Milton-Freewater Aquifer Storage and Recovery Project

Phase 1 Feasibility Study

Submitted by the

Walla Walla Basin Watershed Council

Submitted to the

Oregon Water Resources Department

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Preface

This document presents the results of the Milton-Freewater Aquifer Storage and Recovery Project Phase 1 Feasibility Study (the Feasibility Study). The Feasibility Study was completed by the Walla Walla Basin Watershed Council (WWBWC) under Oregon Water Resources Department Grant No. GB-0129-017.

The Feasibility Study consisted of five tasks completed between 2017 and 2019. These tasks included review of existing infrastructure (Task 1), source water diversion options (Task 2), water quality treatment and source water/groundwater compatibility assessment (Task 3), and stream flow and related supplemental requirements (Task 4 and 5). The work and findings for these tasks are described in three documents which are included herein and include the following:

(1) *Milton-Freewater Aquifer Storage and Recovery Feasibility Study Phase 1*, by EA Engineering, Science and Technology, Inc., Northwest Groundwater Services, LLC, and Murraysmith. This report describes the investigation of existing infrastructure resources within the City of Milton-Freewater and the suitability of this infrastructure for conducting aquifer storage and recovery (Task 1). The report included review of well characteristics, pipeline and pressure zone operations, and pumping operations as they may pertain to and effect ASR testing and potential future operations. This report also described several options for diverting water from the Walla Walla River to a potential aquifer storage and recovery project location (Task 2). Generally, this report found that:

- Several wells may be suitable for future ASR testing and operations.
- Well No. 5 is probably the best suited for conducting ASR as it requires the fewest modifications.
- There are three basic intake options. As long as water rights are not an issue, installing a new diversion structure adjacent to Well No. 5 would be the best option.

(2) A technical memorandum, "Milton-Freewaer Aquifer Storage and Recovery Feasibility Study Project – Investigation of Water Treatment Alternatives (Task 3)," from Murraysmith and Northwest Groundwater Services, LLC to GeoEngineers, Inc. describes water quality treatment alternatives and the results of a preliminary analysis of the compatibility of river water and native groundwater (Task 3). This report was based primarily on existing water quality data and focused on planning level assessments of water quality issues. It found that:

- Using a conventional package treatment system is best suited to the current needs of the City of Milton-Freewater.
- Riverbank filtration or managed aquifer recharge could be a cost-saving alternative the City may want to consider in the future.
- Geochemical incompatibilities between the river water and groundwater are unlikely based on a preliminary analysis.

(3) *Milton-Freewater Aquifer Storage and Recovery Feasibility Study Supplemental Requirements*, by the Walla Walla Basin Watershed Council. This document describes the results of assessing ecological flows, alternative means of supplying water, potential environmental impacts, the need for and feasibility of augmenting in-stream flows, and local and regional water demands (Tasks 4 and 5). Basic findings in this report included the following:

- Diverting up to 8.6 cfs from December to May would likely not impair Walla Walla River hydrology nor fish habitat.

- The adverse impact on the riparian area of installing a diversion structure on the Little Walla Walla River near Well No. 5 would be minimal and temporary.
- The winter-spring diversion would increase the basin's resiliency to future climate changes by relying on drinking water supplies obtained during winter when flows are abundant, instead of relying on diversion during low-flow summer months.
- No adverse impacts to water quality in the receiving aquifer are anticipated.
- The project as proposed will not augment flows in the Walla Walla River but would replace a future diversion of 8.6 cfs during summer low-flow months which would provide a significant benefit to fish habitat. Preventing future decreases in summer flows is both needed and feasible.
- The maximum potential diversion rates for a fully built out ASR system would meet projected future City demands while alternative means of supplying water would not.

The three documents which comprise the Feasibility Study deliverables for the Grant are separated by blue-colored pages to aid in finding the sections of interest.

Milton-Freewater Aquifer Storage and Recovery Feasibility Study Phase 1

Prepared for

Walla Walla Basin Watershed Council
810 South Main Street
Milton-Freewater, Oregon 98762

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
8019 West Quinault Avenue, Suite 201
Kennewick, Washington 99336
(509) 947-5729

and

Northwest Groundwater Services, LLC
22089 S Mint Lake Rd
Beavercreek, OR 97004
(503) 313-5195

and

Murraysmith
888 SW 5th Avenue, Suite 1170
Portland, OR 97204
(503) 225-9010

May 2018
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Milton-Freewater Aquifer Storage and Recovery Feasibility Assessment Phase 1

Prepared for

Walla Walla Basin Watershed Council
810 South Main Street
Milton-Freewater, Oregon 98762

Walla Walla Basin Watershed Council

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
8019 West Quinault Avenue, Suite 201
Kennewick, Washington 99336
(509) 947-5729
and
Northwest Groundwater Services, LLC
22089 S Mint Lake Rd
Beavercreek, OR 97004
(503) 313-5195
and
Murraysmith
888 SW 5th Avenue, Suite 1170
Portland, OR 97204
(503)-225-9010

REGISTERED PROFESSIONAL
OREGON
PHILLIP A. BROWN
Exp 6/1/2018
G1925
GEOLOGIST

5/2/2018

Phil Brown, RG — Date
Owner Northwest Groundwater Services, LLC

April 24, 2018

Kevin Lindsey, RG — Date
Principal, EA Engineering, Science, and Technology, Inc., PBC

May 2018
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LIST OF ACRONYMS AND ABBREVIATIONS

ADD	Available drawdown
AR/ASR	Aquifer Recharge/Aquifer storage and recovery
AR	Aquifer recharge
ASR	Aquifer storage and recovery
bgs	Below ground surface
City	City of Milton-Freewater
CRBG	Columbia River Basalt Group
DEM	Digital elevation model
DD	Drawdown
EA	EA Engineering, Science, and Technology, Inc., PBC
FS	Feasibility study
ft	Feet (foot)
gpm	Gallon(s) per minute
gpm/ft-DD	Gallon(s) per minute per ft of drawdown
in.	Inch(es)
MAR	Managed Aquifer Recharge
mgd	Million gallon(s) per day
NAVD88	North American Vertical Datum of 1988
N/A	Not available
NTU	Nephelometric turbidity unit
NWGS	Northwest Groundwater Services, LLC
O&M	Operation and Maintenance
OHA	Oregon Health Authority
OWRD	Oregon Water Resource Department
PTW	Pump to Waste
RBF	River Bank Filtration
SC	Specific capacity
SWL	Static Water Level
WTP	Water Treatment Plant
WW	Walla Walla
WWBWC	Walla Walla Basin Watershed Council

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1. INTRODUCTION

This report provides EA Engineering, Science, and Technology, Inc., PBC's (EA), Northwest Groundwater Services, LLC (NWGS), and Murraysmith's evaluation of the source water availability and treatment options for a potential aquifer recharge/aquifer storage and recovery AR/ASR system in Milton-Freewater, Oregon. This project is a collaboration between the Walla Walla Basin Watershed Council (WWBWC) and the City of Milton-Freewater (City) who received funding from the Oregon Water Resource Department (OWRD) Feasibility Study (FS) grant program.

A note on terminology: this project is designed to assess the feasibility of using the City's infrastructure (water rights, property, conveyance, and wells) to enhance recharge (i.e. increase water storage) in the basalt aquifer system beneath and near the City. Critical elements in achieving this are to legally acquire available surface water, treat it to acceptable standards, and inject it into the subsurface. If that water is then left in the aquifer to benefit the City, other users, and the surface water resource (by creating a sustainable alternative to summer surface water withdrawals) if is referred to as AR, or Artificial Recharge. If it is recovered by wells and put to beneficial use as drinking water the practice is known as ASR (Aquifer Storage and Recovery). There are significant differences in water treatment requirements between and AR and ASR, and the City will elect which permitting and treatment pathway best suits its need as the project evolves. For this first phase of the Feasibility Study, we will use a shorthand AR/ASR abbreviation.

OWRD has recently classified the basalt aquifer system in the Oregon portion of the Walla Walla Subbasin as a Serious Water Management Problem Area based on declining water levels. Eventually, this may be the first step in reducing withdrawals from the basalt aquifer as a means to make continued use sustainable. The WWBWC and the City understand that negative socioeconomic consequences could result from curtailed use and are exploring the potential to achieve aquifer sustainability through enhancing aquifer recharge rather than curtailing of junior water rights.

In this first phase of the Milton-Freewater AR/ASR assessment, this report focuses on assessing select project elements; source water availability and source treatment options. The City is interested in exploring the potential to usd its municipal water rights for the Walla Walla (WW) River to divert river water for AR/ASR and potentially delivering it to the City system via the existing distribution infrastructure. The point of diversion may be an in-stream location, a shallow induced-infiltration well, or an engineered collection system pumping groundwater in direct hydraulic connection with the Walla Walla River. The suitability of diversion, treatment, injection/recovery, and distribution and delivery systems for the preferred and other alternatives are ranked in this report and they will be reviewed with the WWBWC and the City to determine the path forward. This report, in conjunction with in-stream flow analysis will be used by the WWBWC and the City to determine their preferred path forward. The goal of this study is to provide the City and WWBWC with a clear understanding of the planning-level cost, benefits, and development pathway for AR/ASR implementation.

2. BACKGROUND

AR/ASR projects in the Columbia Basin typically target Columbia River Basalt Group (CRBG) aquifers for drinking water supply or irrigation. These AR/ASR systems store treated surface water or shallow alluvial aquifer groundwater in the deeper CRBG aquifer system to restore water levels and/or for later recovery. Key permitting elements to support OWRD's decision to issue either an AR or ASR limited license and permit (Oregon Administrative Rules 690-350) include characterizing the aquifer, identifying users, evaluating potential impacts, determining water availability, describing land use and the water rights framework, and characterizing source and receiving (groundwater) water quality.

For this phase of the FS, the City is focusing on basic program development plans that focus on City infrastructure, diversion options, water quality, water availability, and treatment requirements. The project is organized into four assessment tasks:

- ***Task 1*** – Existing Well, Intake, Treatment, and Distribution Infrastructure.
- ***Task 2*** – Diversion Options.
- ***Task 3*** – Water Treatment Alternatives.
- ***Task 4*** – Water Availability.

This report presents the combined results of the Task 1 and Task 2 assessments. Task 3 will be completed after 2018 winter sampling to characterize water quality in the Walla Walla River. Task 4 is scheduled for completion later in 2018.

3. TASK 1 – INFRASTRUCTURE ASSESSMENT

The purpose of this task is to develop an AR/ASR implementation plan based on an assessment of the City's infrastructure; municipal supply wells, piping and distribution, waste discharge options, diversion locations, and water treatment site availability. The project team met to exchange information and inspect key elements of the City's water distribution system on 15 August 2017. During this meeting the project team inspected on-the-ground well conditions and features at Wells #1, #5, #8, and #9. This section summarizes the findings from that visit and subsequent document review and uses these to rank the City's wells for potential future AR/ASR use.

3.1 CITY WATER SUPPLY WELLS

The objective of this section is to discuss the characteristics of the City's basalt wells. The City currently has water rights to eight municipal water wells being considered for recharge operations (**Figure 1**). Water right details of each well can be found in the City's Water Management and Conservation Plan Update Addendum (Anderson Perry & Associates 2011). Wells #1 and #2 are near a former fruit packing/processing plant near the Little Walla Walla River diversion. Wells #3 and #6 are located in the downtown area of the City adjacent to the Little Walla Walla River. Well #5 also is adjacent to the Little Walla Walla, next to a parking lot near an industrial warehouse facility. The Key well is near Well #5, approximately 600 feet to the northeast. Wells #8 and #9 are upstream of downtown. Well #8 is located at Marie Dorion Park on the mainstem Walla Walla River near an old power generating facility. Well #9 is located on top of the bluff slightly north of Well #8. Additional location details are discussed in Section 3.3.1.

The City draws water from seven basalt wells, Wells #1, #2, #3, #5, #6, #8, and #9. Well #8 is known to be the least efficient well and also the deepest (Anderson Perry & Associates 2010). Well #9 exhibits indications of biofouling and is only used on a limited basis. **Table 1** provides a summary of well location details. **Tables 2** and **3** respectively, tabulate well construction and hydrologic information for the City's wells. **Appendix A** provides the available water right information for each well. Well #4 has been removed and will not be considered below.

The Key well is a former industrial/potable supply well adjacent to a former fruit packing facility near City Well #5. The City acquired this property and well, which is currently unused. The Key well originally exhibited a very high specific capacity, which may allow ASR use without lowering the pumping water level significantly below the bottom of casing. The original static water level was above the base of casing and if current water levels are similar, then this well would have several advantages including; 16" casing dimeter, high specific capacity, proximity to the industrial sewer system, and ability to retrofit without disrupting current City supply operations. Because this well is not connected to the City's municipal supply, it has the ability to provide non-potable supply for things like industrial use, municipal irrigation, or potentially golf course irrigation which could reduce or eliminate a surface water diversion and increase summer surface water flows.

Table 1 Municipal Well Location Summary

City Well ID	Well Log ID:1	Well Log ID:2	Latitude	Longitude	1/4 1/4	1/4	Section	Township	Range
Well #1	UMAT3961	UMAT3960 UMAT5999	45.93	-118.38	—	SW	12	5	35
Well #2	UMAT3962	—	45.93	-118.39	SE	NW	12	5	35
Well #3	UMAT3930	UMAT3924	45.94	-118.39	NE	SE	2	5	35
Well #5	UMAT3909	—	45.94	-118.39	SW	NW	1	5	35
Well #6	UMAT3923	UMAT 3929	45.94	-118.41	NE	SW	2	5	35
Well #8	UMAT4005	UMAT4010 G13488	45.91	-118.37	SW	SW	18	5	36
Well #9	UMAT3965	UMAT51825	45.92	-118.38	SW	SE	12	5	35
Key Well	UMAT3908	—	45.56	-118.23	SW	NW	1	5	35

Notes:
ID:1 = Original well log.
ID:2 = The second log provided due to well modifications; Wells #1, #3, and #8 were deepened and Well #9 had a liner installed.

Table 2 Well Construction Details

City Well ID	Date Drilled	Ground Elevation [1]	Total Depth (ft)	Casing Diameter (inches)	Casing Depth (ft)	Seal Depth (ft)	Static Water Level (ft, bgs)	Static Water Level Date	Available Drawdown (ft) [2]	Top of Basalt (ft)	Feet of Casing Below Top of Basalt (ft)
Well #1	3/1/1938	1066.6	656	12	84	84	235	1998	-151	46	38
Well #2	10/10/1945	1064.8	902	16[3]	99	99?	225	7/25/2017	-126	70	29
Well #3	12/28/1946	1010.6	575	16	100	43	173	7/11/2017	-73	40	60
Well #5	1/1/1936	1001.6	502	12	212	N/A	195	7/18/2017	17	160	52
Well #6	12/22/1950	983.6	952	12	232	232	257	8/15/2017	-25	55	177
Well #8	4/14/1965	1168.6	1051	16	480	78	291	1997	189	31	449
Well #9	6/22/1951	1156.4	870	12	462	290	323	7/18/2017	139	41	421
Key Well	2/16/1945	1001.6	528	16	109	109	71	12/27/1954	38	92	17

[1]Elevation data was obtained from the Oregon Department of Forestry, 10M Digital Elevation Model http://jollyroger.science.oregonstate.edu/dem/). Metadata indicate NAVD88 is the vertical datum.
[2]Available drawdown calculation is casing depth (ft below ground surface; ft bgs) minus Static Water Level (ft bgs).
[3]Log does not have diameter noted. However, notes 12-inch pump installed so 16-inch diameter is assumed.
Notes:
ft = Feet
gpm = Gallon(s) per minute
gpm/ft = Gallon(s) per minute per foot of drawdown
ID = Identification
N/A = Not available
NAVD88 = North American Vertical Datum of 1988

Table 3 Hydrogeologic Properties

City Well ID	Total Depth (ft)	Static Water Level (ft)	SWL Date	Flow Rate (gpm)	Pump Test Drawdown (ft)	Pump Test Date	Specific Capacity (gpm/ft)	Maximum Pumping Rate[1] (gpm)
Well #1	656	235	1998	1484	182	N/A	8.2	0
Well #2	902	225	7/25/2017	1135	88	N/A	12.90	0
Well #3	575	173	7/11/2017	N/A	N/A	N/A	N/A	N/A
Well #5	502	195	7/18/2017	750	47	1/1/1936	16.0	271
Well #6	952	257	8/15/2017	1500	145	2/29/1972	10.3	0
Well #8	1051	291	1997	1529	197	2/2/1970	7.8	1467
Well #9	870	323	7/18/2017	1501	295	8/17/1951	5.1	707
Key Well[2]	528	49	2/16/1945	1550	32	2/16/1945	48.4	1841

Notes:
[1]Maximum pumping rate calculation is specific capacity (gpm/ft) multiplied by available drawdown (ft). Zero values are where static water level is below the base of the casing.
[2]The pump test conducted was a step-rate test so the last recorded flow rate and water level were used to calculate this specific capacity. Note – current static water levels and performance need to be confirmed.
ft = Feet
gpm = Gallon(s) per minute
gpm/ft = Gallon(s) per minute per foot of drawdown, at time of test
ID = Identification
N/A = Not available

3.2 WELL RANKING CRITERIA

The City wells were evaluated against a series of screening critieria used to prioritize their potential for conversion to recharge operations. These screening criteria include:

- Specific Capacity
- Well Age
- Casing Diameter
- Available Drawdown
- Waste Discharge Options
- Top of Basalt

These are discussed further below.

