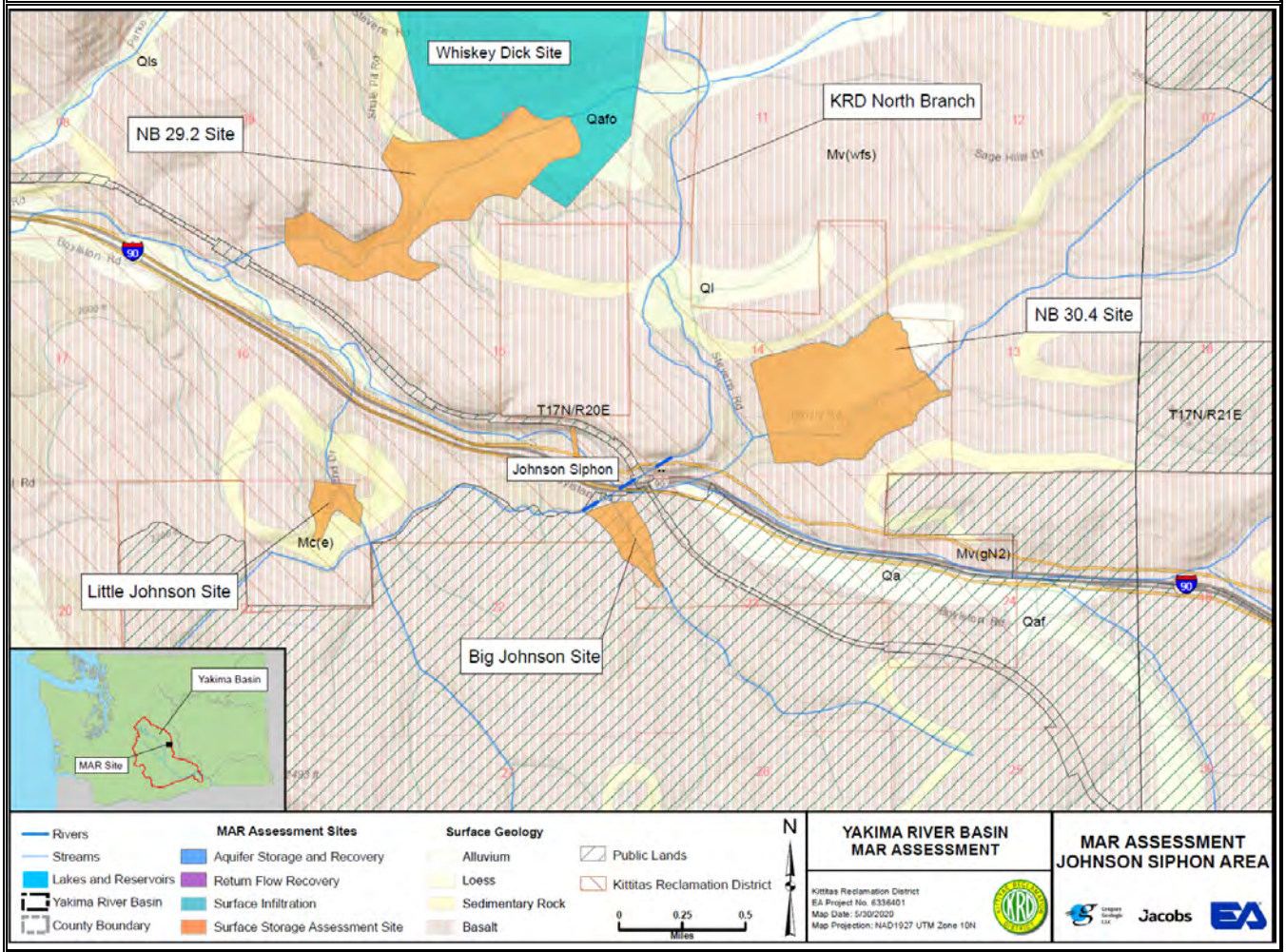
Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation
Location of Yakima River Benefits: 147
Location of Benefits to Water Users: Groundwater users in the lower portion of Badger Pocket
Integration with proposed Integrated Plan or other projects
No known habitat projects in the immediate vicinity.

Project Area Characteristics – Big Johnson

Rank: 75

MAR Project Type: Surface Infiltration or ASR



Location (TRS): T17N, R20E, Sections 22 and 23.

Property Availability

Federal, US Army Corps of Engineers

Site Surface Geology

Miocene Grande Ronde Basalt Mv(gN2)

Project Area Subsurface Conditions

Basalt at surface

Depth to Water

175, Static Water Level in basalt 158’

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Easton Diversion Dam, See Appendix Table 1. Served by KRD Canal, North Branch.

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt. ASR direct injection into Columbia River Basalt using shallow injection wells, recovery possible. Relatively steep slopes for a SAR facility.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, stream gaging, infiltration facilities, ASR wells, monitoring wells.

Water Quality Concerns

Compliance with GWQ Standards

Benefits of Operation

Benefits: Water recovered or released from storage would discharge to the KRD North Branch canal or Park Creek, a tributary to the Yakima River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring			X
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat		X	
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Water recovered or released from storage could be discharged to the KRD North Branch Canal which discharges to the Yakima River at RM 146 or Park Creek, which discharges to the Yakima River at RM 147.4.

Location of Benefits to Water Users: Ground water users in Kittitas area, KRD users downgradient if ASR project developed.

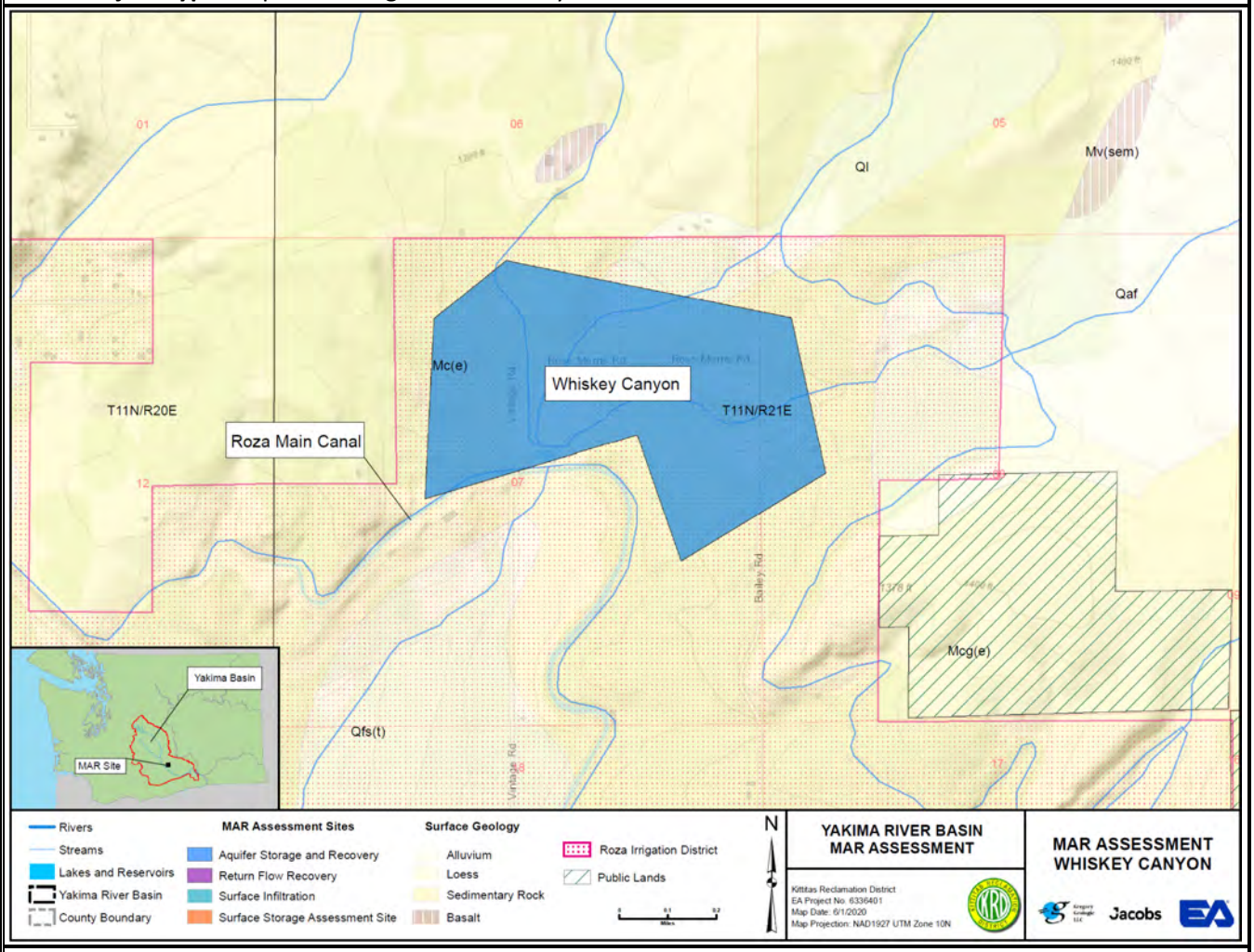
Integration with proposed Integrated Plan or other projects

This site is one of the surface storage assessment sites which could be used in conjunction with an ASR well. This site is one of the sites evaluated for surface storage in Jacobs, 2017.

Project Area Characteristics – Whiskey Canyon

Rank: 76

MAR Project Type: Aquifer Storage and Recovery



Location (TRS): T11N, R21E, Section 7.

Property Availability

Private land.

Site Surface Geology

Quaternary Alluvium.

Project Area Subsurface Conditions

Alluvium and Ellensburg formation, basalt at about 300'.

Depth to Water

Nearby static water levels 300'.

Hydraulic Conductivity Estimate

Variable.

Water Source and Availability

Flood Flows: Peak 50% flood flows 11 cfs.

Roza Diversion Dam (See Appendix Tables 3 & 4).