Specific capacity (SC), expressed in gallons per minute pumped per foot of pumping drawdown (gpm/ft-DD), is a measurement of a well's ability to transmit water in and from the portion of the aquifer system the well intersects. A higher SC well will allow a larger volume of water to be injected and recovered over the same period as a well with lower SC.

— ***Result:*** Based on the available pumping rates (typically measured when the well is installed), the wells with the highest SC are the Key Well at 48.4 gpm/ft, Well #5 with 16.0 gpm/ft, Well #2 at 12.9 gpm/ft, and Well #6 at 10.3 gpm/ft (**Table 3**). The maximum pumping rate based on existing data were calculated for each well to access long term pumping rates. Well #5 and the Key Well depending on the target pumping/injecting rates desired could be good options. The remaining wells either have water levels below the casing which make them less desirable or there is not enough information to make an evaluation. We recommend conducting an aquifer test (Section 6) at any preferred well to assess the current conditions (i.e. specific capacity, available drawdown, etc.) to assess long term reliability of the final well selected.

Well Age—When converting an existing well to a recharge well, it is important to understand the age of the well and construction design. It is generally assumed that newer wells are more likely to have compliant well seals; therefore, newer wells are preferred. Regardless, a downhole video survey is recommended at each well prior to conversion to recharge use to assess the condition as a first step. Plumb/alignment testing may also be indicated to evaluate whehter lowering a pump intake or installing downhole flow control is recommended and feasible.

— ***Result:*** Well #8 is the newest municipal well installed in 1966 followed by Well #9 in 1951 and Well #6 in 1950 (**Table 2**).

Casing Diameter—The diameter of the casing can play a role in how efficiently a well can transmit water into or out of an aquifer. Generally, a larger casing diameter results in a more efficient well in which water more easily moves into and out of the well bore. More importantly, conversion to a recharge well will likely require installation of a downhole control valve and monitoring conduit, which will increase the diameter of the pump column. Therefore, larger casing diameter is preferred for ease of installation and maintaining maximum rates/volumes with properly sized pumping equipment. The City's wells vary in diameter from 8 to 16 inches (in.) (**Table 2**).

— ***Result:*** Wells #2, #3, #8, and the Key well have 16-inch diameter casing, the largest available with the City's wells. Wells #1, #5, #6, and #9 have 12-in. casing diameters so could likely support a system pumping targeting at least 1,000 gpm.

Available Drawdown (ADD)—The ADD is the difference between the bottom of the casing and the SWL. This criterion is used to identify wells that will allow buildup and DD to occur within the casing to protect the pumping equipment and limit the potential for cascading water or exchange with currently unsaturated permeability. Cascading water and aeration of the water column is a common cause of diminished well production as aeration sets up conditions promoting biological and sometimes chemical fouling of the well. Conversely, during injection when water level in a well rises, it is best to avoid a condition where water is exchanged with unsaturated fractures. Introducing aerated water to into a previously unsaturated subsurface environment has the potential to promote unwanted biological and chemical reactions, and the potential for lost water. The greater the depth of the bottom of casing is below the SWL the better chances of avoiding these unwanted conditions. Although it may be possible to conduct ASR operations with all water levels below the base of casing, it would require additional evaluation to assess the potential for lost water or degraded quality, and the City could see air entrained in delivered water.

- ***Result:*** Wells #8, #9, #5, and the Key well appear to meet this criterion for SWL above the base of casing, though Well #5 only has 17 ft of ADD. It is assumed that the intake is set at or below the base of the casing in this location. If the current SC remains near 15 gpm/ft at Well #5, this 17 ft of DD would limit the pumping rate to approximately 250 gpm without dropping the PWL below the base of casing. Well #8 has 189 ft of ADD, Well #9 has 139 ft, and the Key well has 38 ft (**Table 2**). The remaining wells have a SWL that is below the casing, which is not preferred for AR/ASR use. Pumping tests are recommended to confirm current well performance and static/pumping water levels on the top three candidate wells.

Waste Discharge Options—To test and maintain water quality during ASR operations there are periods of time (i.e. pilot testing and backflushing) when water needs to be discharged to waste at a high rate. For maintaining well performance, discharge should be at rates higher than the injection rate to remove particulate. Even very low turbidity water can have enough particulate to cause minor clogging and temporary turbidity load when the pump is turned on. Particulates and oxides that accumulate in the aquifer near the well can be removed by periodic back flushing or a planned pump-to-waste period (typically 10 to 30 minutes) and/or on recovery startup. Even if a well is only used for injection, provision for periodic backflushing is needed to maintain performance.

- ***Result:*** Well #1 has no room for a detention/infiltration basin, but there is an industrial sewer that leads to a detention pond near an agricultural processing plant that could be used. Wells #3, #,6 and #9 also have access to the industrial sewer and Well #9 has a detention pond available about 200 yards south. Well #5 is located in a parking lot next to an industrial facility adjacent to the Little Walla Walla River. Well #5 may be able to discharge to the Little Walla Walla River with an NPDES permit, or surface infiltration on the vacant land north of the adjacent buildings could be a viable alternative. If discharge to the Little Walla Walla River is pursued, it may be necessary to install temporary settling/clarification tanks prior to direct discharge for testing phases. For this study, we have assumed that the Key well has the same waste discharge options as Well #5 as they are located approximately 600 ft apart. There is no disposal option currently at Well #8 in Marie Dorion Park. Direct discharge may not be a good option due to the presence of listed species in the Walla Walla River, and the City prefers to leave the park footprint unaltered. It is however possible to pump waste discharge to the top of the adjacent bluff (roughly 100 feet of lift) where a detention facility could be constructed on City-owned land. Locations are prioritized with respect to discharge options as follows:

  - Wells # 1, #3, #6, and #9 based on industrial sewer access.
  - Well #5 and the Key Well
  - Well #6
  - Well #2

It is also important to consider the following:

***Top of Basalt*—**A potential candidate AR/ASR well needs to have penetrated sufficiently deep into the basalt aquifer system to limit the potential for water to escape into the overlying alluvial aquifer during recharge. Based on our examination of other wells in the Walla Walla Basin, a well that is reported to have penetrated at least 75 ft into basalt has typically intersected at least one water bearing interval and will have limited connection to the overlying alluvial aquifer system.

Result: All wells have penetrated into at least 75 ft of basalt.

3.2.1 Known Well Issues

In addition to the criteria summarized above, the project team talked to City staff, and reviewed available records, to glean additional insights into known well issues that might affect AR/ASR operations. These issues include the following:

- The City's wells provide good water quality, but the City has experienced entrained air problems in several of its wells. Over the years, Wells #2, #3, #5, and #6 have had air problems that have been resolved using different techniques (Anderson Perry & Associates, 2010). Well #1 is the oldest City well and has had air entrainment issues in the past but issues have been resolved by discharging water into the reservoir and letting air off-gas. It is possible that this condition would be mitigated by AR/ASR if static and pumping water levels shifted up. While this has been successfully applied to some basalt wells in the region, it is not always successful.

- The Key was identified after the site visit, and conditions other than documented on the original well log are unknown.

- Well #6 is crooked and has had problems with equipment down the hole during repairs in recent years (Anderson Perry & Associates 2010). Problems such as this commonly inhibit, if not totally prevent, successful installation of necessary injection/recovery infrastructure.

- Well #9 is reported to be biofouled and it has not been used for municipal drinking water supply for several years. Prior to using this well for AR/ASR operations a well condition assessment and rehabilitation should be completed. If successful, rehabilitation has the benefit of bringing a stranded water supply asset back online for the City. Well #8 is not generally used due to the relatively low pumping rate, lift, and efficiency, compared to the other City wells. This does not make it a poor candidate for ASR, though it would not provide the same storage volume as other locations and site development costs are likely to be high relative to others.

No other well issues were identified at this phase of the feasibility study.

3.2.2 Well Accessibility

Accessibility also is an important consideration when looking at the use of an existing well for AR/ASR operations. Because conversion of an existing well to AR/ASR operation usually requires in-well and well head modification, the site needs to be accessible enough to allow the modification work and accommodate new surface infrastructure. Based on that:

- Well #1 is next to the fire station in a residential area with a very small well house but with good access on three sides (**Appendix B**).
- Well #8 at the north end of Marie Dorion Park has no roof hatch but the City indicated the roof was designed to be removed for maintenance.
- Well #9 sits on top of the bluff overlooking the Walla Walla River. Well #9 is a pitless well located outside the well house but the infrastructure inside the well house is complex due to a system intertie. However, but it appears there is adequate room for recharge loop retrofit.
- Well #6 was not visited but it is far from the Little Walla Walla River (making source conveyance an expensive component of development) and not in the target pressure zone. If it is determined that Well #6 or another well is an appropriate alternative, it is recommended to obtain site photographs and potentially conduct another site visit.

3.2.3 Well Ranking Matrix

Each well was ranked most suitable for AR/ASR operations (ranked number [No.] 1) to worst (ranked No. 4 to No. 8 depending on duplicate values) for each category; SC, well age, casing diameter, ADD, waste discharge options, and known well issues. The lower the individual and total number, the more suitable the location is for an AR/ASR system. **Table 4** lists the results of the well-by-well ranking.

Table 4 Well Ranking Matrix

City Well ID	Specific Capacity	Well Age [1]	Casing Diameter [2]	Available Drawdown [3]	Waste Discharge Options [4]	Known Well Issues [5]	Total	Well Rank
Well #8	6	1	1	1	3	1	**13**	1
Key Well	1	3	1	2	3	4	**14**	2
Well #5	2	4	2	2 [6]	3	1	**14**	2
Well #2	3	3	1	4 [6]	3	1	**15**	3
Well #9	7	2	2	1	1	2	**15**	3
Well #1	5	4	2	4 [6]	1	1	**15**	3
Well #6	4	2	2	3 [6]	1	3	**17**	4
Well #3	8	3	1	4 [6]	1	1	**18**	5

Notes:
Ranking is based on 1 is most suitable for AR/ASR, 7 is least suitable. If there was not data available (N/A) then the parameter automatically received the highest number in that category. In the case of a tie, some wells had the same ranking.
[1]Age is grouped by decade starting with 1960 as the most recently drilled with the highest ranking of 1 (1960s) to 5 (1920s).
[2]Casing ranking is grouped by diameter; the largest diameter has the highest rank of 1 (16 inches), 2 (12 inches) and 3 (8 inches).
[3]Available drawdown (ADD) is ranked by; 1 = +100ft ADD, 2 = 0 to 100ft ADD, 3 = 0 to -50ft ADD, and 4 = >-50ft ADD.
[4]Waste Discharge Options are ranked; 1 = Assumed relatively easy to connect to industrial sewer, 2 = Assess to nearby detention or infiltration pond, 3 = Significant infrastructure required, and 4 = Unknown.
[5]Known Well Issues are ranked; 1 = No known issues preventing AR/ASR development, 2 = Condition that requires further assessment, and 3 = Known prohibitive condition.
[6]The static water level is below the bottom of casing.

Based on the well-by-well review; Wells #8, #5 and the Key well are initially interpreted to potentially be the most suitable for demonstration recharge testing based on available information. It appears that with likely good access, proximity to source, disposal options, specific capacity, and diameter, these wells could be converted for testing for the lowest potential cost. However, cumulative project implementation costs were not developed for each well, and if that were included as a ranking criteria, Well #8 would likely drop much lower on this list. The park does not appear to be a good candidate for river bank filtration (RBF), and therefore design, permitting, and construction costs of a new intake and fish screen, infrastructure to move water up and down the adjacent bluf would combine with the relatively low recharge and pumping rates to produce a low $/gallon stored ratio. At Well #5 the relatively low test well development cost would offset the potential risk of entrainment issues associated with limited available drawdown. However, these same potential issues exist with Well #5's current use as a supply well. Whether Well #5 or the Key well are also the best choice for long-term (permanent) AR/ASR operations depends on the City's final approach to source treatment (centralized vs. onsite) and access to adjacent property for construcation/installation of a permanent filtration facility. An advantage of investigating the Key well is that it could be developed without interruption of service from Well #5.

Wells #2, #9, and #1 were ranked third. Wells #2 and #9 have distinct advantages, though access and discharge options at Well #2 are less understood. Well #9 has the advanage of reviving a stranded asset if the well is successfully reconditioned as part of an ASR testing program, and water stored at that location could be delivered to both the the City's pressure zones. These conclusions will be require further well investigation to confirm conditions, and will be paired with development costs at the end of Section 4, which will focus on the top three ranked wells. Addtional comments and thoughts bout these, and the other City wells, are listed in Table 5.

Table 5 Well Ranking Summary

City Well ID	Well Rank	Comments/Issues
Well #8	1	Good access and adjacent to source. Cost not yet factored into ranking. Intake from river level and then pumping waste to top of bluff likely to result in significantly higher development costs at this location. Water treatment plant could be located in parking lot for ASR testing, though would need to be constructed on city property on bluff above park for permanent facility.
Well #5	2	Good access and adjacent to source. Discharge: presence of onsite industrial sewer needs to be confirmed. ASR with PWL below base of casing would be necessary - risk of cascading water. Easement/access for permanent treatment system not evaluated.
Key well	2	Good access and adjacent to source. Discharge: presence of onsite industrial sewer needs to be confirmed. ASR with PWL below base of casing would be necessary - risk of cascading water. Easement/access for permanent treatment system not evaluated.
Well #2	3	Current well performance, casing depth, static and pumping water levels are unknown however the pump was pulled in 2017 and well videoed. This well may be a viable option though 1) additional information is needed and 2) the well is not close to an existing WW River reach or canal so conveyance of treated water would be a relatively high cost.
Well #9	3	AR/ASR at well #9 has several advantages: pressure zones are connected at this location, proximity to a reservoir, and a detention facility. Would require new intake, lift station, and raw water pipeline for onsite treatment.
Well #1	3	Old well, condition and seal assessment needed. SWL below casing. Would require new intake and raw water pipeline for onsite treatment.
Well #6	4	Limited discharge options and reported to be crooked borehole.
Well #3	5	Low specific capacity, limited discharge options, SWL below casing.

4. ENGINEERING PROJECT DEVELOPMENT PLAN

4.1 AR/ASR INFRASTRUCTURE NEEDS

4.1.1 General Requirements

To develop a successful and operational AR/ASR system, both for initial pilot testing/demonstration and permanent long-term operation, there a number of water system infrastructure requirements that must be addressed, including:

- ***Water Source for Recharge***—A source of available water during the low water demand and high streamflow season, generally November to April, to inject for storage in the AR/ASR wells. In most cases, this water is from a nearby surface water body (river or stream). If an existing surface water intake does not exist, then this infrastructure must be constructed to allow for legal diversion of the water from the surface water body.

- ***Water Treatment*****—**The water injected into the AR/ASR well must be treated to state and federal drinking water standards. For a surface water source, treatment will consist of a form of filtration and disinfection. When the project is ASR and drinking water is involved, the Oregon Health Authority will require that municipal treatment techniques are applied prior to injection. If the project is intended for aquifer recharge only, then there is more flexibility on treatment methods, though the criteria and objectives remain the same.

- ***Wellhead Modifications*****—**For demonstration testing, and often for full-scale AR/ASR implementation, the most cost-effective system uses existing groundwater wells for recharge and recovery. Modifications to the wellhead facilities are often required to facilitate and control recharge of water down the well, to support the monitoring and reporting requirements of the permit, and improvements to allow for frequent back-flushing of the well and discharge of water through a pump-to-waste system. If significant automation, variable flow mechanisms, or automated valving is installed, these upgrades can sometimes require electrical system improvements and/or wellhouse modifications.

- ***Recharge Water Conveyance*****—**Except in rare cases, the location of the surface water intake is not adjacent to the AR/ASR wellhead. In this case, either raw water conveyance from the intake to the treatment facility at the wellhead and/or finished water transmission piping from the treatment facility to the wellhead will be required.

4.1.2 Criteria for Concept Development

To define the configuration and magnitude of improvements to address the four components previously described, basic criteria and parameters for demonstration testing, and implementation of a multi-well AR/ASR system are defined in **Table 5**. Further discussion of these criteria and required improvements for demonstration testing and demonstration and full-scale multi-well AR/ASR operation are discussed in greater detail in sections 4.2.1 and 4.2.2.

For this phase of the feasibility study, we have identified two phases of ASR development: demonstration testing and full-scale. Demonstration testing (sometimes called pilot testing) is conducted under a limited license and in many ways, represents the final phase of a feasibility study – proof of concept that water quality will not be impaired, and the recharge/recovery operations will not impair groundwater or surface water resources, other users, or senior water rights. Demonstration testing may occur with temporary controls and equipment to limit design and construction expenditure prior to final proof of concept. However, all other aspects of the system (source water, treatment approach, well location, rates, volumes, duration) may be identical to a permanent (referred to as "full scale" below) system. Conversely, the project development approaches may differ significantly: a demonstration test location would benefit significantly from proximity to source because treatment is likely to be at the wellhead and this would limit conveyance cost. For a permanent or full-scale system that relies on centralized treatment (a new WTP using the existing piping network to convey water to the AR/ASR wells) then proximity to the source is not a cost factor in assessing feasibility.

Table 6 Aquifer Storage and Recovery Concept Design Criteria

Parameter	Demonstration Testing	Full-Scale AR/ASR
Number of wells	1	1 or more wells
Recharge water supply rate[1]	< 2 mgd	Up to 5.5 mgd
Treatment Targets	Federal and State SDWA standards	Federal and State SDWA standards
Wellhead improvements	Flow metering – recharge and recovery	Flow metering – recharge and recovery
	PTW – Discharge pumping rate for 15 minutes	PTW – Discharge pumping rate for 15 minutes
	Recharge rate flow control (throttling capability)	Recharge rate flow control (automated valving and controls)

[1] Recharge water supply rate based on 75% of the current discharge rate of the largest well for demonstration testing and 75% of the City's future peak daily demand for full-scale AR/ASR operation.
Notes:
mgd = Million gallon(s) per day
PTW = Pump to waste
SDWA = Safe Drinking Water Act

4.1.3 Water Source for Recharge Supply

The Walla Walla River served as the historical source of drinking water for the City. However, all of the infrastructure associated with this supply source has been abandoned and/or removed. Because the City of Milton-Freewater's drinking water supply is from seven active groundwater wells located throughout the City recharge water supply from the Walla Walla River will require the construction of new water intake facilities. The City also holds municipal water rights for surface water supply from the Walla Walla River.

Potential Surface Water Intake Locations

Based on discussion with City and WWBWC staff, three locations for siting of surface water intake facilities are considered for this phase of the feasibility study:

1. ***Marie Dorion Park (site of the historical river intake and surface water treatment facility)—***A dam at this location provided grade control associated with the historical drinking water intake and hydroelectric power generation facilities at this location. The dam has since been removed limiting the opportunity for a traditional streambank or in-river diversion at this location. Based on the presence of a sand and gravel streambank below the flood protection wall at the Park, there appears to be good potential for RBF or streambed filtration at this location. However, historic land use at this location creates uncertainty with respect to subsurface conditions and further exploration is not recommended at this time. This potential intake location is located near Well #8 but is more than one mile from other City water system infrastructure. Because of land use restrictions at Marie Dorion Park, the water would need to be conveyed from the river to the top of the adjacent bluff for treatment (where permanent facilities could be constructed) then back downhill to recharge at well #8, or perhaps along the top of the bluff to Well #9.

2. ***At the Bonneville Power Administration funded Little Walla Walla River diversion immediately downstream of Cemetery Bridge—*** The 220 cfs intake is a modern diversion constructed with automated traveling fish screens and flow regulating and monitoring equipment. This diversion is located within a half mile of the City's Wells #1 and #2, and water can be either piped from this location to a City main or diverted to locations closer to supply wells through the Little Walla Walla River. Any new mainstem intake would focus on this location to manage very high design, permitting, and construction costs of a new intake.

3. ***City owned properties adjacent to the Little Walla Walla River—***Flow from the Walla Walla River is diverted into the Little Walla Walla River at the location described in Option 2. The Little Walla Walla River flows north through the City to near NE 8th Street where a control structure splits flow into three separate channels: East Little Walla Walla River, West Little Walla Walla River, and Hudson Bay Canal. This section of the Little Walla Walla River through the City is generally classified today as irrigation water conveyance channels. As such, it is anticipated that permitting a new intake should be streamlined relative to the Walla Walla River where the presence of fish species will influence approach. Further, the Little Walla Walla River runs adjacent to the Well #5 and the Key well site and is close to Wells #1, #2, and #3.

A summary of the pros/cons of each of these options is tabulated in **Table 6**.

Table 6 Comparison of Intake Location Options

Intake Location	Proximity to Existing Well for Demonstration Testing	Proximity to Existing Wells for Full AR/ASR	Ease of Intake Permitting	Ease of Water Right	Ease of Intake Design/ Operation
1	High[1]	Low	Low	High	Low
2	Medium	Medium[2]	High[3]	Medium	High
3	High	High	High	Low[4]	High

1 – An intake at this location feeding a WTP above Well #8 could conceivable serve both wells #8 and #9.
2 – This improves to "high" if the concept is centralized treatment near the intake, and treated water is distributed to wells through the existing conveyance piping.
3 – High because a permitted structure and fish screen already exists at this location. Access to the site and an easement for construction a pump station has not been evaluated.
4- Diversion of winter flows from the mainstem to the Little Walla Walla for the purpose of recharge has not been evaluated and requires additional examination.

As Table 6 illustrates, Option 2 and Option 3 best meet the criteria identified for comparison. Option 3 is well suited to a phased implementation of demonstration testing followed by a staged development of additional AR/ASR at other City wells using either similar near-well onsite treatment or a centralized treatment facility. For this study, Option 3 is the preferred option, particularly for demonstration testing, and will serve as the basis for developing a concept design and preliminary cost estimates for the intake, treatment, wellhead, and conveyance components. However, the ability of the irrigation district to operate the diversion in winter (and the acceptability of that action to other watershed stakeholders) needs further evaluation.

4.1.4 Surface Water Treatment for Recharge

There are four primary approaches available to the City for treating the Walla Walla River surface water for AR/ASR recharge. The City's 2009 Water System Master Plan (Anderson Perry, 2010) includes a detailed discussion of the four treatment technology approaches, including:

- Slow sand filtration.
- Conventional rapid sand filtration.
- Packaged treatment units.
- Membrane filtration.
- RBF/MAR (managed aquifer recharge)

The findings of that analysis relative to water for AR/ASR recharge are summarized below.

Slow sand filtration is a low cost and low technology option for the City but would require a large land area to implement. Typical slow sand filter loading rates are in the range of 100 gallons per day per square foot. For demonstration testing at up to 2 million gallons per day (mgd), this would require 20,000 square ft of filter surface area. For permanent recharge operations, high turbidity levels in the treated water can be a concern as high turbidity levels can result in well clogging. Slow sand filtration is unlikely to be able to produce acceptable turbidity levels (less than 1 nephelometric turbidity unit [NTU]) through the recharge season when river turbidity levels are typically quite high (more than 100 NTUs). For these reasons, slow sand filtration is not further considered as a viable treatment technology for injection into wells for this project.

Custom designed and built conventional rapid sand filtration water plants have the advantage of being highly customizable with custom-designed unit treatment processes to address a broad range of water quality issues to produce high quality finished potable water. The disadvantages of this treatment method include high capital and operation and maintenance (O&M) costs, complex operation requiring highly qualified and certified experience operations staff, and development of systems for handling and disposal of treatment process residuals.

Packaged water treatment systems are available from multiple manufacturers. Like custom conventional rapid sand filtration, these package treatment systems typically include some form of sedimentation, coagulation, flocculation and filtration. The primary advantage of these systems over a custom conventional rapid sand filtration is that many packaged systems are designed to provide similar water quality in a smaller footprint with less operation complexity. This approach may be the most applicable for efficient setup of a demonstration test program at the first well location. Similar modular packaged treatment facilities could then be acquired and sited for each future AR/ASR well in a multi-well system. Selection of an appropriate packaged treatment system would require additional investigation to confirm the appropriate unit processes and filtration media to meet the water quality goals.

Membrane filtration systems have a relatively small footprint, less operational complexity and competitive capital and O&M costs relative to the other treatment technologies presented. Similar to a packaged treatment system, membrane filtration systems are somewhat modular allowing for multiple installations at strategic sites in close proximity to an intake or well. In order to achieve acceptable water quality for effective membrane operation, it is likely that a pre-treatment system will be required. An automatic filter/screen system installed upstream of the membrane filters would likely be adequate to reduce the turbidity and concentration of suspended solids in the raw water to acceptable levels to avoid membrane fouling.
Both membrane filtration and a packaged treatment system present the greatest opportunity for implementation to support demonstration testing and flexibility in adaptation to a full-scale multi-well AR/ASR system. For the purpose of this study, membrane filtration is the preferred option and will serve as the basis for developing a concept design and preliminary cost estimates for the intake, treatment, wellhead, and conveyance components. Further investigation and treatment system pilot testing will be required before full-scale implementation for production of water for AR/ASR recharge.

RBF/MAR both have the potential to either treat raw surface water sufficiently to be used for direct recharge to the basalt aquifer, or to pre-treat the water (through reduction in turbidity) sufficiently to lower primary treatment costs. One of the key advantages to both methods is that they eliminate the need to comply with OHA treatment technique requirements that are in effect when water is removed from a surface water supply and piped directly to a well. If a land application or induced infiltration step is inserted between the raw surface water source and the pipeline to the well, then achieving measurable water quality criteria drives the treatment process rather than managing long term risk to human health from possible contaminants. The physical conditions needed to support RBF at Marie Dorion Park appear to exist, though further exploration is not recommended due to historic land use nearby.

MAR using the well-known shallow alluvial aquifer system has potential to be a key component in the City's ASR treatment approach. One concept is to land apply raw surface water for infiltration, then recover the infiltrate with an alluvial well or wells after it has been filtered/polished in the subsurface. Because the shallow alluvial aquifer has the potential to have been impacted by surface contamination, a pumping well has the potential to produce impacted groundwater if not carefully sited and operated. One concept for consideration would be to surround the alluvial recovery well with infiltration basins or trenches, and then pump the well at rates designed to manage gradients to prevent capture of potentially impacted groundwater. If sufficient land and subsurface conditions are available, an MAR/Recovery treatment system has the potential to supply winter water to more than one deep ASR well. This option would require significant surface area of suitable land near the ASR well to limit conveyance costs. In addition, site characterization is necessary prior to design to assess subsurface conditions. Consequently, this option will not be carried forward unless the City identifies a parcel suitable for acquisition and exploration.

4.1.5 Wellhead Improvements

To begin AR/ASR operations at an existing municipal groundwater supply well, there are a number of important improvements that must be made to manage recharge and to meet the monitoring/reporting requirements of an AR/ASR Limited License. A brief description of these items is presented below:

- ***Bi-directional flow metering***—Each AR/ASR wellhead must include flow monitoring to accurately measure the rate and volume of water for both recharge and recovery. Recharge and recovery are typically transmitted through a common main at the wellhead, so a bi-directional flow meter is needed to measure these flows. A bi-directional flow meter is typically installed for this purpose. Existing flow meters at the wellhead or located adjacent in a vault would be replaced to achieve this requirement.

- ***Dedicated pump-to-waste piping***—Most of the City's existing wells are configured with deep well pump control valves that pump-to-waste at pump startup, primarily to managing hydraulic transients (surge events). In addition to this pump and distribution system protection, the ability to periodically operate the pump during the recharge and storage to cycles for backflushing of the aquifer is a critical function for AR/ASR. To achieve this, dedicated automated valving to allow for pump-to-waste operations is needed. This is generally achieved through the addition of a second globe style control valve and branch line that discharges to atmosphere separate from the pump control valve which closes shortly after pump startup. Installation of a dedicated pump-to-waste tee and control valve can be accommodated at each of the wells. Reconfiguration of the wellhead discharge header will be required for most wells for this purpose and for installation of recharge flow control valving.

- ***Pump-to-waste discharge***—The volume of water generated during a backflushing event is far greater than the water discharged during a normal pump startup. Onsite detention facilities, or discharge to a storm or sewer conveyance system with adequate capacity is needed. Based on the capacity of the City's wells, a rate of up to 2 mgd for a duration of 15 minutes is a good planning target. Several of the City's wells are in close proximity to an existing industrial sewer collection system that runs through the City. It is assumed that conveyance of pump-to-waste water to this system can be accomplished at most of the City wells and that onsite detention will not be required except at wells #8 and #9.

- ***Recharge Flow Control***—Valving to achieve a constant recharge rate into the well is required. This is typically achieved through the installation of a hydraulically operated globe style flow control valve located on the recharge loop that bypasses the pump control valve. As with the pump-to-waste system, this improvement will require reconfiguration of the wellhead discharge piping but with the possible exception of well #1, there appears to be adequate space within the well houses visited to accommodate this.

Based on our site visit to several of the City wells, it appears that major modification of the well discharge piping will be required to accomplish all of the improvements described above, but these modifications have been completed successfully at other projects with wells of a similar age and there are no apparent fatal flaws to accomplishing these improvements within the confines of the site and well house at each of the City's wells.

4.1.6 Recharge Water Conveyance

Based on the AR/ASR demonstration and full-scale expansion concepts described in this section (near-well diversion and wellhead treatment) limited conveyance of raw or finished water is anticipated. For flows up to 2 mgd, a 12-in. diameter main between the intake and treatment facilities, and between the treatment facilities and wellhead is recommended. Based on the specific flow rates anticipated, this pipe size recommendation should be refined during final design as there may be opportunity to reduce the diameter to an 8-in. diameter main.

4.2 DEVELOPMENT PROCESS

A discussion of the major steps required to develop the infrastructure needed to implement an AR/ASR program at the demonstration testing phase and for full-scale development is presented below. A demonstration project is assumed at Well #5, and full-scale development is assumed to expand the system to five wells. This section also presents a duration for each component of implementation and planning level project cost estimates for demonstration testing.

4.2.1 Pilot Testing

Based on the analysis presented above, from the perspective of infrastructure needs to support AR/ASR demonstration testing, Well #5 is the most viable. The proximity to the Little Walla Walla River and adequate space onsite for siting treatment facilities are major factors. A timeline for completing the improvements required to start demonstration testing at Well #5 include:

- ***Recharge Water Intake Siting and Permitting (5 months).*** At Well #5 and the Key well, siting and permitting of a new surface water intake is expected to be very straightforward assuming that each of the regulatory agencies involved in the review and approval of a surface water intake concur that this stretch of the Little Walla Walla River is in fact irrigation conveyance channel. If this is not the case, a duration of 12 months or longer should be expected, with significant restrictions placed on the configuration and operation of the intake. A simple intake design is anticipated for this site, consisting of a skid-mount pump and removable above ground suction pipe to the canal. A coarse fish screen would be on the pump suction pipe in the Little Walla Walla River. The piping and screen could be removed during periods when recharge is halted.

- ***Water Treatment Technology Selection (4 months).*** Selection of the appropriate water treatment technology should be confirmed through a scaled demonstration testing program. Pilot testing should be conducted with the selected treatment technology for at least 2 months during the period with the greatest degradation of raw water quality. This will typically be in the spring season when Walla Walla River flows are high due to spring rain events. This task could be completed concurrently with the recharge water intake permitting. A membrane treatment configuration would consist of a package membrane treatment system, skid mounted, and installed in a treatment building. In addition, pre-treatment would consist of automatic filter screens to reduce turbidity and remove coarse sediment to protect the filters.