Conceptual Operational Model

ASR target for Storage and Recovery of Roza water in Ellensburg formation.

Estimated Costs and Cost Elements

Medium - Diversion structures, piping, recharge wells, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Leakage to Yakima River near Zillah. Yakima RM 91.

Location of Benefits to Water Users: Recovered storage water to Roza water users.

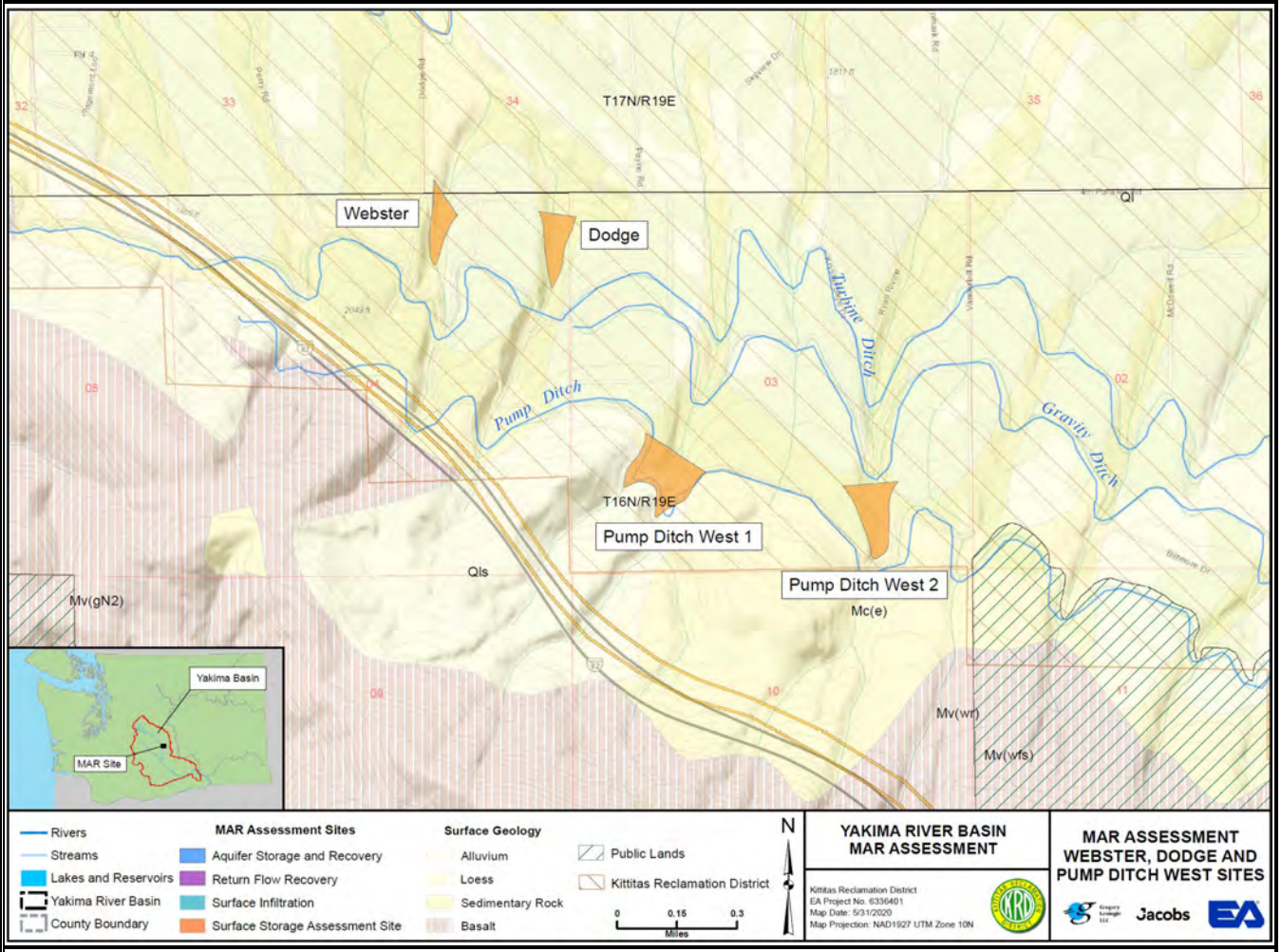
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Webster and Dodge

Rank: 80

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Sites



Location (TRS): Webster - T16N, R19E, Section 4 and T17N, R19E, Section 34, Dodge - T16N, R19E, Sections 3 and 4.

Property Availability

Private

Site Surface Geology

Loess and sandstone and clay of the Ellensburg Formation

Project Area Subsurface Conditions

Sandstone and clay

Depth to Water

150 – 250 ‘

Hydraulic Conductivity Estimate

~ 0.5 ft/day (Ely et al, 2011)

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1) at RM 202. Served by KRD North Branch Canal to Pump Ditch. KRD conserved water.
Flood Flows: N/A

Conceptual Operational Model
Infiltration pond and/or subsurface galleries using flood flows and canal deliveries.
Estimated Costs and Cost Elements
Medium - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells
Water Quality Concerns
Tail end of irrigation canal
Benefits of Operation
Benefits: Increase baseflow discharge to Yakima River and nearby tributaries.

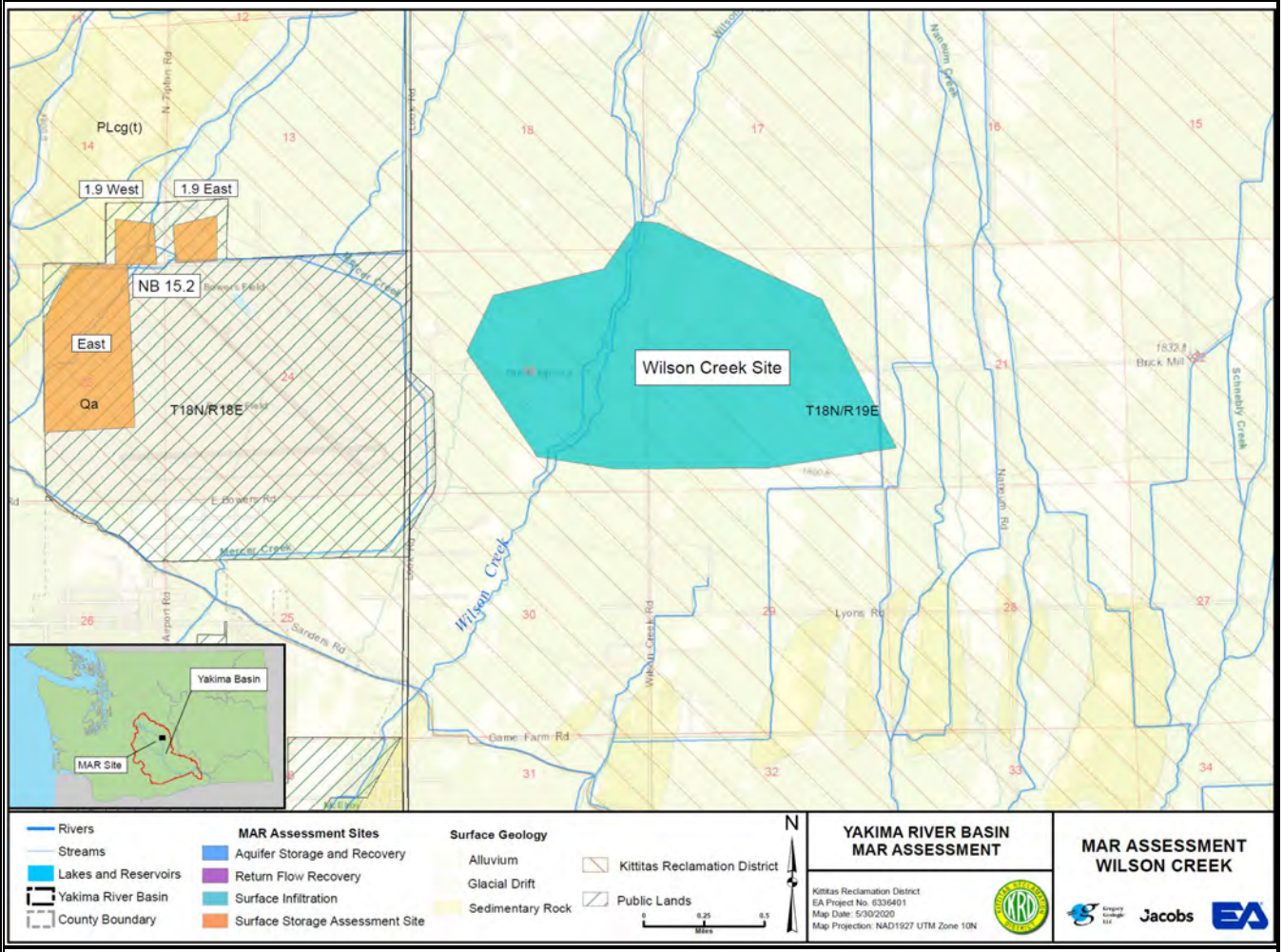
Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity		X	
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation
Location of Yakima River Benefits: 147
Location of Benefits to Water Users: Groundwater users in the lower portion of Badger Pocket
Integration with proposed Integrated Plan or other projects
No known habitat projects in the immediate vicinity.

Project Area Characteristics – Wilson Creek

Rank: 82

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T18N, R19E, Sections 17, 18, 19, 20 and 21.

Property Availability

Private, cultivated land

Site Surface Geology

Quaternary Alluvium

Project Area Subsurface Conditions

Thorp Sandstone over Ellensburg Formation and Basalt. Ellensburg at 80' below land surface.

Depth to Water

120'

Hydraulic Conductivity Estimate

0.5 – 10 ft/day in Ellensburg, (Ely et al, 2011). Higher values in course grained alluvium.