- ***Improvement Design*** (***4 months).*** Once the previous two tasks are complete, design of the intake, treatment system, and wellhead improvements can commence.

- ***Construction (9–12 months).*** Construction of the designed improvements is anticipated to take approximately 9 to 12 months depending on lead-times for treatment equipment, seasonal regulatory restrictions on in-water work, and seasonal City constraints to taking the well out-of-service.

- ***Total Duration to prepare for Demonstration Testing (18–25 months).***
  While it may be possible to implement a less-robust pilot system in a shorter duration, the proposed implementation program presented herein provides the City with the best opportunity for seamless operation and minimal operational hurdles. In addition, if demonstration testing proves that AR/ASR can effectively be implemented on a full-

scale, this demonstration operation will serve as the foundation of the full-scale AR/ASR system without the need for further improvements.

Permitting tasks are not included in this timeline. Early phases of AR/ASR permitting generally occur prior to beginning design and construction, while the remainder occur as the demonstration project evolves and additional information is developed. The initial phases of permitting to acquire regulatory concurrence on the project framework would add roughly 6-months to the total duration of the and would generally add 6 months to the project duration, and the first phase of demonstration testing another 6 to 12 months.

4.3 MULTI-WELL AQUIFER STORAGE AND RECOVERY SYSTEM

The timeline presented above reflects the typical timeline for engineering design and construction implementation of AR/ASR at additional wells in the City system. It should be anticipated that a phased implementation of AR/ASR expansion could be achieved through the development of one additional well every 2 years. This assumes separate intakes on the Little Walla Walla River and development of satellite treatment facilities. There may be opportunity to develop a single intake and treatment facility to serve two nearby wells, such as Well #1 and Well #2, reducing overall development cost and duration.

4.4 DEMONSTRATION TESTING PROGRAM DEVELOPMENT – PLANNING LEVEL PROJECT COST ESTIMATE

An estimated project cost has been developed based on the project design parameters. Cost estimates represent opinions of cost only, acknowledging that final costs of the project will vary depending on actual labor and material costs; market conditions for construction; regulatory factors; final project scope; project schedule; and other factors. The Association for the Advancement of Cost Engineering International classifies cost estimates depending on project definition, end usage and other factors. The cost estimates presented here are considered Class 5 with an end use being concept screening and an expected accuracy range of -40 percent to +80 percent. As the project is better defined, the accuracy level of the estimates can be narrowed.

Table 7 presents a planning level project cost estimate for development of the infrastructure to support an AR/ASR demonstration testing program at the City's Well #5, assuming a 2 MGD recharge rate, which may be suitable to supply two ASR wells. Table 8 presents a planning level project cost estimate for the same system at a 1 MGD recharge rate. It is assumed that the Key well and Well #5 have similar development costs, though a physical inspection of the Key well is needed to confirm condition and infrastructure needs.

Table 7 Planning Level Project Cost Estimate
Well #5/Key Well AR/ASR Demonstration Testing Improvements at 2MGD Recharge Capacity

Item	Estimated Cost
Recharge Water Intake	$ 150,000
Water Treatment	$3,900,000
Wellhead Improvements	$180,000
Subtotal - Construction	***$4,230,000***
Engineering (20%)	$850,000
Non-ASR Permitting and Administration (5%)	$200,000
Contingency (20%)	$850,000
ASR Permitting and Aquifer Testing	$275,000
Total	***$6,405,000***

Table 8 Planning Level Project Cost Estimate
Well #5/Key Well AR/ASR Demonstration Testing Improvements at 1 MGD Recharge Capacity

Item	Estimated Cost
Recharge Water Intake	$ 150,000
Water Treatment	$2,100,000
Wellhead Improvements	$150,000
Subtotal - Construction	***$2,400,000***
Engineering (20%)	$480,000
Non-ASR Permitting and Administration (5%)	$120,000
Contingency (20%)	$480,000
ASR Permitting and Aquifer Testing	$275,000
Total	***$3,755,000***

An alternative to both treatment and disposal for both the Key and #5 well locations would be to utilize vacant land north of the adjacent warehouse. The concept would be to pump water from the little Walla Walla River (either directly or through river-adjacent induced infiltration), and polish that water through infiltration into the shallow alluvial aquifer. That water could then be captured by a new alluvial well or wells and then delivered directly to the Key well or Well #5, perhaps without additional treatment. The same infiltration basin could be used to manage waste discharge and recycle the produced water once turbidity is removed and could be sized to supply multiple ASR wells. If this treatment/discharge management option is pursued, the following elements would need to be further defined:

1. Land availability and acquisition costs.

2. An environmental assessment of this site and characterization of soil and shallow groundwater conditions.

3. A monitoring system

4. Design and construction costs for the intake or infiltration system, infiltration basin, alluvial recovery system, and conveyance to/from the Key and Well #5 locations.

To be consistent with planning-level cost estimating for other treatment alternatives, this concept is preliminarily developed in Table 9.

Table 9 Planning Level Project Cost Estimate
Well #5/Key Well AR/ASR Demonstration Testing Improvements
MAR System (1 mgd capacity)

Item	Estimated Cost
Recharge Water Intake	$ 150,000
Basin Construction	$100,000
Alluvial Capture Well (well, wellhouse, pumping, mechanical and electrical systems)	$750,000
Conveyance Piping	$150,000
Disinfection	$50,000
Wellhead Improvements	$150,000
Subtotal - Construction	***$1,350,000***
Land Acquisition	$1,000,000
Site Characterization (soil sampling, 3 monitoring wells, GW sampling, write-up)	$75,000
Non-ASR Permitting and Administration (5%)	$70,000
Engineering (20%)	$270,000
Contingency (20%)	$270,000
ASR Permitting and Aquifer Testing	$275,000
Total	***$3,310,000***

5. CONCLUSION

Based on the physical ranking and known existing conditions, Well #5 and the Key well are the most viable AR/ASR wells but there are trade-offs associated with each. Well #5 has limited ADD (17 ft) and the Key well has a limited ADD (38 ft) but are adjacent to the Little Walla Walla River and are downstream of the diversion point. Therefore, one of these two wells are likely to be the best location for demonstration testing.

6. RECOMMEDATIONS

Recommendations at this phase of the project involve developing a scope of work (for the next phase of the feasibility study) to address the primary uncertainties surrounding demonstration project development at Well #5/Key well. These include:

1. Well Condition Assessment, including:

    a. Specific Capacity Test (last measured 1936)

    b. Aquifer test to assess reservoir size, response, and recharge area of influence

    c. Video survey to observe casing condition, well depth, evidence of seal, storage intervals (if evident), assess risk of cascading water, assess stability of pump intake location, and biological activity.

2. Confirm presence, distance, and hydraulic carrying capacity of industrial sewer for waste discharge connection. Confirm feasibility of discharge to sanitary sewer for demonstration testing, and develop a detailed cost estimate for well improvements and connections.

3. Confirm feasibility of adding a point of diversion to the City's surface water right adjacent to Well #5, and diverting a portion of the mainstem flow into the Little Walla Walla River.

4. Consult with agencies to evaluate the viability of a direct intake adjacent to Well #5 in the Little Walla Walla River.

5. Confirm that the City wishes to develop an ASR project vs. an AR project. If ASR, consult with OWRD and OHA to ensure that the preferred treatment method for demonstration testing will satisfy OHA's treatment technique requirements, then develop a detailed design and construction cost estimate for source appropriation and conveyance.

6. Finalize design elements (power regeneration, recharge flow control, automation, power, logic controller(s), etc. to finalize construction cost estimates.

7. Develop an ASR permitting flow-path, timeline, and cost estimate specific to the Well #5 project.

7. NEXT STEPS

For this phase of the feasibility study, the next steps are limited to the completion of Tasks 3 and 4. These are summarized as:

TASK 3 – Investigate Water Treatment Alternatives: Work under this task will involve developing a final water treatment alternative recommendation for meeting the requirements of ORS-690-350 based on characterization of source water chemistry.

- Collect samples of raw Walla Walla River source water and basalt groundwater.
- Analyze for geochemical compatibility through comparison to other projects, and to support an engineering assessment of water treatment requirements.
- Three Surface water samples will be collected in winter months to characterize the water likely available for treatment and storage. One groundwater sample will be collected at Well #5.
- EA will coordinate the timing with WWBWC staff to collect three surface water samples at hydrograph positions most likely to be associated with water availability. A staff geologist will coordinate with the laboratory, place a bottle order, provide monitoring equipment, prepare containers, and travel to Milton-Freewater to collect samples with staff support.

TASK 4 – Conduct Analysis of Instream Flows and Alternatives: Work with WWBWC staff to prepare an analysis of by-pass, optimum peak, flushing and other ecological flows of the Walla Walla River and the effect of diversion for groundwater storage on those flows.

Final conclusions and recommendations for next steps will be included with the Task 3 and 4 Report to be completed mid-2018.

8. REFERENCES

Anderson Perry & Associates. 2010. *City of Milton-Freewater, Oregon Water Management and Conservation Plan Update.* October.

Anderson Perry & Associates. 2011. *City of Milton-Freewater, Oregon Water Management and Conservation Plan Update Addendum.* May.

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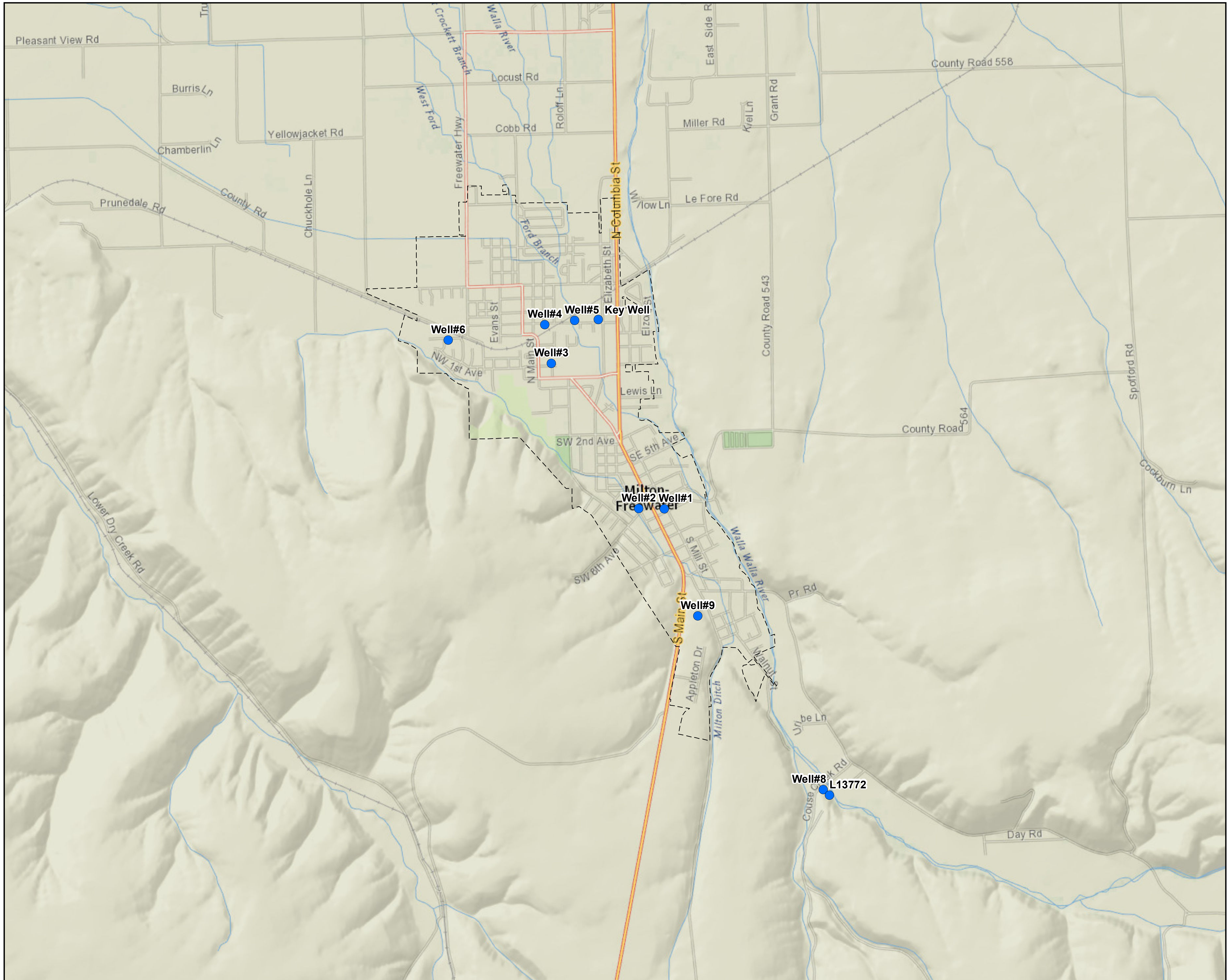
Figures



LEGEND

- Milton-Freewater Wells
- City Limits 2016

0 0.35 0.7 1.4
Miles

Milton Freewater WWBWC ASR Feasibility Study Phase 1

Figure 1. Well Locations

Appendix A

Water Rights

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Well No. 1

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* MILTON CITY, A MUNICIPAL CORPORATION

of Milton *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* a well

a tributary of Walla Walla River *for the purpose of* domestic, industrial, commercial and municipal use,

under Permit No. U-102 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* January 18, 1937;

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 1.5 c.f.s. measured at the point of diversion from the well or source of appropriation,

or its equivalent in case of rotation.

The point of diversion is located in the SE¼NW¼, Section 12, Township 5 North, Range 35 East, in Block 7 McCoy's Addition of Milton,

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to of one cubic foot per second per acre,

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

S½ of SW¼ and a fraction of SW¼ SE¼
Section 1
NE¼ SW¼ and SE¼
Section 2
All of Section 12 except NE¼ NE¼
E½ NE¼ of Section 13,
Township 5 North, Range 35 East, W. M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

After the expiration of fifty years from the date of this certificate or on the expiration of any federal power license issued in connection with this right, and after not less than two years' notice in writing to the holder hereof, the State of Oregon, or any municipality thereof, shall have the right to take over the dams, plants and other structures and all appurtenances thereto which have been constructed for the purpose of devoting to beneficial use the water rights specified herein, upon condition that before taking possession the State or municipality shall pay not to exceed the fair value of the property so taken, plus such reasonable damages, if any, to valuable, serviceable and dependable property of the holder of this certificate, not taken over, as may be caused by the severance therefrom of the property taken in accordance with the provisions of section 47-508, Oregon Code 1930.

WITNESS the signature of the State Engineer, affixed

this 31st *day of* January *, 193*9

CHAS. E. STRICKLIN
State Engineer

Recorded in State Record of Water Right Certificates, Volume 11 *, page* 12070

3961 UMAT 3961
OBSERVATION WELL

5N/35-12-F(1)
UMATILLA

Milton Freewater #1

Application No. U 109
Permit No. U 102
Well No. #1

G 5389

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Date of Report ________________, 193__

#. 40' of Lot 5, Block 7, McCoy's Addition to Milton City, Oregon.

1. Location of well: S. W. ¼ of Section 12 Twp. 5 N Rge. 35 E. W. M.
2. Name of nearest natural surface stream Walla Walla River
3. Distance from well to that stream: 1000 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: 9.5 feet.
5. Date of beginning drilling or digging January 2, 1937
6. Date well was completed March 1, 1938

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
	At surface	ft.
	ft.	ft.
(SEE SHEET ATTACHED)	ft.	ft.
	ft.	ft.
	ft.	ft.
	ft.	ft.
	ft.	ft.
	ft.	ft.
	ft.	ft.

Remarks:

WELL INFORMATION

8. Diameter of well 12" inches. Depth of well 652 feet.
9. Depth at which water was first encountered 90' feet.
10. Water level when completed: 87' feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.: See log attached.

This well for "standby" service only.

UMAT 3961

5N/35-12 F(1)
UMATILLA

PUMP INFORMATION

12. Manufacturer of pump: Fairbanks-Morse & Company
13. Address: 1220 First Avenue South, Seattle, Washington
14. Data on name or base plate: #32523 - Seattle No.7310
 0 Stage 12" Imp. 7472, Figure 0920, 1750 R.P.M.
 Outside column 9" O. D., Length 150', Shaft 1 5/8" Dia.