Water Source and Availability

Flood Flows: 50% flood flow 387 cfs

Flows from nearby Irrigation Canals: Easton Diversion Da. (See Appendix Table 1). Served by KRD North Branch Canal.

Conceptual Operational Model

Capture then recharge or use canal leakage, possible ASR in Ellensburg Formation or SAR on Alluvial fan. Infiltration ponds, canal leakage capture with horizontal drains, flood water and canal delivery capture.

Estimated Costs and Cost Elements

Low – Medium. Diversion structures, piping, infiltration ponds, stream gaging, production, and monitoring wells.

Water Quality Concerns

None with SAR, compliance with state Groundwater Quality Standards with ASR.

Benefits of Operation

Benefits: Increase flows in Wilson Creek, improves riparian habitat and cold water refugia. Integrates with other on-going habitat and conservation projects.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity			X
Increase mainstem flow	X		
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring		X	
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use		X	

Location of Benefits of Operation

Location of Yakima River Benefits: RM 151

Location of Benefits to Water Users: Groundwater users near airport

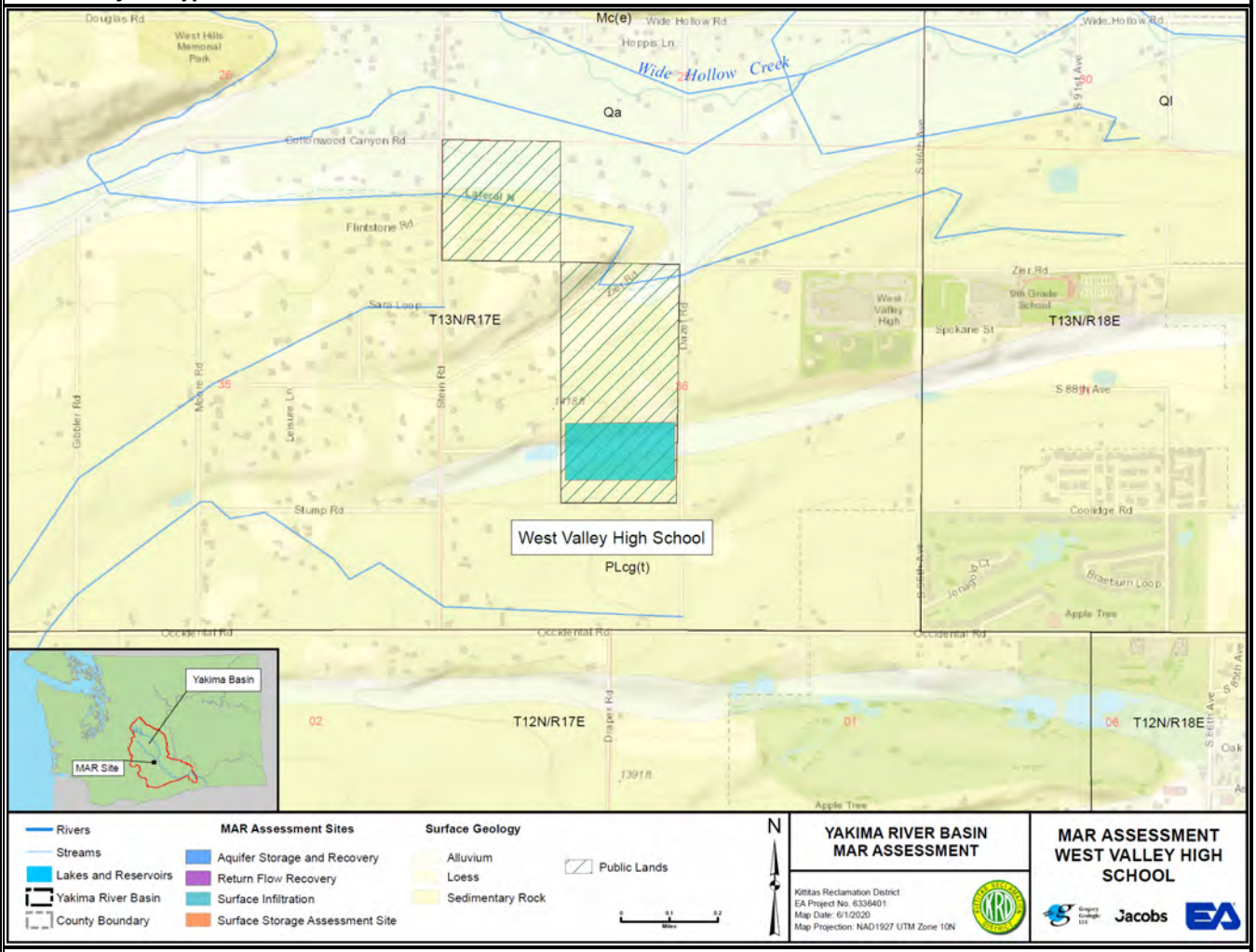
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity. Potential habitat projects in nearby tributaries.

Project Area Characteristics – West Valley High School

Rank: 83

MAR Project Type: Surface Infiltration



Location (TRS): T13N R17E Section 36.

Property Availability

DNR Managed

Site Surface Geology

Quaternary Alluvium.

Project Area Subsurface Conditions

Thorp Gravels.

Depth to Water

Alluvium 20’ statics, 200’+ Thorp wells 80’ static.

Hydraulic Conductivity Estimate

Deep Alluvium, high Hydraulic Conductivity.

Water Source and Availability

Flood Flows: Not significant.

Flows from nearby Irrigation Canals: Likely.

Conceptual Operational Model

Surface infiltration pond in center of section 36.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, stream gaging, monitoring wells.

Water Quality Concerns

Intense agricultural area, runoff concerns

Benefits of Operation

Benefits: Increase baseflow discharge to KRD Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: At Union Gap. Yakima RM 107.

Location of Benefits to Water Users: Ground water users in lower Ahtanum Valley.

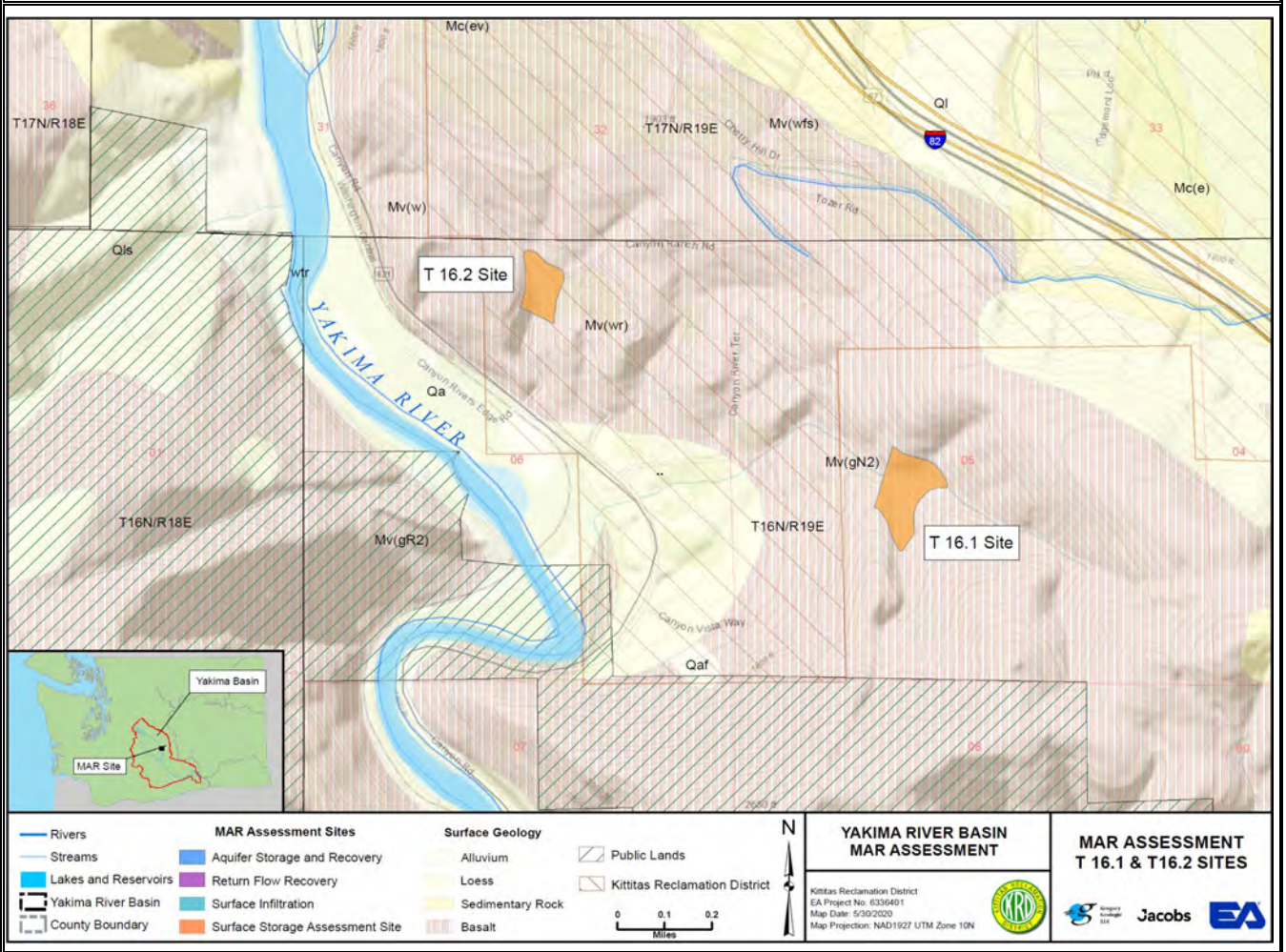
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – T 16.1 and 16.2

Rank: 84

MAR Project Type: Shallow Aquifer Recharge at Surface Storage Assessment Site



Location (TRS): T 16.1 - T16N, R19E, Section 5 and T 16.2 - T16N, R19E, Section 6.