15. Data on pump bowl assembly:

16. Size of pump: 12"
17. Rated capacity: 1000 gallons per minute. 80 pounds pressure
18. Rated speed: 1800 revolutions per minute. water to water hd.
19. Number of stages: 6
20. Size of intake pipe: 9"
21. Size of discharge pipe: 12"
22. Length of intake pipe: 150'
23. Length of discharge pipe: Direct into 12" city main
24. Suction lift: (difference in elevation between water surface in well and pump)

25. Discharge lift: (difference in elevation between pump and end of discharge line)

26. Depth of pump intake below ground surface: 187' feet.
27. Remarks: 187' to bottom of intake pipe

MOTOR OR ENGINE INFORMATION

28. Name of manufacturer: Fairbanks-Morse & Co.
29. Address: 1220 First Avenue South, Seattle, Washington
30. Type of motor or engine: 100 H.P., Morse Type, 1750 R.P.M., 3 phase, 60 cy., 440 volts, vertical ball bearing, hollow shaft squirrel cage.
31. Data on name or base plate:

32. Rated horsepower: 100
33. Rated speed of motor or engine: 1750 revolutions per minute.

34. Rated Capacity of Pump (with described motor)

1000	g.p.m. at	305	ft. head
1200	g.p.m. at	250	ft. head
1250	g.p.m. at	240	ft. head
	g.p.m. at		ft. head
	g.p.m. at		ft. head

35. Remarks:

UMAT 3961

F(1)
5N/35-12 #1
UMATILLA CO

CAPACITY TEST

36. Date of test: April 22 37. Temperature of water 58°F. or ____°C.
38. Motor speed during test: ____
39. Test made by (weir, tank or other means): Orifice

40. Pounds pressure	TOTAL HEAD	*Total lift in feet	Gallons per min.	°Feet to water level	□ Draw-down	+Time
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.
___lbs.,	Gauge at pump	Total___ft.___in.		ft.	ft.	M.

(See report of Fa banks-...se Engineer attached)

* Difference in elevation between water level in well and outlet of pump test line.
° Distance from ground level to water surface in well.
□ Distance water level is lowered during time interval.
\+ Hour and minute at which observation was made.

41. Installation will work efficiently under normal head of 305 ft.
42. Water is discharged into: 12" city water main
43. Was water lowered to pump intake by test? ____
44. Remarks: ____

GENERAL INFORMATION

45. Name of contractor or other party who drilled or dug well: A. A. Durand
Address: Walla Walla, Washington
46. Pump and motor were installed by: Carleton M. Mull, Fairbanks-Morse Co.
Address: Yakima, Washington
47. Capacity test was made by: Carlton M. Mull
Address: Yakima, Washington
48. General remarks: Checked by Mr. White, Engineer, Oregon Insurance Rating Bureau, Portland, Oregon

Report made by Milton City
(sign here)
[illegible]
Bus. Mgr.

UMAT 3961

U-102

F(1)

5N/35-12

UMATILLA CO

LOG OF MILTON WELL - UMATILLA COUNTY

From 1	to	30 ft.	gravel	
30	to	37 "	Cement & Gravel	
37	to	46 "	Gravel & Clay	
46	to	60 "	Black Rock	
60	to	98 "	Rock & Clay	
98	to	115 "	Black Rock	
115	to	122 "	Hard Black Rock	
122	to	140 "	Medium Rock	
140	to	145 "	" "	Soft Red Brown
145	to	180 "	" "	Black
180	to	186 "	Hard Black Rock	
186	to	202 "	Medium Grey Rock	
202	to	212 "	Soft " "	
212	to	249 "	Medium Brown Rock	
249	to	256 "	Hard Brown "	
256	to	280 "	Soft Brown Rock	
280	to	367 "	Medium Grey Rock	
367	to	416 "	" Black Rock	
416	to	440 "	" Grey "	
440	to	450 "	" Black "	
450	to	651 "	" Grey "	

3N/35-12-~~RH~~ F111
UMATILLA

UMAT 3961

MILTON CITY, OREGON APRIL 22, 1938

Test made Fairbanks, Morse Turbine Pump

Pump #32523, Seattle No. 7316

6 Stage 12" Imp. -747-E Fig 6920 - 1750 R.P.M.

Outside column 9" O.D. Length 150 ft. shaft 1-5/8" Dia.

Capacity 1000 G.P.M. at Water to Water head 300 Ft.

Motor Fairbanks, Morse 100 H.P. Type HSZU - 1800 R.P.M.

Motor No.324047 - Fr.JL163B - 3 ph. 60 cycle 440 Volt.

118 Amps. F.Load Speed 1755 R.P.M.

Test Data:-Pump Started at 2:55 P.M.; Stopped at 5:30 P.M.

Length of air line below pump floor level 177' + 5'7" =182'7"

Draw down gauge before pumping = 37 lbs. = 85.5 ft.

Pumping at no pressure on discharge.

Draw gauge 10# = 23.1 Ft.

Pumping level 140 Ft.

Capacity thru 9.5" orifice in 12" O.D. Pipe 10" = 1400 G.P.M.

K. W. demand at power 1 mile distance 90 K.W. X 1.34 = 1201 H.P.

Discharge pressure 30# = 69.3 Ft.

Draw down gauge reading 14# = 32.25 Ft.

Capacity thru 9.5" orifice 8" = 1200 G.P.M.

Discharge pressure 50# = 115.5 Ft.

Draw down gauge 16 lbs = 36.98 Ft.

Discharge thru 9.5" orifice 7" = 1150 G. P. M.

Motor Speed 1762 - 1775 - 1760 R.P.M.

Motor In Put 127 Amps - 121 - 125 - P.Factor 90%

Discharge pressure 80 lbs. = 184.8 Ft.

Draw down gauge = 21 lbs. = 48.5 Ft.

Discharge thru 9.5" orifice 5-1/4" = 1000 G.P.M.

Motor Speed 1752 - 1754 - 1760 R. P. M.

Motor In Put 125 Amps - 124 - 122. P. Factor 88%

UMAT 3961

Umatilla

SN/35-12F(1)

Oregon State Board of Health

SANITARY ENGINEERING LABORATORY

REPORT OF MINERAL ANALYSIS OF WATER

Location of source Milton-Freewater Description of source #1

Analysis by MP Date 11/10/5[illegible] Collected by ______ Date 6/25/5[illegible]

RESULTS

	Parts per million
Turbidity	5
Color: Apparent ______ True	3
Odor: Hot ______ Cold	
Total Solids	150
Loss on Ignition	[illegible]
Silicon (SiO_2)	49
Chloride (Cl)	4.8
Sulfate (SO_4)	5.4
Calcium (Ca)	14
Magnesium (Mg)	2.3
Aluminum (Al)	0
Orthophosphates (PO_4)	.10
Metaphosphates $(PO_3)_6$	
Alkalinity (as $CaCO_3$): Carbonate	0
Bicarbonate	78
Hardness (as $CaCO_3$)	[illegible]
Sodium and Potassium (as Na)	25
Iron (Fe)	0
Manganese (Mn)	0
Fluoride (F)	.1
Carbon Dioxide (CO_2)	2.5

pH 7.9

Remarks ______

PHE-10

UMAT 3961

STATE ENGINEER
Salem, Oregon

State Well No. 5N/35-12F(1)

County UMATILLA

Application No.

Water Level Record

OWNER: MILTON FREEWATER OWNER'S NO. # 1

Description of measuring point:

Date	Water Level Feet (above) (below) Land Surface	DATE	WATER LEVEL	Date	Water Level Feet (above) (below) Land Surface	DATE	WATER LEVEL
5-28-37	85.5	6-55	145	4-57	140	10-59	193
7-45	107	8	149	8	160	11	164
5-52	136	9	140	9	165	12	165
3-15-54	137	10	139	10	160	1-60	168
3-30	136	11	142	11	156	2	174
4	138	12	140	12	158	3	186
5	135	2-56	140	1-58	155	4	165
6	145	3	138	3	155	5	170
7	147	4	145	4	153	6	175
9	136	5	142	5	155	7	183
10	132	7	151	8	165	8	180
11	135	8	154	10	150	9	176
12	132	9	155	11	157	10	174
1-55	135	10	150	12	150	11	173
2	132	11	148	3-59	145	1-61	169
3	134	12	145	4	150	2	182
4	130	1-57	148	8	164	4	195
5	134	2	147	9	173	5	190

REMARKS:

UMAT 3961

STATE ENGINEER
Salem, Oregon

State Well No. 5N/35-12F(1)

County UMATILLA

Application No.

Water Level Record

OWNER: MILTON FREEWATER OWNER'S NO. #1

Description of measuring point:

Date	Water Level Feet ~~(above)~~ (below) Land Surface	Remarks	Date	Water Level Feet (above) (below) Land Surface	Remarks
6-61	182		4-20-64	181	
7	180		5-18	183	
11	170		6-15	196	
12	172		7-13	205	
11-62	190		8-24	204	
12	188		9-21	205	
1-63	200		10-26	202	
2	200		12-28	193	
3	200				
4	204				
5	195				
6	207				
10-28	200				
11-20	193				
12-2	194				
1-13-64	188				
2-24	185				
3-17	210				

REMARKS:

State Printing 86814

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

RECEIVED
MAY 10 1971
STATE ENGINEER
SALEM, OREGON

UMAT 3960

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

UMAT 3960

State Well No. 5N/35-12 dd bd
State Permit No. U-109

(1) OWNER:
Name CITY OF MILTON-FREEWATER ORE.
Address M-F ORE.

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☐ Reconditioning ☒ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

CASING INSTALLED:
Threaded ☒ Welded ☐
12" Diam. from 0 ft. to 84 ft. Gage ?
PREVIOUSLY INSTALLED
" Diam. from ft. to ft. Gage

PERFORATIONS:
Perforated? ☐ Yes ☐ No.
Type of perforator used SEE LOG
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☐ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WATER LEVEL: Completed well.
Static level 202 ft. below land surface Date 3-15-71
ian pressure lbs. per square inch Date

(9) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? CONTRACTOR
Yield: 1484 gal./min. with 182 ft. drawdown after 24 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 62° Was a chemical analysis made? ☐ Yes ☒ No

(10) CONSTRUCTION:
Well seal—Material used CEMENT
Depth of seal 84 ft.
Diameter of well bore to bottom of seal 12 in.
Were any loose strata cemented off? ☐ Yes ☒ No Depth
Was a drive shoe used? ☒ Yes ☐ No
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(11) LOCATION OF WELL:
County UMATILLA Driller's well number
SE ¼ NE ¼ Section 12 T. 5N R. 35 E W.M.
Bearing and distance from section or subdivision corner Begining @ the center of section 12, N. 850' Thence W. 250' to well # 1

(12) WELL LOG:
Diameter of well below casing 12"
Depth drilled 656 ft. Depth of completed well 656 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level as drilling proceeds. Note drilling rates.

MATERIAL	From	To	SWL
WELL WAS ORIGINALLY DRILLED IN 1930S, REPORTED TO HAVE BEEN 651' ~~[illegible]~~ ACTUAL DEPTH WAS 636' CASING HAD BEEN PERFORATED WE PRESSURE GROUTED THROUGH PERFORATIONS SHUT OFF SURFACE WATER ENTERING PERFORATIONS, MADE TEST NO LOSS OF WATER WITH HOLE FILLED TO TOP UNDER 50PSI AFTER CEMENTING			
GREY BASALT	636	642	202
BLACK BASALT	642	656	202

Work started 1-21 1971 Completed 3-17 1971
Date well drilling machine moved off of well 3-16 1971

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [signature] (Drilling Machine Operator) Date 3-31, 1971
Drilling Machine Operator's License No. 361

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME CHARLES JUNGMANN DRILLING CO. (Person, firm or corporation) (Type or print)
Address 105 REES AVE. W. W. WASH.
[Signed] [signature] (Water Well Contractor)
Contractor's License No. 286 Date 3-31 1971

(USE ADDITIONAL SHEETS IF NECESSARY)

RECEIVED
JAN 4 1970
STATE ENGINEER
SALEM, OREGON

Permit No. G-4924

APPLICATION FOR A PERMIT

To Appropriate the Ground Waters of the State of Oregon

I, City of Milton-Freewater (Name of applicant)

of P. O. Box 108, Milton-Freewater, Oregon (Postoffice Address), *county of* Umatilla,

state of Oregon, *do hereby make application for a permit to appropriate the following described ground waters of the state of Oregon, SUBJECT TO EXISTING RIGHTS:*

If the applicant is a corporation, give date and place of incorporation

....

1. *Give name of nearest stream to which the well, tunnel or other source of water development is situated* Walla Walla River (Name of stream)

tributary of Columbia River

2. *The amount of water which the applicant intends to apply to beneficial use is* 2.0 *cubic feet per second or* 900 *gallons per minute.*

3. *The use to which the water is to be applied is* domestic, industrial, commercial and municipal use.

4. *The well or other source is located* 850 *ft.* N (N. or S.) *and* 250 *ft.* W (E. or W.) *from the* S.E. *corner of* S.E. ¼ of the N.W. ¼ of Section 12 T. 5 N. R. 35 E.W.M. (Section or subdivision)

The S.E. corner of the S.E. ¼ of the N.W. ¼ of Section 12 T. 5N R. 35 E. W. M. is also the center of said Sec. 12 (If preferable, give distance and bearing to section corner) (If there is more than one well, each must be described. Use separate sheet if necessary)

being within the S.E. ¼ N.W. ¼ *of Sec.* 12, *Twp.* 5 N, *R.* 35 E., *W. M., in the county of* Umatilla

5. *The* (We intend to use existing pipeline to ~~xxxx~~ existing well) (Canal or pipe line) *miles in length, terminating in the* S.E. ¼ N.W. ¼ (Smallest legal subdivision) *of Sec.* 12, *Twp.* 5 N, *R.* 35 E., *W. M., the proposed location being shown throughout on the accompanying map.*

6. *The name of the well or other works is* City of Milton-Freewater Well No. 1
old permit No. U-102

DESCRIPTION OF WORKS

7. *If the flow to be utilized is artesian, the works to be used for the control and conservation of the supply when not in use must be described.*

....

8. *The development will consist of* redeveloping one (1) well (Give number of wells, tunnels, etc.) *having a diameter of* 12 *inches and an estimated depth of* 800 *feet. It is estimated that* 0 feet *feet of the well will require* .... (Kind) *casing. Depth to water table is estimated* 112 (Feet)

100' of 12" steel casing in already installed in well, perforations are recorded in the casing at 50'. Perforations will be sealed by pressure grouting. G 4924

G 4924

CANAL SYSTEM OR PIPE LINE—

9. *(a) Give dimensions at each point of canal where materially changed in size, stating miles from headgate. At headgate: width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(b) At .... *miles from headgate: width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(c) Length of pipe, ... *ft.; size at intake* .... *in.; in size at* .... *ft. from intake* .... *in.; size at place of use* .... *in.; difference in elevation between intake and place of use,* .... *ft. Is grade uniform?* .... *Estimated capacity,* .... *sec. ft.*

10. *If pumps are to be used, give size and type* 1500 G.P.M. turbine

Give horsepower and type of motor or engine to be used 200 H.P. electric

11. *If the location of the well, tunnel, or other development work is less than one-fourth mile from a natural stream or stream channel, give the distance to the nearest point on each of such channels and the difference in elevation between the stream bed and the ground surface at the source of development*

Walla Walla River is 1000' to East. River channel is approximately 9' lower than well site.

12. *Location of area to be irrigated, or place of use* ....

Township N. or S.	Range E. or W. of Willamette Meridian	Section	Forty-acre Tract	Number Acres To Be Irrigated
5 North	Range 35 E.	Sec. 12		Municipal
5 North	Range 35 E.	Sec. 1		Municipal
5 North	Range 35 E.	Sec. 11		Municipal
5 North	Range 35 E.	Sec. 2		Municipal
5 North	Range 35 E.	Sec. 13		Municipal
5 North	Range 36 E.	Sec. 18		Municipal
6 North	Range 35 E.	Sec. 35		Municipal

(If more space required, attach separate sheet)

Character of soil Gravel

Kind of crops raised ....