Property Availability

Private

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Basalt

Depth to Water

Unknown

Hydraulic Conductivity Estimate

Variable, 4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Easton Diversion Dam (See Appendix Table 1). Served by KRD North Branch Canal at RM 202. KRD conserved water. Pumping to sites would be required.
Flood Flows: N/A.

Conceptual Operational Model

Surface infiltration into engineered drainage into basalt.

Estimated Costs and Cost Elements

High - Diversion structures, piping, infiltration ponds or galleries, stream gaging, production wells, monitoring wells, pumps, remote sites.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow to Yakima River. Delay runoff.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: RM 146

Location of Benefits to Water Users: Downstream of RM 146.

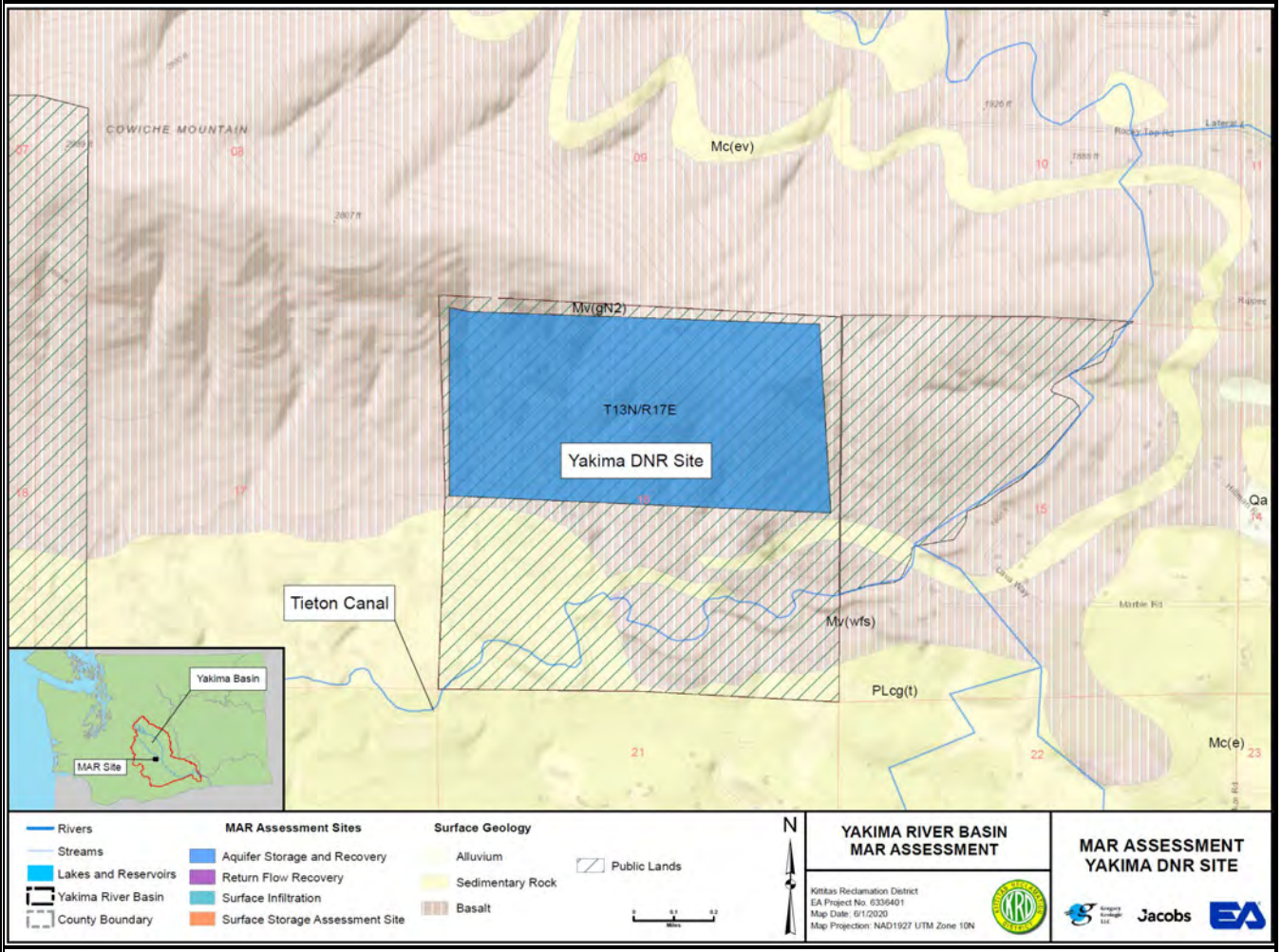
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Yakima DNR

Rank: 86

MAR Project Type: Aquifer Storage and Recovery



Location (TRS): T13N, R17E, Section 16.

Property Availability

Public Land - DNR

Site Surface Geology

Basalt

Project Area Subsurface Conditions

Basalt

Depth to Water

Greater than 230 feet

Hydraulic Conductivity Estimate

4 – 100 ft/day in basalt interflow zones (Ely et al, 2011)

Water Source and Availability

Flood Flows: N/A

Flows from nearby Irrigation Canals: Yakima-Tieton Canal diversion on the Tieton River.

Conceptual Operational Model

Water delivered from Yakima-Tieton Irrigation District Canal for recharge and recovery in basalt aquifer.

Estimated Costs and Cost Elements

Medium – Pumps, pipes, ASR and monitoring wells, potentially water treatment required.

Water Quality Concerns

End of irrigation canal, recharge must comply with State Groundwater Quality Standards.

Benefits of Operation

Benefits: Increase groundwater supply in the Ahtanum Valley, reduce late-season diversions from Tieton River.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow		X	
Water is Exchangeable with TWSA		X	
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Below diversion on Tieton River to mouth of Naches River at Yakima RM 116.

Location of Benefits to Water Users: Yakima-Tieton Irrigation District water users, groundwater users in the Ahtanum Valley.

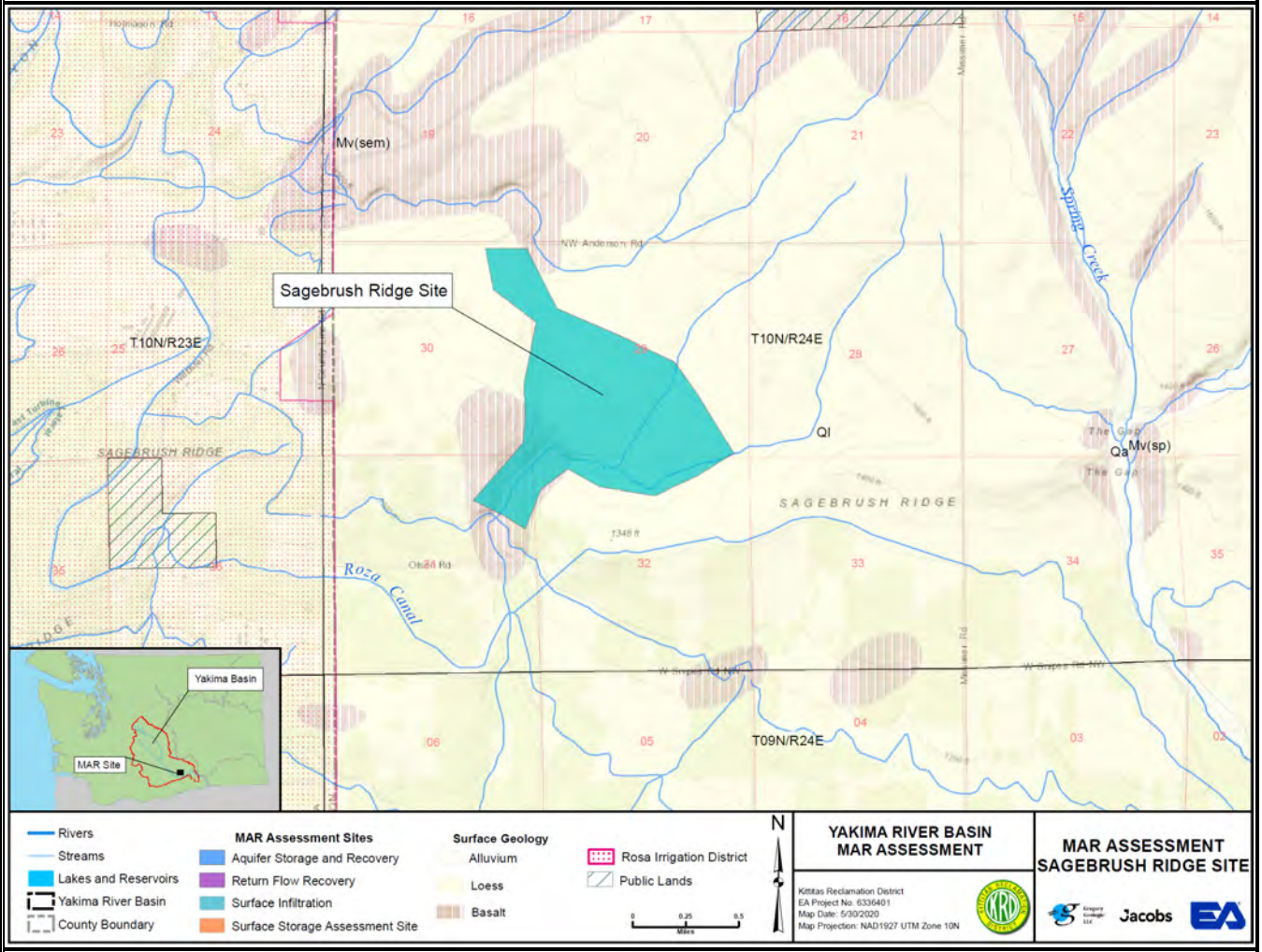
Integration with proposed Integrated Plan or other projects

No known habitat projects in the immediate vicinity.

Project Area Characteristics – Sagebrush Ridge

Rank: 87

MAR Project Type: Surface Infiltration



Location (TRS): T10N R24E Sections 29-32.

Property Availability

Private land.

Site Surface Geology

Quaternary Alluvium, Saddle Mountains Basalt.

Project Area Subsurface Conditions

Saddle Mountains Basalt

Depth to Water

Approximately 120’.

Hydraulic Conductivity Estimate

Water Source and Availability

Flood Flows: Minor

Flows from nearby Irrigation Canals: N/A (Roza Canal downhill).

Conceptual Operational Model

Surface storage/infiltration pond.

Estimated Costs and Cost Elements

Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.

Water Quality Concerns

None

Benefits of Operation

Benefits: Increase baseflow discharge to Roza Canal and nearby tributaries.

Benefits	Low	Medium	High
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use		X	
Mitigate effect of permit exempt withdrawals		X	
Mitigate impact of drought well production on Yakima River or tributaries		X	
Recover conveyance leakage for beneficial use	X		

Location of Benefits of Operation

Location of Yakima River Benefits: Vicinity of Grandview. Yakima RM 55.

Location of Benefits to Water Users: Ground water users in the vicinity of Grandview, Roza Canal users downstream from this location.

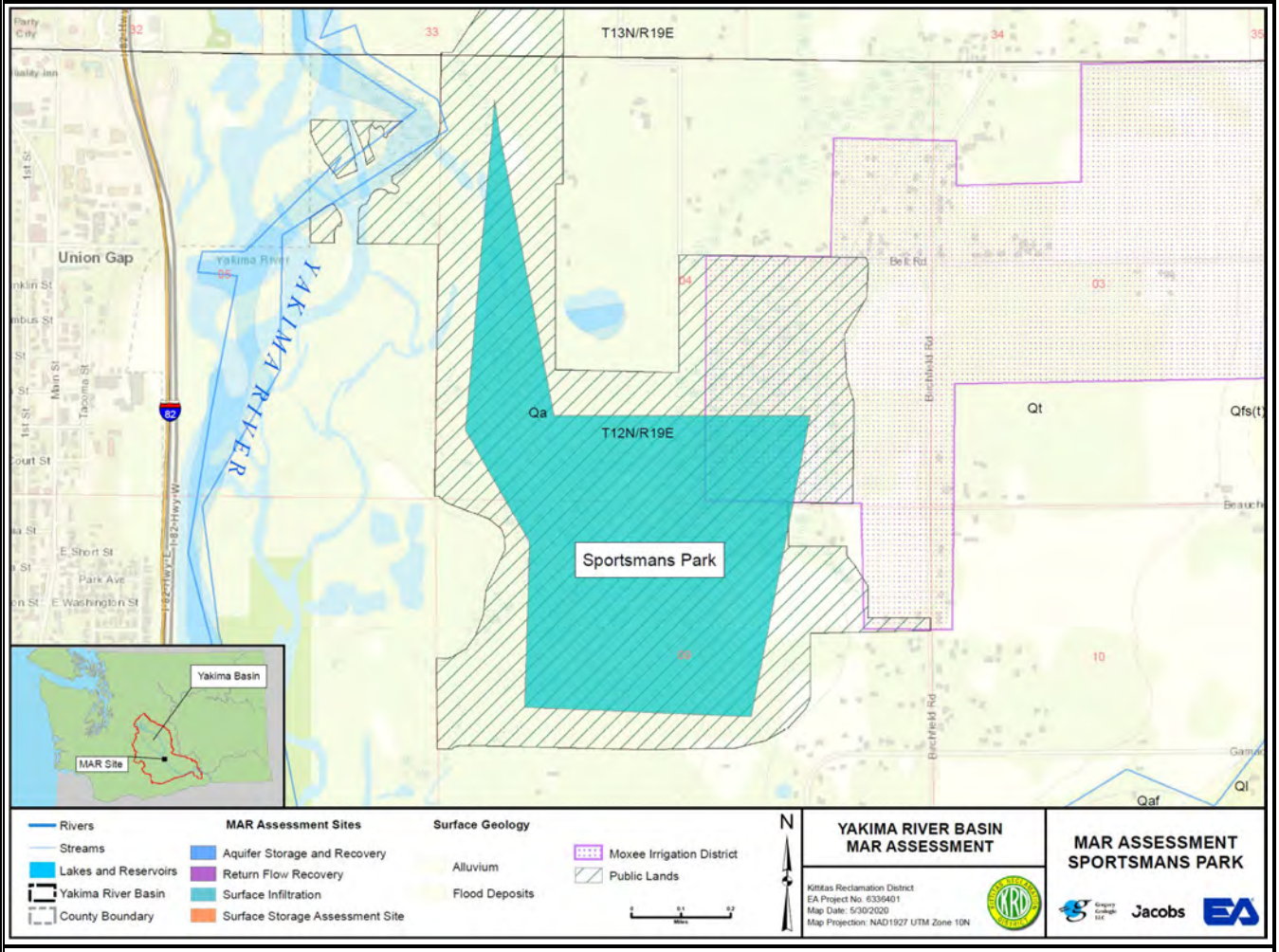
Integration with proposed Integrated Plan or other projects

No habitat projects in the immediate vicinity.

Project Area Characteristics – Sportmans Park

Rank: 89

MAR Project Type: Shallow Aquifer Recharge



Location (TRS): T12N, R19E, Sections 4 and 9.

Property Availability

Public

Site Surface Geology

Quaternary Alluvium

Project Area Subsurface Conditions

Sand and Gravel

Depth to Water

Shallow, 10 feet or less

Hydraulic Conductivity Estimate

Relatively high in coarse alluvium

Water Source and Availability

Yakima River – See Roza Diversion for monthly values

Conceptual Operational Model

Surface infiltration in ponds and infiltration galleries
No irrigation canal flows.

Estimated Costs and Cost Elements			
Low - Diversion structures, piping, infiltration ponds or galleries, stream gaging, monitoring wells.			
Water Quality Concerns			
None			
Benefits of Operation			
Benefits: Delay runoff, later season baseflow discharge to Yakima River			
Benefits	**Low**	**Medium**	**High**
Increase tributary flow: RMs affected & site proximity	X		
Increase mainstem flow	X		
Water is Exchangeable with TWSA	X		
Seasonal flow improvement: summer, fall, winter, spring	X		
Improves cold water refugia	X		
Improves riparian and/or floodplain habitat	X		
Helps ESA species- steelhead and/or bull trout	X		
Mitigate curtailment of junior water use	X		
Mitigate effect of permit exempt withdrawals	X		
Mitigate impact of drought well production on Yakima River or tributaries	X		
Recover conveyance leakage for beneficial use	X		
Location of Benefits of Operation			
Location of Yakima River Benefits: RM 108			
Location of Benefits to Water Users: Downstream of Yakima River Mile 108			
Integration with proposed Integrated Plan or other projects			
No known habitat projects in the immediate vicinity.			

Appendix B

Draft Report Comment and Response Table

Comment Response Tracking Table

Yakima Basin MAR Assessment

Yakima Basin MAR Assessment	**Report**	**July 27, 2021, Final Draft**	

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
1	1 -1	Please specify that the IP is not intended to expand use, just satisfy existing uses.	Danielle Squeochs, Yakama Nation	Revise report to read: *"…by increasing water supply for the proratables in a drought year……"*	**Revise report text**
2	1 - 3	Should include additional information regarding the other irrigation districts. This section should include background on other irrigation districts, as well. The intent of this study was for KRD and consultants to work with other districts such as SVID, KID, SMID, etc. for a consolidated strategy across the YB.	Danielle Squeochs, Yakama Nation	The intent of the study was to identify, evaluate, and rank potential MAR project opportunities at a coarse level. Information from irrigation districts where an identified priority project was located was gathered and used in the assessment.	No action required.
3	2 – Figure 2	Page 2, Figure 1, Yakima Basin MAR Assessment Study Area – The KID boundaries are not included on the map. KID is a major irrigation district served with Bureau of Reclamation Yakima Project water, and we are curious as to why we were omitted from the study, especially since our diversion was included in it. We request that KID be included on the map, and we request an explanation as to why we were not included in the study despite our diversion being considered.	Danielle Squeochs, Yakama Nation	KID and the lower basin irrigation districts were evaluated at a coarse level and no immediate or priority opportunities were identified. The limited scope of work and budget for the project only allowed coordination with Districts where the highest priority actions were identified.	No action required
4	2 - 2	Page 2 last paragraph and wherever water availability is discussed: It should be acknowledged multiple times in the report that the volumes computed for available water using the skimming rules are upper bounds of potential available water. Further analysis will be needed to determine the priority of storing surface water or groundwater.	U.S. Bureau of Reclamation	It is acknowledged that the water availability quantities presented below (subsections 5.1.1-11) represent the maximum volumes that potentially could be diverted after meeting the required physical and biological constraints. It's further acknowledged that this quantity of water available for any given site may need to be "shared" between multiple storage sites as the YBIP facilities are implemented over time. The	No action required

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
				RiverWare model will be the tool used to optimize how best to partition available water amongst one or more storage sites.	
5	2 - 2	Were these achieved through the course of this study? Where is this analysis?	Kennewick Irrigation District	The report describes the analysis and results.	No action required.
6	3 - 1	These tasks were also important to achieve the secondary objectives.	Danielle Squeochs, Yakama Nation	Acknowledged	No action required.
7	3 – last bullet	Was this done for all districts?	Danielle Squeochs, Yakama Nation	Per the limited scope of work and budget, infrastructure analysis was only required for those Districts where a priority project was located.	No action required.
8	5 - 4	come back to this...	Danielle Squeochs, Yakama Nation	Acknowledged	No action required.
9	7 - 2	There is the potential to consider some type of conservation easement. This should be considered in future studies.	Danielle Squeochs, Yakama Nation	Acknowledged	No action required
10	9 - 1	How do you do the flow increases and the seasonal flow improvement, you would have assumptions tied to those evaluations.	Joel Freudenthal, Yakima Co. Public Services	Revise report to read: *"Assumptions include qualitative evaluations of drainage speed and distance based on subsurface thickness and overall sediment texture. For example, silty material will take more time to drain to the stream than clean gravel material."*	**Revise report text**
11	9 – 6th bullet	Should be reach downstream of Union Gap	Danielle Squeochs, Yakama Nation	Revise report to read: "*Applies downstream of Union Gap."*	**Revise report text**
12	11 - 1	General raising of water table, impacting farming, septic, drainage, corrosion, rust, etc.	Joel Freudenthal, Yakima Co. Public Services	Revise report to read: *"Raising the water table could impact farming, septic drainage, and cause corrosion or rust."*	**Revise report text**