MUNICIPAL SUPPLY— **G 4924**

13. *To supply the city of* Milton-Freewater

in Umatilla *county, having a present population of* 4,510

and an estimated population of 5,000 (5,000) *in 19*80 (80)

ANSWER QUESTIONS 14, 15, 16, 17 AND 18 IN ALL CASES

14. *Estimated cost of proposed works, $* 20,000

15. *Construction work will begin on or before* January 15 1971

16. *Construction work will be completed on or before* May 15, 1971

17. *The water will be completely applied to the proposed use on or before* October 1, 1971

18. *If the ground water supply is supplemental to an existing water supply, identify any application for permit, permit, certificate or adjudicated right to appropriate water, made or held by the applicant.* Permit No. U-102 allows a water right for 1.5 C.F.S. on Well No. 1 dated January 18, 1937

[signature]
(Signature of applicant)

Remarks: It is the intent of this Application for water right to allow the City of Milton-Freewater to rework existing Well No. 1, Permit No. U-102 and develop additional water up to a capacity of 3.5 c.f.s. or 1573 G.P.M. The City Of Milton-Freewater does not wish to change the priority date of the existing Permit No. U-102, for 1.5 c.f.s., dated Jan. 18 1937.

Work to be done on the well includes sealing recorded perforations at 50', checking seal into basalt and deepening well in an attempt to improve the capacity of the well. Also when a pump is installed after reworking the discharge flange will be installed above ground and well casing will be extended above ground level to meet State of Oregon requirements.

STATE OF OREGON,
County of Marion, } *ss.*

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for ....

In order to retain its priority, this application must be returned to the State Engineer, with corrections on or before ...., *19*....

WITNESS my hand this .... *day of* ...., *19*....

....
STATE ENGINEER

By ....
ASSISTANT

STATE OF OREGON,
County of Marion, } ss.

PERMIT

This is to certify that I have examined the foregoing application and do hereby grant the same, SUBJECT TO EXISTING RIGHTS and the following limitations and conditions:

The right herein granted is limited to the amount of water which can be applied to beneficial use and shall not exceed 2.0 *cubic feet per second measured at the point of diversion from the well or source of appropriation, or its equivalent in case of rotation with other water users, from* Well No. 1

The use to which this water is to be applied is municipal

If for irrigation, this appropriation shall be limited to .... *of one cubic foot per second or its equivalent for each acre irrigated and shall be further limited to a diversion of not to exceed* .... *acre feet per acre for each acre irrigated during the irrigation season of each year;*

and shall be subject to such reasonable rotation system as may be ordered by the proper state officer.

The well shall be cased as necessary in accordance with good practice and if the flow is artesian the works shall include proper capping and control valve to prevent the waste of ground water.

The works constructed shall include an air line and pressure gauge or an access port for measuring line, adequate to determine water level elevation in the well at all times.

The permittee shall install and maintain a weir, meter, or other suitable measuring device, and shall keep a complete record of the amount of ground water withdrawn.

The priority date of this permit is January 4, 1971

Actual construction work shall begin on or before November 23, 1972 *and shall thereafter be prosecuted with reasonable diligence and be completed on or before October 1, 19*73
Extended to Oct. 1, 1984 — Extended to Oct. 1979

*Complete application of the water to the proposed use shall be made on or before October 1, 19*74
Extended to Oct. 1, 1984 — Extended to Oct. 1979

WITNESS my hand this 23rd *day of* November, *19*71.

[signature]
STATE ENGINEER

BC- Extended to October 1, 1989; 10-1-94; 10-1-99

Application No. G-5389
Permit No. G-4924

PERMIT
TO APPROPRIATE THE GROUND WATERS OF THE STATE OF OREGON

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 4th *day of* January, *19*71, *at* 8:00 *o'clock* A *M.*

Returned to applicant:

Approved: November 23, 1971

Recorded in book No. ____ *of Ground Water Permits on page* G-4924

CHRIS L. WHEELER
STATE ENGINEER

Drainage Basin No. 2 *page* 68

$27.00

Umat 5999

RECEIVED
APR 11 1994
WATER RESOURCES DEPT.
SALEM, OREGON

5N/35E/12bb

STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

(START CARD) # 53338

(1) OWNER: Well Number #1
Name City of Milton Freewater
Address PO Box 6
City Milton Freewater State OR Zip 97862

(2) TYPE OF WORK:
☐ New Well ☐ Deepen ☒ Recondition ☐ Abandon

(3) DRILL METHOD:
☒ Rotary Air ☐ Rotary Mud ☐ Cable
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☒ Other Municipal

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 584 ft.
Explosives used ☐ Yes ☒ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
12	0	584	NA			

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from ____ ft. to ____ ft. Size of gravel ____

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:					☐	☐	☐	☐
					☐	☐	☐	☐
		NA			☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ____

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ____
☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
		NA				☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
			1 hr.
	NA		

Temperature of Water ____ Depth Artesian Flow Found ____
Was a water analysis done? ☐ Yes By whom ____
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ____
Depth of strata: ____

(9) LOCATION OF WELL by legal description:
County Umatilla Latitude ____ Longitude ____
Township 5 N or S. Range 35 E or W. WM.
Section 12 NW ¼ NW ¼
Tax Lot 06500 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) SE 9th & Mill St.

(10) STATIC WATER LEVEL:
228 ft. below land surface. Date 3-29-94
Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found 228

From	To	Estimated Flow Rate	SWL

(12) WELL LOG:
Ground elevation ____

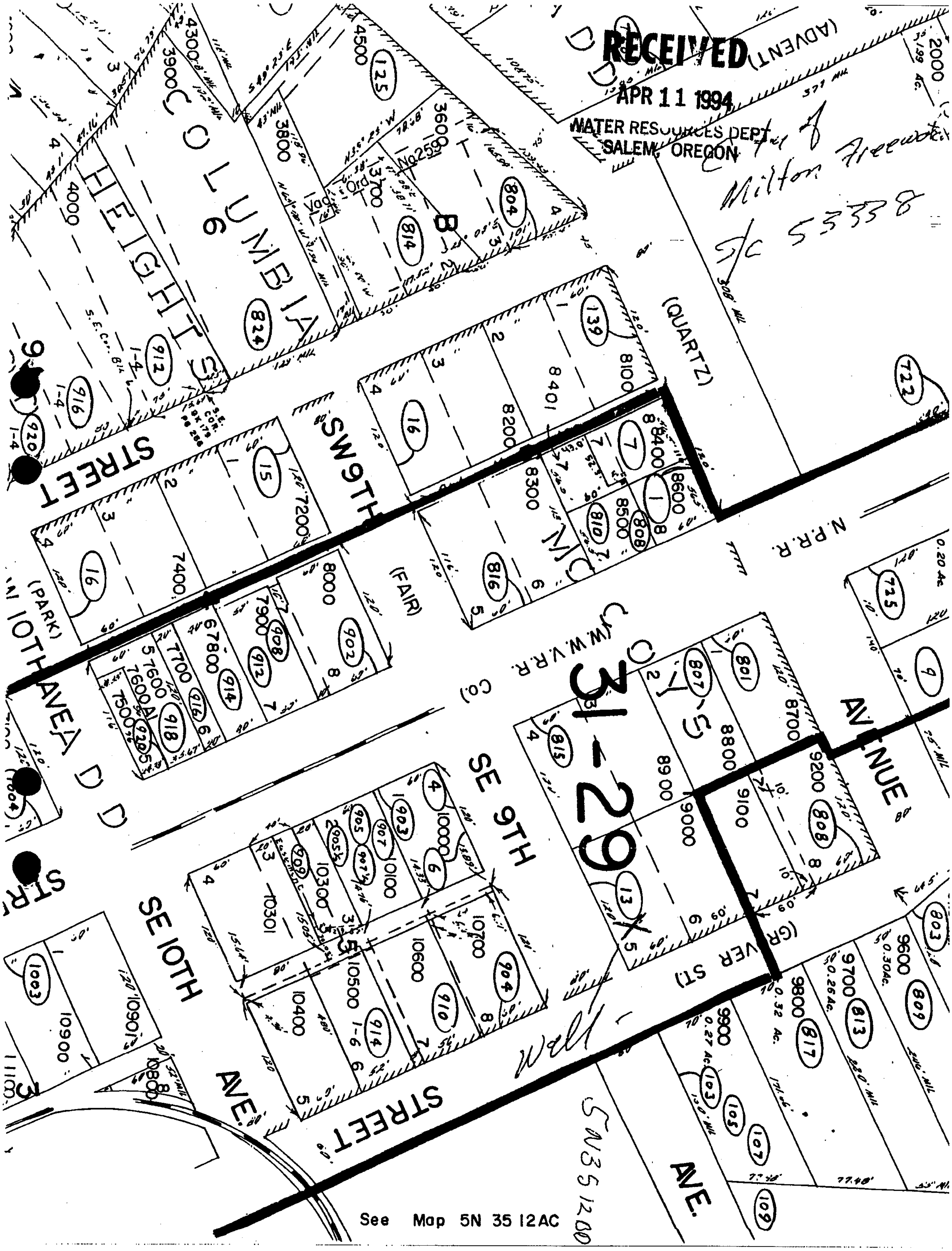
Material	From	To	SWL
Ran 12" Stabilizers down well to straighten for lowering of Turbine pump			
Cleaned well out to 584 ft.			
Stabilizers reamed off side of well @ 584 ft & is starting new hole			

Date started 3-8-94 Completed 3-29-94

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.
WWC Number ____
Signed ____ Date ____

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 259
Signed [signature] Date 3-31-94

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT SECOND COPY - CONSTRUCTOR THIRD COPY - CUSTOMER 9809C 10/91


RECEIVED
APR 11 1994
WATER RESOURCES DEPT
SALEM, OREGON
Milton Freewater
G/C 55338
COLUMBIA
HEIGHTS
SW 9TH
SE 9TH
SE 10TH
STREET
AVENUE
AVE.
(QUARTZ)
(FAIR)
(PARK)
N.P.R.R.
(W.W.V.R.R. CO.)
31-29
Well
SN35 12DD
See Map 5N 35 12AC

• Well No.2

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, That MILTON CITY, a municipal corporation of Milton, State of Oregon, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of a well a tributary of for the purpose of municipal under Permit No. U-150 of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from February 28, 1944;

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 3.0 cubic feet per second

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the SE¼ NW¼, Section 12, Township 5 North, Range 35 East, W. M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to - - - - - - - of one cubic foot per second per acre,

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

SW¼ NW¼,	NE¼ NE¼,
NW¼ SW¼,	Section 11,
SW¼ SW¼,	NW¼ NE¼,
SE¼ SW¼,	SW¼ NE¼,
Section 1,	SE¼ NE¼,
SW¼ NE¼,	NW¼,
SE¼ NE¼,	NE¼ SW¼,
SE¼,	NW¼ SW¼,
Section 2,	SE¼ SW¼,
	SE¼,
	Section 12,

T. 5 N., R. 35 E., W. M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed this 1st day of March, 1949.

CHAS. E. STRICKLIN
State Engineer

Recorded in State Record of Water Right Certificates, Volume 13, page 15548

Well # 2

UMUMAT 3962
3962
OBSERVATION WELL

5N/35-12F(2)
UMATILLA

Application No. U 159
Permit No. U 150
Well No. #2

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Date of Report October 10, , 1945

1. Location of well: SE ¼ of NW ¼ of Section 12 Twp. 5 N Rge. 35E , W. M.
2. Name of nearest natural surface stream Walla Walla River
3. Distance from well to that stream: 1,500 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: ______ feet.
5. Date of beginning drilling or digging May 6, 1944
6. Date well was completed ______

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
Gravel	At surface	ft.
Gravel (cement)	28 ft.	42 ft.
Black Basalt	70 ft.	146 ft.
Brown Rock	216 ft.	14 ft.
Black & Brown Basalt	230 ft.	331 ft.
Gray Basalt	561 ft.	93 ft.
Black & Gray Basalt	654 ft.	67 ft.
Brown Basalt	721 ft.	40 ft.
Red & Gray Rock	761 ft.	4 ft.
~~Remarks~~ Black & Gray Basalt	765 - 902'	137 ft.

Remarks: 902 ' total depth of well. From 230' - 902' static water level was 105'.

WELL INFORMATION

8. Diameter of well ______ inches. Depth of well 902' feet.
9. Depth at which water was first encountered 230 feet.
10. Water level when completed: 105 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.: Water first encountered at 57' depth of well with water level 17' 6" below ground level. Cased out, casing extending to a depth of 99'.

UMAT 3962 Well # 2

5N/35-12 F(2)

UMATILLA

PUMP INFORMATION

12. Manufacturer of pump: Peerless Pump Company - Los Angeles, Calif.
13. Address:
14. Data on name or base plate: Serial No. 24875 Bottom bowls 260' column Size 12" MA. Stage 10., Type head 14B., Suction 10" Standard, Size discharge 10" Std.
15. Data on pump bowl assembly:
16. Size of pump: 12" MA
17. Rated capacity: 1,000 gallons per minute.
18. Rated speed: 1,800 RPM revolutions per minute.
19. Number of stages: 10
20. Size of intake pipe: 12
21. Size of discharge pipe: 10"
22. Length of intake pipe: 260' (Column)
23. Length of discharge pipe: 30'
24. Suction lift: (difference in elevation between water surface in well and pump) 170'
25. Discharge lift: (difference in elevation between pump and end of discharge line) Pumping against 65 lb. main pressure.
26. Depth of pump intake below ground surface: 260' feet.
27. Remarks:

MOTOR OR ENGINE INFORMATION

28. Name of manufacturer: U. S. Electric
29. Address: Los Angeles, Calif.
30. Type of motor or engine: C. F. U.
31. Data on name or base plate: Serial No. 49¢345., HP - 125., RPM - 1800., Frame 984A., Volts 2300., Phase 3., Cycle 60.
32. Rated horsepower: 125
33. Rated speed of motor or engine: 1800 revolutions per minute.
34. Rated Capacity of Pump (with described motor)

1000	g.p.m. at	400	ft. head
	g.p.m. at		ft. head
	g.p.m. at		ft. head
	g.p.m. at		ft. head
	g.p.m. at		ft. head

35. Remarks:

UMAT 3962 Well # 2

5N/35-12 F(2)
UMATILLA
#2

CAPACITY TEST

36. Date of test: 9-21-45 37. Temperature of water 55 °F. or ____ °C.
38. Motor speed during test: 1780 & 1785
39. Test made by (weir, tank or other means): 6" Orifice - calibrated.

40.

Pounds pressure	TOTAL HEAD	*Total lift in feet	Gallons per min.	°Feet to water level	▭ Draw-down	+Time
101 lbs.,	Gauge at pump	Total 178 ft. ___ in.	986	107 ft.	71 ft.	11:30 M. A.M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
60 lbs.,	Gauge at pump	Total 195 ft. ___ in.	1135	107 ft.	88 ft.	1:40A M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
100 lbs.,	Gauge at pump	Total 172 ft. ___ in.	990	107 ft.	65 ft.	1:30P M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.
___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	ft.	M.

* Difference in elevation between water level in well and outlet of pump test line. 107'
° Distance from ground level to water surface in well. 105' Static
▭ Distance water level is lowered during time interval.
\+ Hour and minute at which observation was made.

41. Installation will work efficiently under normal head of 400 ft.
42. Water is discharged into: City water mains.
43. Was water lowered to pump intake by test? Drawn down to depth of 178'
44. Remarks: While running only. Returned to 107' static level when stopped.

GENERAL INFORMATION

45. Name of contractor or other party who drilled or dug well: A. A. Durand & Son
Address: Walla Walla, Wash.
46. Pump and motor were installed by: A. A. Durand & Son under supervision of B.M.Kunes Address: Peerless Pump Co. Los Angeles Calif.
47. Capacity test was made by: B. M. Kunes, Peerless Pump Co.
Address: Los Angeles, Calif.
48. General remarks: ____

Report made by ____________
(sign here)

STATE ENGINEER
Salem, Oregon

UMAT 3962 Well # 2

State Well No. 5N/35-12F(2)

County UMATILLA

Application No.

Water Level Record

OWNER: MILTON FREEWATER OWNER'S NO. #2

Description of measuring point:

Date	Water Level Feet (above) (below) Land Surface	DATE	WATER LEVEL	Date	Water Level Feet (above) (below) Land Surface	DATE	WATER LEVEL
9-21-45	105	11-55	140	10-58	152	2-62	167
9-17-51	132	12	140	3-59	142	3	167
3-54	138	1-56	140	5	152	6	182
4	138	2	142	7	170	8	187
5	135	3	140	8	165	12	183
6	147	5	144	12	165	1-63	176
7	155	6	155	2-60	175	2	178
9	136	7	164	4	160	3	176
10	132	8	155	6	175	4	172
11	135	10	160	7	184	6	197
12	148	10-57	163	11	173	8	202
1-55	136	11	160	12	170	9	203
2	133	12	158	1-61	168	11-18	185
3	134	4-58	165	3	165	12-21	180
4	134	5	166	6	180	1-20-64	178
5	150	7	170	7	175	2-24	175
6	147	8	165	11	170	3-17	175
9	142	9	165	1-62	169	4-27	170

REMARKS:

STATE ENGINEER
Salem, Oregon

UMAT 3962 Well # 2

State Well No. 5N/35-12F(2)

County UMATILLA

Application No.

Water Level Record

OWNER: MILTON-FREEWATER OWNER'S NO. #2

Description of measuring point:

Date	Water Level Feet (above) (below) Land Surface	Remarks	Date	Water Level Feet (above) (below) Land Surface	Remarks
5-25-64	172				
6-22	180				
7-13	195				
8-24	194				
10-26	194				
11-23	188				
12-21	182				

REMARKS:

State Printing 88814

STATE ENGINEER
Salem, Oregon

UMAT 3962 Well # 2

State Well No. 5/35-12F2

County Umatilla

Application No.

Chemical Analysis

OWNER City of Milton-Freewater OWNER'S NO. 2

ANALYST U S G S Address

Date of Collection Nov. 18, 1946

Point of Collection

	P.P.M.	E.P.M.
Silica (SiO_2)		
Iron (Fe) Total	0.0	
Manganese (Mn)		
Calcium (Ca)	17.	
Magnesium (Mg)	7.4	
Sodium (Na)	33.	
Potassium (K)		
Bicarbonate (HCO_3)	104.	
Carbonate (CO_3)		
Sulfate (SO_4)	9.9	
Chloride (Cl)	5.8	
Fluoride (F)	0.3	
Nitrate (NO_3)	0.2	
Boron (B)		
Dissolved Solids	106.	
Hardness as $CaCO_3$	73.	
Specific Conductance (Micromhos at 25°C)	18.	
pH		
Percent Sodium	30.	
Sodium Absorption Ratio (S.A.R.)		
CLASS		

State Printing 66013

UMAT 3962 ——————Well # 2   5N/35-12F(2)

Umatilla

Oregon State Board of Health

SANITARY ENGINEERING LABORATORY

REPORT OF MINERAL ANALYSIS OF WATER

Location of source Milton-Freewater Description of source Well #2

Analysis by [illegible] Date [illegible] Collected by ______ Date 6/25/5[illegible]

RESULTS

Parts per million

Turbidity		[illegible]
Color: Apparent	True	2
Odor: Hot	Cold	
Total Solids		1[illegible]7
Loss on Ignition		63
Silicon (SiO_2)		61
Chloride (Cl)		[illegible].3
Sulfate (SO_4)		3.5
Calcium (Ca)		15
Magnesium (Mg)		10
[illegible]		
[illegible]		
Metaphosphates $(PO_3)_6$		
Alkalinity (as $CaCO_3$): Carbonate		0
Bicarbonate		85
Hardness (as $CaCO_3$)		71
Sodium [illegible] (as Na)		22
Iron (Fe)		.15
Manganese (Mn)		0
Fluoride (F)		.2
Carbon Dioxide (CO_2)		2.3

pH 7.9

Remarks ______

PHE-10

Well No. 3 1/2

Permit A-2-136-1-46

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* MILTON CITY A MUNICIPAL CORPORATION

of Milton *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* Milton City Well No. 3, tributary to Walla Walla River *a tributary of* Columbia River *for the purpose of* municipal use *under Permit No.* U-172 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* January 10, 1946 ;

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 3.50 cubic feet per second

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the NE¼ SE¼, Section 2, Township 5 North, Range 35 East, W. M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to ----- *of one cubic foot per second per acre,*

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

SW¼ NW¼
NW¼ SW¼
SW¼ SW¼
SE¼ SW¼
Section 1
SE¼ NE¼
SW¼ NE¼
NE¼ SE¼
NW¼ SE¼
SW¼ SE¼
SE¼ SE¼
Section 2
NE¼ NE¼
Section 11
NW¼ NE¼
SW¼ NE¼
SE¼ NE¼
NE¼ NW¼
NW¼ NW¼
SW¼ NW¼
SE¼ NW¼
NE¼ SW¼
NW¼ SW¼
SE¼ SW¼
NE¼ SE¼
NW¼ SE¼
SW¼ SE¼
SE¼ SE¼
Section 12
T. 5 N., R. 35 E., W. M.

Well No 3

2/2

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this 28th *day of* February , *19*50 .

CHAS. E. STRICKLIN *State Engineer*

Recorded in State Record of Water Right Certificates, Volume 14 *, page* 16998

STATE ENGINEER
Salem, Oregon

UMAT 3930

OBSERVATION WELL UMAT 3930 Well Record

Well # 3

STATE WELL NO. 5/35-2 dad
COUNTY UMATILLA
APPLICATION NO.

OWNER: Milton-Freewater
MAILING ADDRESS:

LOCATION OF WELL: Owner's No. 3
CITY AND STATE:

¼ ¼ Sec. T. N. S., R. E. W., W.M.

Bearing and distance from section or subdivision corner

Altitude at well 1,010±

Section

TYPE OF WELL: Drilled Date Constructed

Depth drilled 550 Depth cased 100

CASING RECORD:

20-16 inch

FINISH:

AQUIFERS:

Basalt

WATER LEVEL:

50 feet below land surface, June, 1946

PUMPING EQUIPMENT: Type Turbine H.P.
Capacity 1,500 G.P.M.

WELL TESTS:
Drawdown ft. after hours G.P.M.
Drawdown ft. after hours G.P.M.

USE OF WATER Public Supply Temp. °F. , 19
SOURCE OF INFORMATION USGS
DRILLER or DIGGER
ADDITIONAL DATA:
Log X Water Level Measurements Chemical Analysis Aquifer Test

REMARKS:

UMAT 3930 Umatilla 5N/35-2K(D)

237 Well # 3 dad

Oregon State Board of Health

SANITARY ENGINEERING LABORATORY

REPORT OF MINERAL ANALYSIS OF WATER

Location of source Milton-Freewater Description of source Pump 3

Analysis by MHP Date 11/12/52 Collected by Date 6/25/52

RESULTS

	Parts per million
Turbidity	4
Color: Apparent ___ True	3
Odor: Hot ___ Cold	
Total Solids	164
Loss on Ignition	67
Silicon (SiO_2)	59
Chloride (Cl)	9.6
Sulfate (SO_4)	6.2
Calcium (Ca)	18
Magnesium (Mg)	11
Aluminum (Al)	0
Orthophosphates (PO_4)	.07
Metaphosphates $(PO_3)_6$	
Alkalinity (as $CaCO_3$): Carbonate	0
Bicarbonate	88
Hardness (as $CaCO_3$)	81
Sodium ~~and Potassium~~ (as Na)	15
Iron (Fe)	.15
Manganese (Mn)	0
Fluoride (F)	.1
Carbon Dioxide (CO_2)	2.9

pH 7.9

Remarks

PHF-10

STATE ENGINEER
Salem, Oregon

UMAT 3930 Well # 3

State Well No. 5/35-2J(1)

County UMATILLA

Application No.

Water Level Record

OWNER: MILTON FREEWATER OWNER'S NO. #3

Description of measuring point:

Date	Water Level Feet (below) Land Surface	DATE	WATER LEVEL	Date	Water Level Feet (below) Land Surface	Remarks
6-46	50	10-55	80	7-61	83	
2-26-53	78	2-56	82	2-24-64	114	
2-54	98	5	78	3-17	109	
3-15	84	6	92	4-20	108	
3-30	105	7	105	5-18	106	
4	80	8	96	6-19	119	
5	78	11	85	7-6	129	
6	85	12	95	9-21	133	
8	90	1-57	88	10-26	132	
10-10	90	2	88	11-23	123	
10-30	86	3	84	12-21	116.6	
2-55	78	5-58	99			
3	78	10	98			
4	75	11	90			
5	78	12	86			
6	90	3-59	80			
8	92	5	90			
9	85	4-61	99			

REMARKS:

State Printing 89314

UMAT 3930

RECEIVED
DEC 30 1946
STATE ENGINEER
SALEM OREGON

Well # 3

5N/35-2J(1)
UMATILLA

dad

Milton Freewater

Application No. U 191
Permit No. U 172
Well No. 3

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Date of Report December 28, 1946

1. Location of well: N.E.1/4 of S.E1/4 of Section 2 Twp. 5 Rge. 35 E, W. M.
2. Name of nearest natural surface stream Walla Walla River
3. Distance from well to that stream: 2670 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: ______ feet.
5. Date of beginning drilling or digging January 27, 1946
6. Date well was completed June 1, 1946

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
Gravel	At surface	40 ft.
Solid Rock	40 ft.	3 ft.
Black Basalt	43 ft.	133 ft.
Crevice and green shale	176 ft.	1 ft.
Black Basalt	177 ft.	62 ft.
Brown Rock	239 ft.	10 ft.
Black Basalt	249 ft.	14 ft.
Brown Rock	263 ft.	24 ft.
Black Basalt	287 ft.	201 ft.
Loose Gray Stone	488 ft.	3 ft.
Hard Black Basalt	491 ft.	47 ft.
Black Porous Rock	538 ft.	12 ft.

Remarks: Some Crevices at 209-218 feet; brown rock caved at 285 feet.

WELL INFORMATION

8. Diameter of well 16" I.D. inches. Depth of well 550 feet.
9. Depth at which water was first encountered 60 feet.
10. Water level when completed: 50 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.: 20" casing to depth of 43 feet. 16" casing inside of 20" and to depth of 100 feet below surface. Cement seal between 20" and 16" casing at 40-43 feet. Balance filled with cuttings.

NC

Well # 3

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the STATE ENGINEER, SALEM, OREGON 97310 within 30 days from the date of well completion.

RECEIVED
MAR 10 1969
STATE ENGINEER
SALEM, OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

UMAT 3924

State Well No. 5N/35-2da
State Permit No. 6172

(1) OWNER:
Name MILTON CITY ORE.
Address MILTON FREEWATER ORE.

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☐ Reconditioning ☒ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

CASING INSTALLED: Threaded ☐ Welded ☐
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

PERFORATIONS: Perforated? ☐ Yes ☐ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☐ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WATER LEVEL: Completed well.
Static level 130 ft. below land surface Date 1-27-69
...esian pressure lbs. per square inch Date

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " "
" " "
Bailer test 180 gal./min. with 8 ft. drawdown after 8 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ☐ Yes ☒ No

(10) CONSTRUCTION:
Well seal—Material used CEMENT - BENTONITE
Depth of seal 105 ft.
Diameter of well bore to bottom of seal 16 in.
Were any loose strata cemented off? ☐ Yes ☒ No Depth
Was a drive shoe used? ☐ Yes ☐ No
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(11) LOCATION OF WELL:
County UMATILLA Driller's well number
NE ¼ SE ¼ Section 2 T. 5 R. 35 EAST W.M.
Bearing and distance from section or subdivision corner

(12) WELL LOG: Diameter of well below casing 16
Depth drilled 575 ft. Depth of completed well 575 ft. OK

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level as drilling proceeds. Note drilling rates.

MATERIAL	From	To	SWL
BLACK BASALT	535	575	40

Work started 12-19 1960 Completed 2-4 1969
Date well drilling machine moved off of well 2-4 1969

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] William H. Jung... (Drilling Machine Operator) Date 2-4, 1969
Drilling Machine Operator's License No. 230

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME CHARLES JUNGMANN DRILLING CO. (Person, firm or corporation) (Type or print)
Address 105 REES AVE. W. W. WASH.
[Signed] Charles Jungmann (Water Well Contractor)
Contractor's License No. 236 Date 2-24, 1969

(USE ADDITIONAL SHEETS IF NECESSARY)

23533

RECEIVED
APR 8 1955
STATE ENGINEER
SALEM, OREGON

Permit No. U-718

APPLICATION FOR A PERMIT

To Appropriate the Underground Waters of the State of Oregon

I, Milton-Freewater (Name of applicant)

of Milton-Freewater (Postoffice), county of Umatilla,

state of Oregon, do hereby make application for a permit to appropriate the following described underground waters of the state of Oregon, SUBJECT TO EXISTING RIGHTS:

If the applicant is a corporation, give date and place of incorporation

Milton-Freewater, Oregon January 1, 1951

1. Give name of nearest stream to which the well, tunnel or other source of water development is situated Little Walla Walla River (Name of stream)

tributary of Columbia River

2. The amount of water which the applicant intends to apply to beneficial use is 2.7 cubic feet per second.

3. The use to which the water is to be applied is Domestic and Commercial

4. The place where the water is to be pumped or developed is located 2" Iron Pipe is N 32° - 2' E 365.5 ft. 317.5 of 1/4 corner between sections 1 & 2 T 5 N. R. 35 EWM (Give distance and bearing from section corner)
2" pipe is S. 50° - 35' W. of well in S.W. ¼ of N.W. ¼ sec. 1 Twp. 5NR. 35 EWM
S.W. ¼

being within the of Sec. , Twp , R.

W. M., in the county of Umatilla

5. The (Canal or pipe line) to be miles in length, terminating in the (Smallest legal subdivision) of Sec. , Twp. R. , W. M., the proposed location being shown throughout on the accompanying map.

6. The name of the well or other works is Well No. 5

DESCRIPTION OF WORKS

7. If the flow to be utilized is artesian, the works to be used for the control and conservation of the supply when not in use must be described.

8. The development will consist of one well (Give number of wells, tunnels, etc.) having a diameter of 8" O.D. Pipe inches and an estimated depth of 502 feet.

This well pumps directly into the water system.

WELL NO. 5 PAGE 2 OF 5

U-718

CANAL SYSTEM OR PIPE LINE—

9. (a) *Give dimensions at each point of canal where materially changed in size, stating miles from headgate. At headgate: width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(b) *At* .... *miles from headgate: width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(c) *Length of pipe,* .... *ft.; size at intake,* .... *in.; in size at* .... *ft. from intake* .... *in.; size at place of use* .... *in.; difference in elevation between intake and place of use,* .... *ft. Is grade uniform?* .... *Estimated capacity,* .... *sec. ft.*

10. *If pumps are to be used, give size and type* Peerless turbine [redacted] 1200 G.P.M.

Give capacity and type of motor or engine to be used 150 H.P. U.S. Motor

11. *If the location of the well, tunnel, or other development work is less than one-fourth mile from a natural stream or stream channel, give the distance to be the nearest point on each of such channels and the difference in elevation between the stream bed and the ground surface at the source of development*

35 feet to Little Walla Walla River (no difference in elevation)

Little Walla Walla River in reality is a power canal to operate flour mill

12. *Location of area to be irrigated, or place of use* Water system of former City of Freewater

Township	Range	Section	Forty-acre Tract	Number Acres To Be Irrigated
5 N	WILLAMETTE MERIDIAN 35 EWM	1	N.W. ¼ of N.W. ¼	
			S.W. ¼ of N. W. ¼	
			N½ of N.E. ¼ of S.W. ¼	
5 N	35 EWM	2	N/E ¼ of N.W. ¼	
			S.E. ¼ of N.W. ¼	
			N.E. ¼ of N.E. ¼	
			N.W. ¼ of N.E. ¼	
			S.W. ¼ of N.E. ¼	
			S.E. ¼ of N.E. ¼	

(If more space required, attach separate sheet)

(a) *Character of soil* ....

(b) *Kind of crops raised* ....

MUNICIPAL SUPPLY—

13. (a) *To supply the city of* To supply portion of City of Milton-Freewater

Umatilla (Name of) *county, having a present population of* 3851

and an estimated population of .... *in* 1950

U-718

Appraised value

14. Estimated cost of proposed works, $ [illegible]

15. Construction work will begin on or before Completed in 1936

16. Construction work will be completed on or before

17. The water will be completely applied to the proposed use on or before This well has been in operation since 1936.

Robert L. Bunton
(Signature of applicant)

City Manager

Remarks: In Item 2, the amount requested is slightly higher than we are now using because some time in the future we may want to put in larger pumps. This was accomplished in June 1954 and the above notes are the status of the present setting.