YAKIMA BASIN MAR REPORT REVIEW AND COMMENT FORM

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
13	13 - 2	The water code states the water use must not be detrimental to the public interest (this is different than the public welfare).	Danielle Squeochs, Yakama Nation	Comment is not correct. RCW 90.03.290(3): The department shall make and file as part of the record in the matter, written findings of fact concerning all things investigated, and if it shall find that there is water available for appropriation for a beneficial use, and the appropriation thereof as proposed in the application will not impair existing rights or be detrimental to the public welfare, it shall issue a permit stating the amount of water to which the applicant shall be entitled and the beneficial use or uses to which it may be applied.	No action required
14	13 - 3	Needs further clarification. Mitigation for domestic use? Or mitigation for other impacts?	Danielle Squeochs, Yakama Nation	Revise text to read: *"...and mitigation of consumptive water use."*	**Revise report text**
15	14 - 2	Any new authorization would likely need to go through WTWG.	Danielle Squeochs, Yakama Nation	Revise text to read: *"Applications for new water rights would be reviewed by the Water Transfer Workgroup. Any new water right permits would be part of the reservation by Reclamation."*	**Revise report text**
16	18 - 1	Page 18 and all skimming rules: Is the requirement that the amount skimmed is limited to the difference of the flow at Parker and 5000 cfs or just that flow at Parker is above 5000 cfs? The first would ensure that irrigation demands can be met while still skimming and maintaining flows at 5000 cfs, the later might drop flows below Parker if flows are skimmed when Parker is at or above 5000 cfs and irrigation demand is met. In other words, the first description is the way the calculation should be done and the text should be edited to explicitly say that was what was done.	U.S. Bureau of Reclamation	Language is clear and appropriate on skimming criteria throughout the document.	No action required
17	18 – 1st bullet	Good. We need clarification from ECY on what process is needed to do this.	Danielle Squeochs, Yakama Nation	Acknowledged	No action required

YAKIMA BASIN MAR REPORT REVIEW AND COMMENT FORM

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
18	18 – 2nd bullet	Not necessarily. New storage for Cle Elum, KDRPP and other projects is reaching back to the May 10th 1905 date. Assuming no impairment. It would depend on the purpose of use.	Danielle Squeochs, Yakama Nation	This water could have a very junior priority date depending on the purpose of use.	No action required
19	20 - 2	below a certain threshold?	Danielle Squeochs, Yakama Nation	No, not below a certain threshold.	No action required.
20	24 - 1	NACW	Joel Freudenthal, Yakima Co. Public Services	Revise report text to include *"...Naches gauge (NACW)"*	**Revise report text**
21	27 – 1st table	To Roza's own benefit, who controls the power generation, Roza or BOR	Joel Freudenthal, Yakima Co. Public Services	This comment is not applicable to this report.	No action required
22	34 thru 37	Pages 34 through 37, Prosser Dam (Kennewick Irrigation Diversion Canal), Scenario 1: 50% power water subordination, and Prosser Dam (Kennewick Irrigation Diversion Canal), Scenario 1: 100% power water subordination, along with related figures and tables on these pages. As a general comment, much of the availability analysis is focused on quantifying the amount of water that may be available for diversion and infiltration outside of the irrigation season. For each of the water availability scenarios, it is assumed that no water will be diverted during the irrigation season (minus the smolt out-migration period). The 6/16 to 10/31 time period assumption for irrigation season is a little confusing; perhaps it is based upon the average storage control period where excess flows over Parker would not be available for MAR diversion? Based on this assumption, it would not be expected that diversion outside of irrigation season would negatively affect TWSA or KID water supply for full water years. However, in a potential water short year where TWSA may be prorated, an availability assumption needs to be included to not divert water that would decrease TWSA and increase prorationing of junior water rights, or reduce excess flows in the lower river for KID irrigation diversions. In addition, diverting water after the irrigation season has the potential to reduce over-winter reservoir filling and TWSA for subsequent water short year(s). The question is whether forecasting can be robust enough to make that future risk based decision. For the	Kennewick Irrigation District	Detailed response broken down: Comment a: "As a general comment, much of the availability analysis is focused on quantifying the amount of water that may be available for diversion and infiltration outside of the irrigation season." Response a: Your observation is correct. There were two reasons for this, 1) to protect spring smolt outmigration flows and, 2) it was assumed no water would be available during the irrigation season, which is mostly, but not entirely true (see Response b). Comment b: "The 6/16 to 10/31 time period assumption for irrigation season is a little confusing; perhaps it is based upon the average storage control period where excess flows over	Table 16 was revised to correct the error.

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
		Prosser Dam scenarios, the irrigation season is noted as June 16 – October 20, but no water is shown available in April through Sept on the data tables, presumably to account for the smolt out-migration season (October 21 to March 15). It is not obvious what fills the March 15 to June 16 window, and the shortened irrigation season assumption from April 15.		Parker would not be available for MAR diversion?" Response b: You are correct in pointing out that the stated "6/16 to 10/31 time period assumption for irrigation season" is not precise and thus perhaps confusing. This is because the front ends of the irrigation season and smolt outmigration period overlap. For the analysis it was important to clearly define the March 16 – June 30 smolt outmigrate period, which resulted in not accurately defining the irrigation season from an irrigation district's perspective. For this water availability analysis, it was assumed no water would be "skimmed" during the defined smolt outmigration period unless a high minimum river discharge was first met. At the Chandler diversion this was conservatively set at >7000 cfs. In addition, as you correctly assumed in your comment, in general no water would be available for "skimming" during the irrigation season; and this is especially true as Parker (PARW) flows approach the Storage Control Date, which usually are rapidly approaching the Title-XII target flow. Comment c: "However, in a potential water short year where TWSA may be prorated, an availability assumption needs to be included to not divert water that would decrease TWSA and increase prorationing of junior water rights, or	

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
				reduce excess flows in the lower river for KID irrigation diversions. In addition, diverting water after the irrigation season has the potential to reduce over-winter reservoir filling and TWSA for subsequent water short year(s). Response c: Let me preface my response that I may not be clearly comprehending your comment, and thus may require further clarification. Since the "skimming" criteria are irrespective of water type years (drought vs non-drought), there should be no impact to TWSA. Specific to the Chandler diversion, the YRWP gauge was used for the analysis, which is located downstream of the diversion, so any "skimmed" flow would have already accounted for flow needed for KID irrigation and/or Chandler power generation. Regarding your second comment on this point, it's not clear how to me how diverting water after the irrigation season would reduce the potential to fill the reservoirs or impact TWSA in a subsequent year(s). To be clear all "skimmed" water would be from natural high flow events that occur downstream of the reservoirs, so there should be no negative impact to TWSA. Comment d:	

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
				"It is not obvious what fills the March 15 to June 16 window, and the shortened irrigation season assumption from April 15." Response d: The minimum flow "skimming" criteria at Prosser (YRPW) for this period was >7000 cfs. This is a conservatively (meaning erroring to the side to favor smolt survival) chosen value based on USGS' 2018 and 2019 smolt survival to flow relationships. At times this flow criterium was meet in the period of record, which accounts for why there is some water available for months that coincide with the smolt outmigration period. Comment e: "instream flows outside of the irrigation season?" Response e: Thank you for your observation, these values were reversed in Table 16, and will be corrected in the final version. To the second part of the question, for the non-irrigation period the "skimming" criteria was conservatively set at the 75th-percentile flow for each date (e.g. 1/15, 2/15, etc.) in the RiverWare model period of record. Because this high flow value had to be met first before water could be "skimmed", the minimum Prosser target flows were always exceeded. Comment f: "Why was flows above the 75th percentile daily flow chosen as the amount	

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
				which "skimmed" flows would become available?" Response f: The 75th percentile flow value was somewhat arbitrarily selected as a "conservative" daily flow target that was assumed would protect high flow events necessary for river channel maintenance.	
23	38	Page 38, including tables and figures – Table 16 shows median amounts of water available at each diversion, and gives two figures for Prosser under two scenarios, 50% and 100% subordination. Why is more water available under 50% subordination than 100% subordination (94,500 vs 48,600 KAF) and how do these numbers account for subordination flows to meet the target flows at Prosser to benefit instream flows outside of the irrigation season? Subordination water for MAR would only be available after those obligations are met by Reclamation, and it is not clear that this is considered in this analysis. Why was flows above the 75th percentile daily flow chosen as the amount which "skimmed" flows would become available?	Kennewick Irrigation District	50% power subordination means canal capacity during the non-irrigation season is shared equally between skimming and power water therefore, less skimming water available compared to 100% subordination (no power water). Outside the irrigation season the daily 75th percentile target flow was the applied criteria applied so it was considered. This is clearly explained in the report.	No action required.
24	39	Need a clear statement on the limitations of using stream stats.	Danielle Squeochs, Yakama Nation	Revise text to read: *"StreamStats provides estimates of various streamflow statistics for user-selected sites by solving equations that were developed through a process known as regionalization. This process involves use of regression analysis to relate streamflow statistics computed for a group of selected stream gauges within or near a region of study (usually a state) to basin characteristics measured for the stations.* *Streamflow statistics from existing gages in the USGS National Streamflow Statistics Program (NSS) are linked through a background process*	**Revise report text**

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
				to StreamStats in which StreamStats provides the needed basin characteristics to NSS for an ungaged site. Then NSS estimates the streamflow statistics, sends them back to StreamStats, and then StreamStats presents the statistics and the basin characteristics to the user. *There are assumptions and errors inherent in all regression processes. Gaged sites have measurement error, so initial statistics reported in NSS are imprecise. Basin characteristics for ungaged basins are also subject to error, and regressions based thereon are also imprecise.* *Users should be mindful of the potential for large errors in Streamstats estimates for individual basins. Comparisons between basins in similar settings should be valid, but design of structures in individual basins should be empirically assessed."*	
25	39 – Table 17	Ahtanum, Cowiche, Wenas, Rattlesnake, Toppenish, Satus	Joel Freudenthal, Yakima Co. Public Services	As noted in the text, Table 17 lists tributaries to the Yakima above the Umtanum gage. The reviewer comment lists tributaries below the Umtanum gauge and, they are either 1) subject to work underway by the Yakima Flood Control district, or 2) on the Yakima Nation, therefore not included in this study. Text added to the Yakima MAR Assessment Phase 1 Report is as follows: *"Flood flows downstream from Umtanum are generally subject to flood control activities of the Yakima County Flood Control District or located*	**Revise report text**

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
				on the Yakima Nation. Yakima Nation lands are not included in this study." Revise Table 17 title to read: *"Estimated Flood Flow Water Availability from Tributary Streams Above the Umtanum Gauge."* Note: that several sites below Umtanum have been assessed in the summary sheets and during the scoring process, they did not score very high.	
26	41 - 1	Please include a statement that YN and WIP will are in the process of completing their own independent MAR strategy.	Danielle Squeochs, Yakama Nation	Revise text to read: *"The Yakama Nation and Wapato Irrigation District are conducting their own independent MAR strategy."*	**Revise report text**
27	41 - 1	Pages 41+ Infrastructure Analysis and GIS data and maps – Again, KID is omitted from the study and our infrastructure is not considered despite our diversion being included. KID has robust GIS datasets available, but none was requested for this study. Please provide an explanation as to why KID was not considered in a "basin-wide" study that included our diversion. It would seem logical that KID infrastructure and lands would be needed for MAR water diverted at Prosser Dam.	Kennewick Irrigation District	The Prosser Diversion was included to provide gauge data to support the Yakima River water availability analysis. Yakima River water availability was not specific to district. In addition, the infrastructure analysis task with limited funding by Ecology included a focus only on the districts where the top 20 projects were identified. KID had no projects identified in the top 20.	No action required
28	41 - 1	KID should be included in this analysis, unless they declined to participate. If they did decline, then that should be noted. Other districts that should be included... Selah Naches, Sunnyside, Cascade, Westsite, Benton.	Kennewick Irrigation District	The infrastructure analysis task as funded by Ecology included a focus on the districts where the top 20 projects were identified. KID had no projects identified in the top 20. KID and other districts can use the methodology defined in the coarse analysis to identify and rank projects as needed.	No action required

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
29	41 - 2	South Naches, NSID and related Wapatox and Gleed. YVCC and W Valley, and WIP Ahtanum	Joel Freudenthal, Yakima Co. Public Services	The infrastructure analysis task as funded by Ecology included a focus on the districts where the top 20 projects were identified.	No action required
30	43 – Figure 30	Actually to the east	Joel Freudenthal, Yakima Co. Public Services	Acknowledged	No action required
31	44 – Figure 31	Why not infiltrate on top of Andesite?	Joel Freudenthal, Yakima Co. Public Services	Andesite projects were not considered, and bedrock/basalt projects did not score particularly well given the assessment criteria.	No action required
32	47 - 1	Please note they are cheaper than surface storage.	Danielle Squeochs, Yakama Nation	Revise text to read: *"Although MAR projects are much cheaper than surface storage, they are expensive to operate."*	**Revise report text**
33	47 - 2	Please specify where this fits within the framework and objectives of YBIP. We need to be very clear that we are not proposing to expand irrigation.	Danielle Squeochs, Yakama Nation	This MAR project falls within the groundwater storage element of the Yakima Basin Integrated Plan framework. Revise text to read: *"MAR projects are conceived with the notion of recovery or recharged water in mind. Recovery can be passive, where the recharged water mitigates impacts of existing or future planned uses of water by its very presence or where discharge of the recharged water to connected surface waters increases flow, most desirably during late summer. Both conditions could benefit in and out of stream uses by increasing stream flow when needed or supplementing supply to pro-rated water rights. Typically, passive recharge projects are publicly funded."*	**Revise report text**

YAKIMA BASIN MAR REPORT REVIEW AND COMMENT FORM

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
34	47 - 3	The Yakama Nation is on record with not supporting these types of projects as part of the Hirst/Foster fix. Please remove reference or caveat it appropriately.	Danielle Squeochs, Yakama Nation	Revise text to read: *"...promoted in other Washington basins."*	**Revise report text**
35	48 - 4	I believe there is also a previous withdrawal that is often cited and referenced.	Danielle Squeochs, Yakama Nation	Acknowledged	No action required
36	48 - 4	Please correct this, Reclamation, the Yakama Nation and Ecology will need to agree to any new water right. This section neglects to include the role that the YN plays as one of the three sovereigns.	Danielle Squeochs, Yakama Nation	Acknowledged	**Sentence added to note the role the YN has in reviewing any water right decisions.**
37	48 - 5	Please cite the source. This is a nebulous statement and it needs clarification.	Danielle Squeochs, Yakama Nation	Insert after policy: *"(Ecology Focus Sheet F-WR-92-108, Revised 2007: Focus on Capture and Reuse of Irrigation Water)."*	**Revise report text** **Add to references**
38	49 - top	Please remove the language about elevating MAR above other uses. This is an interpretation, which is not supported by the language in the statute. The fact that groundwater is called out, does not elevate it. CW 90.03.255 Applications for water right, transfer, or change—Consideration of water impoundment or other resource management technique. The department shall, when evaluating an application for a water right, transfer, or change filed pursuant to RCW 90.03.250 or 90.03.380 that includes provision for any water impoundment or other resource management technique, take into consideration the benefits and costs, including environmental effects, of any water impoundment or other resource management technique that is included as a component of the application. The department's consideration shall extend to any increased water supply that results from the impoundment or other resource management technique, including but not limited to any recharge of groundwater that may occur, as a means of making water available or otherwise offsetting the impact of the diversion of surface water proposed in the application for the water right, transfer, or change. Provision for an impoundment or other resource management technique in an application shall	Danielle Squeochs, Yakama Nation	Revise to read: *"...90.03.255 seems to advocate for MAR as an alternative to make water available or otherwise offset the impact of a diversion of surface water proposed in an application for water right, transfer, or change."*	**Revise report text**

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
		be made solely at the discretion of the applicant and shall not otherwise be made by the department as a condition for approving an application that does not include such provision. This section does not lessen, enlarge, or modify the rights of any riparian owner, or any existing water right acquired by appropriation or otherwise.			
39	49 - 2	Please rephrase this. It comes across as an opinion and the point is unclear. Is the issue that the recovery efficiency is not 100% or are we saying that it should be more than 100%? And it does not include the benefits that communities like Yakima, West Richland, and White Salmon gain from having increased water security. Also, all systems are leaky. Surface reservoirs leak too. Permits are issued for the amount of water stored, not the amount of water put in.	Danielle Squeochs, Yakama Nation	Acknowledged. This is an opinion widely held by the developers of ASR projects in Washington and elsewhere, and the subject of many proposals in many locales. Oregon settled the matter by statute, allowing no more than the full amount injected under the underlying water right, but often limiting the recovery to 95% as demonstrated in limited license procedures [ORS 537.534(5)(b)]. Washington has yet to arrive at a consistently applied solution to reservoir loss evaluation.	No action required.
40	49 - 4	It's not custom, it the law and policy.	Danielle Squeochs, Yakama Nation	Revise report to read: *"...custom, law, policy, and customer need."*	**Revise report text**
41	51 - 1	Is there an annual cut? Does this make sense in context of the aquifer or is this just random policy determined by their legislator?	Danielle Squeochs, Yakama Nation	Yes, there is a 5% cut for the recharge season.	**Revise report text**
42	52 - 2	What are the pitfalls of this system that we could learn from?	Danielle Squeochs, Yakama Nation	Revise text to explain pitfalls of the system (may or may not verbatim): *"The major pitfall is the need to develop and staff institutions that account for and manage the water, plus the attendant costs, as well as the need for existing institutions to give up authority over small portions of the basin in favor of system wide management."*	**Revise report text**

YAKIMA BASIN MAR REPORT REVIEW AND COMMENT FORM

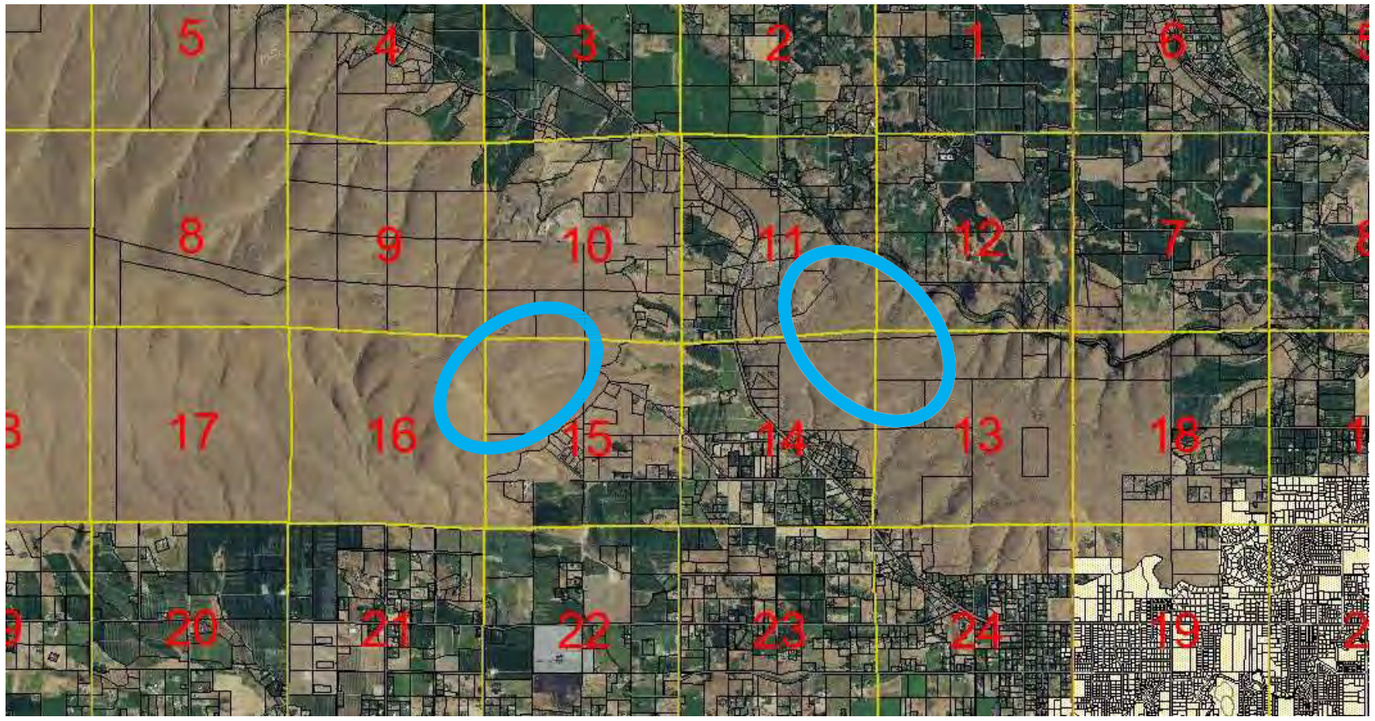
No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
43	53 - 1	While I cannot speak for the Yakama Nation, I think it is unlikely that my leadership would support this type of MAR structure. Thank you for compiling this information, let's move on to implementing some projects.	Danielle Squeochs, Yakama Nation	Acknowledged.	No action required
44	53 - 4	How would this address the issue of aquifers with chronic declines?	Danielle Squeochs, Yakama Nation	As noted in this paragraph, recharge can benefit users in recharged aquifer units.	No action required
45	56 – Table 19	Please look at the well logs in Big and Little Creek, there is a glacial clay layer that will make storage difficult in the area proposed.	Danielle Squeochs, Yakama Nation	The Big and Little Creek areas have a variable lithologic makeup, in places clayey near the surface, in places gravelly, and elsewhere cemented. There is often a sandy/gravelly horizon below lower permeability stratum. Any MAR development in the Big and Little Creek areas will require on-site assessment. Given the site characteristics study-wide, the presence of a discontinuous clay in this area does not exclude it from study.	No action required
46	58 - top	Page 58 Conclusions and recommendations – This section mentions "More than 100,000 acre-feet of water is being artificially recharged by leaky irrigation canals and irrigation practices. Capture and use of this water, in lieu of releases from Reclamation's reservoirs, could potentially save tens of thousands of acre-feet per year." Is there more information as to where in the basin these leaky canals are located, and when/where the return flows would return to the river? This information will be important in prioritizing projects and ensuring that benefits are occurring where they are most needed, and any negative impacts to instream flows or water supply are identified and mitigated.	Kennewick Irrigation District	As yet, there is little information readily available to assess this beyond the broad statement.	No action required
47	58 – 6th bullet	Can we please take the coal mines off the list? There is risk for subsidence and impacting water supplies for entire communities. These systems are already filling and draining. I have also been called to a site visit where a homeowner was being flooded by unexpected drainage from an adit. There are other storage locations with much lower risk.	Danielle Squeochs, Yakama Nation	The coal mines do have the potential to be used for large volumes of groundwater storage and should not be eliminated from consideration without further analyses.	No action required
48	58 – 8th bullet	It is unlikely that YN leadership would support this request.	Danielle Squeochs, Yakama Nation	Acknowledged.	No action required

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
49	58 – 9th bullet	I think we need to have a better-defined set of goals. Then define MAR strategies that could meet those goals, then evaluate whether those strategies meet the defined goals. For instance, what is the real benefit of pushing storage control date back in the year - in dry years (is it possible or desirable), in normal years (is there carryover capacity in the reservoirs or the new MAR facility that has benefits in dry years), or in wet years (is there any benefit). This report is about feasibility, not benefits, not economic efficiency of providing benefits. We need to get a better handle on what we are trying to achieve before we move forward on any field based next steps.	Joel Freudenthal, Yakima Co. Public Services	Revise bullet to read: *"Identify data gaps and specific needs for MAR implementation at the highest-ranking MAR locations."* Potentially revise "Begin" to *"Continue"*	**Revise report text**
50	59 - top	including staggering the end of irrigation season to let water held in structural basins drain to downstream users?	Joel Freudenthal, Yakima Co. Public Services	Acknowledged.	No action required
51	59 - top	Some acknowledgement of the potential difficulties of infiltration capacity is needed and a discussion of the need for further evaluation.	U.S. Bureau of Reclamation	Revise to include the following: *"Throughout most of the Study Area, subsurface conditions are highly vertical and laterally variable as expected in Glacial terranes. Tills, drifts, and associated sediments have highly variable hydraulic conditions which may preclude significant recharge. Site specific assessment of existing conditions is critical to project success."*	**Revise report text**
52	Hot Sheets	Need a category for uncertainty or current unknowns/concerns in order for others to assess at a snapshot.	Danielle Squeochs, Yakama Nation	This is inherent in the current rankings and all projects have data gaps. There are always unknowns and quantifying is subjective. See limitations section in report.	No action required
53	A-3	And a big clay layer at about 20 ft bgs. See ECY reports	Danielle Squeochs, Yakama Nation	See response to comment 45.	No action required
54	A - 5	Tough to do over the long term due to sediment starvation from Rimrock. Providing sediment to river would achieve similar ends, improve habitat, increase storage in Rimrock, Triple dipper!!!!	Joel Freudenthal, Yakima Co. Public Services	Acknowledged.	No action required

YAKIMA BASIN MAR REPORT REVIEW AND COMMENT FORM

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
55	A - 5	Slope stability?	Danielle Squeochs, Yakama Nation	Acknowledged. More geologic information will be required as part of site-specific analysis.	No action required
56	A - 7	Glacial clay exists at 20 feet bgs. Darrington phyllite is discontinuous and fracture flow. See ECY reports.	Danielle Squeochs, Yakama Nation	See response to comment 45.	No action required
57	A - 8	Little Creek	Danielle Squeochs, Yakama Nation	Acknowledged. Revise Little Creek hot sheet (Benefits of Operation category) to refer to Little Creek rather than Big Creek.	**Revise hot sheet**
58	A - 9	See Kittitas County work done by Aspect.	Danielle Squeochs, Yakama Nation	Acknowledged. They have not released the report yet. Will be done for site-specific analysis.	No action required
59	A-13	Canal is obliterated, not there, would require massive re-easement of the canal to restore conveyance across private properties....Some of these types of projects need to be evaluated for increased losses due to evapotranspiration, especially the alluvial fan ones. As water exits the lower fans on the spring line, or in the cottonwood case as water enters lower Wenas and is slowed by the basalts that come to the surface there, the water can be uptaken by plants and transpired.	Joel Freudenthal, Yakima Co. Public Services	Site evaluation claims no canal water available. Evapotranspiration losses on individual site considerations are acknowledged, but beyond the scope of this investigation.	No action required
60	A - 19	Lots of clay...	Danielle Squeochs, Yakama Nation	Comment acknowledged.	No action required
61	A - 21	Again, why not on andesite. Flows down through then either hits the Ellensburg formation or ancestral Naches River Gravels and charges the river either way. Much simpler and YTID has some capacity for supplying sites.	Joel Freudenthal, Yakima Co. Public Services	See response to Comment #31.	No action required
62	A - 23	Can be fed by Naches River as well through existing Monson pump stations off of NSID, or by new pumping plant from YTID proposal. Tunneling through the divide between the Naches and Wenas could really lower pumping costs.	Joel Freudenthal, Yakima Co. Public Services	Acknowledged. Potential project scored only on flood flows.	No action required

No.	Page Paragraph	Reviewer Comment	The reviewer who made the comment to the report	Response	Action Required
		According to Vacarro, this storage site returns water to the Naches, although likely would benefit lower Wenas and certainly the groundwater users in Wenas as well. Very large capacity site.			
63	A - 73	Why not on the Grande Ronde and other grand ronde outcrops South of I-90 traversed by Highline canal?	Joel Freudenthal, Yakima Co. Public Services	See Johnson projects.	No action required
64	A - 109	See comment. Add, want to evaluate the valley/fracture in top of ridge.	Joel Freudenthal, Yakima Co. Public Services	Revise hydraulic conductivity estimate to read: *"Large valley/fracture system at top of ridge."*	**Revise hot sheet text**
65	A - 133	Massive spill from Yakima Valley Canal Company could be used here.	Joel Freudenthal, Yakima Co. Public Services	Acknowledged	No action required
66	See map below	Township 13N R17E Both sites on BLM land, both fed by now abandoned sections of YTID ditch (can be gravity fed from YTID). Eastern site is on fractured Frenchman Hills member, Western Site is on Grand Ronde.	Joel Freudenthal, Yakima Co. Public Services	Comment acknowledged. Basalt flow textural considerations at this site unknown. BLM land in section 13 and 14 are in the Frenchman Hills. These sites should be considered as part of future detailed MAR feasibility studies.	No action required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