In case you do not have the log of this well, below is a copy:

Well #5 Drilled by A. A. Durand & Son 1936

Altitude of top of ground above sea level 995

Log

Recent alluvium and old gravel

	Thickness Ft.	Depth Ft.
Soil	3	3
Gravel, loose	77	80
Clay	10	90
Boulders & Gravel	45	135
Clay & Sand	10	145
Gravel & Loose Boulders	15	160
Basalt Black, Hard	85	245
Basalt Red, Porous	45	290
Basalt Blue, Black	115	405
Basalt Red	30	435
Basalt Black Water Bearing	67	502

Casing 18" set to 40 ft.
12" set to 172 ft.

STATE OF OREGON,
County of Marion, } ss.

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for ....

In order to retain its priority, this application must be returned to the State Engineer, with corrections on or before ...., 19.....

WITNESS my hand this .... *day of* ...., 19.....

STATE ENGINEER

STATE OF OREGON, }
County of Marion, } ss.

PERMIT

This is to certify that I have examined the foregoing application and do hereby grant the same, SUBJECT TO EXISTING RIGHTS and the following limitations and conditions:

The right herein granted is limited to the amount of water which can be applied to beneficial use and shall not exceed 2.70 cubic feet per second measured at the point of diversion from the well or source of appropriation, or its equivalent in case of rotation with other water users, from Well No. 5

The use to which this water is to be applied is [redacted] municipal

If for irrigation, this appropriation shall be limited to - - - - of one cubic foot per second

and shall be subject to such reasonable rotation system as may be ordered by the proper state officer.

The well shall be so cased as to prevent the loss of underground water.

The priority date of this permit is April 13, 1955.

Actual construction work shall begin on or before July 20, 1956 and shall thereafter be prosecuted with reasonable diligence and be completed on or before October 1, 1957

Complete application of the water to the proposed use shall be made on or before October 1, 1958

WITNESS my hand this 20th day of July, 19 55.

Lewis A. Stanley
STATE ENGINEER

Application No. U-809
Permit No. U-718

PERMIT
TO APPROPRIATE THE UNDERGROUND WATERS OF THE STATE OF OREGON

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 13th day of April 1955, at 1:00 o'clock P. M.

Returned to applicant:

Corrected application received:

Approved:
July 20, 1955

Recorded in book No. 3 of Permits on page U-718

LEWIS A. STANLEY STATE ENGINEER

Drainage Basin No. 7 Page 24C

Fees Paid $24.00

State Printing Dept 2118

WELL NO. 5

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* CITY OF MILTON-FREEWATER

of Milton-Freewater, *State of* Oregon, *has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* Well No. 5 *a tributary of* Little Walla Walla River, trib. of Columbia River *for the purpose of* municipal *under Permit No.* U-718 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* April 13, 1955;

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 2.70 cubic feet per second

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the SW¼SW¼NW¼, Section 1, Township 5 North, Range 35 East, W.M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to - - - - - - - - - *of one cubic foot per second per acre,*

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

NW¼NW¼
SW¼NW¼
N½ NE¼SW¼
Section 1
NE¼NW¼
SE¼NW¼
NE¼NE¼
NW¼NE¼
SW¼NE¼
SE¼NE¼
Section 2
Township 5 North, Range 35 East, W.M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this 20th *day of* December, 1957.

LEWIS A. STANLEY
State Engineer

Recorded in State Record of Water Right Certificates, Volume 17, *page* 23533.

Well # 5

STATE ENGINEER
Salem, Oregon

UMAT 3909

Well Record

STATE WELL NO. 5N/35-1E(2)
COUNTY Umatilla
APPLICATION NO. U- 809

OWNER: City of Milton-Freewater

MAILING ADDRESS:

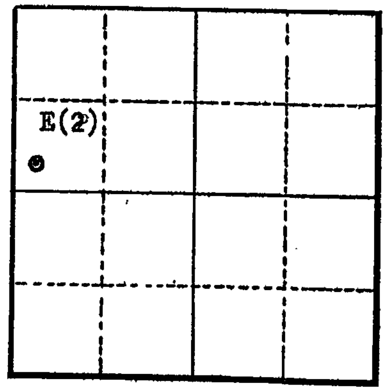
LOCATION OF WELL: Owner's No. 5

CITY AND STATE: Milton-Freewater, Oregon

SW ¼ NW ¼ Sec. 1 T. 5 N., R. 35 E., W.M.

Bearing and distance from section or subdivision corner N. 32°2'E. 365.5' from W¼ cor. of sec. 1 to a 2" iron pipe, thence S.50°35'W. 31.5' to the well.

Altitude at well 995'



Section 1

TYPE OF WELL: Drilled Date Constructed 1936

Depth drilled 502' Depth cased 212'

CASING RECORD:

18 inch set from 0 to 40 feet
12 inch set from 40 to 212 feet

FINISH:

AQUIFERS:

Basalt from 435 to 502 feet

WATER LEVEL:

67 feet (10/5/54)
120 feet (5/1/57)

PUMPING EQUIPMENT: Type Peerless turbine H.P. 150
Capacity 1200 G.P.M.

WELL TESTS:

Drawdown 47 ft. after ______ hours 750 G.P.M.
Drawdown ______ ft. after ______ hours ______ G.P.M.

USE OF WATER Municipal Temp. ______ °F. ______, 19____
SOURCE OF INFORMATION USGS U-718
DRILLER or DIGGER A.A. Durand & Son

ADDITIONAL DATA:

Log X Water Level Measurements X Chemical Analysis ______ Aquifer Test ______

REMARKS:

STATE ENGINEER
Salem, Oregon

Well # 5

State Well No. 5N/35-1E(2)
County UMATILLA
Application No. U801

Well Log

Owner: Milton-Freewater Owner's No. 5

Driller: A.A. Durand & Son Date Drilled 1936

CHARACTER OF MATERIAL	(Feet below land surface) From	To	Thickness (feet)
Soil	0	3	3
Gravel and boulders, partly cemented & partly loose	3	80	77
Clay	80	90	10
Bowlders and gravel	90	135	45
Clay and sand	135	145	10
Gravel and bowlders, loose	145	160	15
Basalt, black, hard	160	245	85
Basalt, red porous	245	290	45
Basalt, blue and black hard	290	405	115
Basalt, red	405	435	30
Basalt, black, water bearing	435	502	67

Umatilla Well # 5 5N/35-1E(2)

Oregon State Board of Health
SANITARY ENGINEERING LABORATORY

REPORT OF MINERAL ANALYSIS OF WATER

Location of source Milton-Freewater Description of source Pump #5

Analysis by MHP Date 11/12/54 Collected by Date 6/25/54

RESULTS

	Parts per million
Turbidity	2
Color: Apparent ___ True	3
Odor: Hot ___ Cold	
Total Solids	149
Loss on Ignition	58
Silicon (SiO_2)	48
Chloride (Cl)	7.6
Sulfate (SO_4)	3.7
Calcium (Ca)	15
Magnesium (Mg)	6.5
Aluminum (Al)	0
Orthophosphates (PO_4)	.15
Metaphosphates $(PO_3)_6$	
Alkalinity (as $CaCO_3$): Carbonate	0
Bicarbonate	70
Hardness (as $CaCO_3$)	65
Sodium (as Na)	14
Iron (Fe)	.13
Manganese (Mn)	0
Fluoride (F)	.1
Carbon Dioxide (CO_2)	2.3

pH 7.8

Remarks

PHE-10

STATE ENGINEER
Salem, Oregon

State Well No. 5N/35-1E(2)

County UMATILLA

Well # 5

Application No. U-809

Water Level Record

OWNER: MILTON-FREEWATER OWNER'S NO.

Description of measuring point: MOUNT HOLE ON NE CORNER OF WELL 1.5' ABOVE L.S.D.

Date	Water Level Feet (above) (below) Land Surface	Remarks	Date	Water Level Feet (above) (below) Land Surface	Remarks DATE	WATER LEVEL
11-9-61	101.21	RD & WSB	1-56	80	3-58	95
5-54	65		2	74	4	95
6	83		3	80	7	102
8	85		4	82	8	100
9	67		5	78		
10	73		10	89		
11	76		11	80		
12	72		12	80		
1-55	75		1-57	80		
2	70		2	81		
3	70		3	76		
4	68		4	80		
5	71		9	102		
8	86		10	98		
9	76		11	95		
10	74		12	86		
11	74		1-58	95		
12	82		2	95		

REMARKS:

State Printing 89314

23519

Permit No. U-2372

APPLICATION FOR A PERMIT

To Appropriate the Underground Waters of the State of Oregon

I, City of Milton-Freewater, Oregon (Name of applicant)

of Milton (Postoffice), county of Umatilla

state of Oregon, do hereby make application for a permit to appropriate the following described underground waters of the state of Oregon, SUBJECT TO EXISTING RIGHTS:

If the applicant is a corporation, give date and place of incorporation Charter Milton-Freewater January 1, 1951

1. Give name of nearest stream to which the well, tunnel or other source of water development is situated Walla Walla River (Name of stream) tributary of Columbia River

2. The amount of water which the applicant intends to apply to beneficial use is 3.5 cubic feet per second.

3. The use to which the water is to be applied is City Water Supply (Domestic and Industrial)

4. The place where the water is to be pumped or developed is located 2" I.P. = S 86° 44' W - 527. feet from center Section 2 Twp 5 N. Range 35 EWM and Well is S. 22° 37' E. - 39 from Iron Pipe (Give distance and bearing from section corner)

being within the N.E. ¼ of S.W. ¼ of Sec. 2 Twp. 5 N R. 35 E. W. M., in the county of Umatilla

5. The 8" Pipe Line (Canal or pipe line) to be 15 feet [illegible] in length, terminating in the N.E. ¼ of S.W. ¼ (Smallest legal subdivision) of Sec. 2 Twp. 5 N R. 35 E, W. M., the proposed location being shown throughout on the accompanying map.

6. The name of the well or other works is Milton-Freewater Well No. 6

DESCRIPTION OF WORKS

7. If the flow to be utilized is artesian, the works to be used for the control and conservation of the supply when not in use must be described.

8. The development will consist of one (Give number of wells, tunnels, etc.) having a diameter of 12 inches and an estimated depth of 952 feet

([illegible] in size, stating miles from [illegible]) .... feet; width on bottom .... depth of water .... [illegible] .... feet fall per one

.... miles from headgate: width on top (at water line) .... feet; width on bottom .... feet; depth of water .... feet; .... feet fall per one thousand feet.

(d) Length of pipe, ... ft.; size at intake, ... in.; in size at .... ft. from intake .... in.; size at place of use .... in.; difference in elevation between intake and place of use, ... ft. Is grade uniform? .... Estimated capacity, ... sec. ft.

10. If pumps are to be used, give size and type Cook Deep Well Turbine Pump - 7 stages; 2" shaft; 150 feet of 10" Column J 1300 GPM 305 Ft.

Give capacity and type of motor or engine to be used 125 HP General Electric Motor - 220/440

11. If the location of the well, tunnel, or other development work is less than one-fourth mile from a natural stream or stream channel, give the distance to be the nearest point on each of such channels and the difference in elevation between the stream bed and the ground surface at the source of development

12. Location of area to be irrigated, or place of use in water system of former city of Freewater

Township	Range	Section	Forty-acre Tract	Number Acres To Be Irrigated
5 N	35 EWM	1	N.W. ¼ of N. W. ¼	
			S.W. ¼ of N.W. ¼	
			N½ of N. E. ¼ of S.W.¼	
		2	N.E. ¼ of N.W. ¼	
			S.E. ¼ of N.W.¼	
			N.E. ¼ of N.E. ¼	
			N.W. ¼ of N.E. ¼	
			S.W. ¼ of N.E. ¼	
			S.E. ¼ of N. E.¼	

(If more space required, attach separate sheet)

(a) Character of soil ....

(b) Kind of crops raised ....

MUNICIPAL SUPPLY—

13. (a) To supply the city of Milton-Freewater

Umatilla (Name of) county, having a present population of 3851

and an estimated population of .... in 19........

... on or before ___ Well Drilled in 1950

... will be completed on or before ___ Pump installations, July, 1952

The water will be completely applied to the proposed use on or before ___ March 1, 1952

City of Milton-Freewater
by: Robert L. [illegible]
Robert L. Brunton
City Manager

Remarks: This well was drilled by the former City of Freewater in 1950 and abandoned as being dry. The City of Milton-Freewater has been running test on this well for sometime and has found an adequate water supply. The water was tested by the State and found to conform to standards of purity for drinking water. However, the well is now in the process of being sealed off.

STATE OF OREGON, }
County of Marion, } ss.

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for ....

In order to retain its priority, this application must be returned to the State Engineer, with corrections on or before ...., 19 ....

WITNESS my hand this .... *day of* ...., 19 ....

STATE ENGINEER

... that I have examined the foregoing application and do hereby grant the same, ... RIGHTS and the following limitations and conditions:

... right herein granted is limited to the amount of water which can be applied to beneficial use and ... not exceed 3.50 cubic feet per second measured at the point of diversion from the well or ... of appropriation, or its equivalent in case of rotation with other water users, from Milton-Freewater ... No. 6

The use to which this water is to be applied is municipal

If for irrigation, this appropriation shall be limited to - - - - - of one cubic foot per second

and shall be subject to such reasonable rotation system as may be ordered by the proper state officer.

The well shall be so cased as to prevent the loss of underground water.

The priority date of this permit is July 16, 1952

Actual construction work shall begin on or before August 29, 1953 and shall thereafter be prosecuted with reasonable diligence and be completed on or before October 1, 1954

Complete application of the water to the proposed use shall be made on or before October 1, 1955

WITNESS my hand this 29th day of August, 1952

Chas E Stricklin
STATE ENGINEER

Application No. U-571

Permit No. U-462

PERMIT
TO APPROPRIATE THE UNDERGROUND WATERS OF THE STATE OF OREGON

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 16th day of July, 1952, at 1:00 o'clock P. M.

Returned to applicant:

Corrected application received:

Approved:
August 29, 1952

Recorded in book No. 2 of Permits on page 462

CHAS. E. STRICKLIN
STATE ENGINEER

Drainage Basin No. 7 Page [illegible]

Fees Paid $26.00

State Printing Dept.

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* CITY OF MILTON-FREEWATER

of Milton-Freewater *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* Milton-Freewater Well No. 6 *a tributary of* Walla Walla River *for the purpose of* municipal *under Permit No.* U-462 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* July 16, 1952 *;*

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 3.50 cubic feet per second

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the NE¼SW¼, Section 2, Township 5 North, Range 35 East, W.M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to - - - - - - - - - *of one cubic foot per second per acre,*

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

NW¼NW¼
SW¼NW¼
N½NE¼SW¼
Section 1
NE¼NW¼
SE¼NW¼
NE¼NE¼
NW¼NE¼
SW¼NE¼
SE¼NE¼
Section 2
Township 5 North, Range 35 East, W.M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this 20th *day of* December *, 19*57.

LEWIS A. STANLEY *State Engineer*

Recorded in State Record of Water Right Certificates, Volume 17 *, page* 23519.

STATE ENGINEER
Salem, Oregon

UMAT 3929

OBSERVATION WELL
UMAT 3929
Well Record
Well # 6

STATE WELL NO. 5N/35-2L1
COUNTY Umatilla
APPLICATION NO. U-511

OWNER: City of Milton Freewater
MAILING ADDRESS: Milton Freewater
CITY AND STATE:

LOCATION OF WELL: ~~Owner's No. 6~~

NE ¼ SW ¼ Sec. 2 T. 5 N. ~~S.~~, R. 35 E. ~~W.~~, W.M.

Bearing and distance from section or subdivision corner

Altitude at well

Section 2

TYPE OF WELL: Drilled Date Constructed 12-22-50
Depth drilled 952' Depth cased 61'

CASING RECORD:
16 inch
12 inch

FINISH:

AQUIFERS:
Basalt

WATER LEVEL:
71' (12-22-50)

PUMPING EQUIPMENT: Type Cook H.P. 125
Capacity 1500 G.P.M.

WELL TESTS:
Drawdown ft. after hours G.P.M.
Drawdown ft. after hours G.P.M.

USE OF WATER Municipal Temp. °F. , 19
SOURCE OF INFORMATION U-511
DRILLER or DIGGER Geo. Scott
ADDITIONAL DATA:
Log ✓ Water Level Measurements ✓ Chemical Analysis ✓ Aquifer Test
REMARKS:

STATE ENGINEER
Salem, Oregon

UMAT 3929

Well # 6

State Well No. 5N/35-2L (1) caa

County UMATILLA

Application No.

Water Level Record

OWNER: MILTON FREEWATER OWNER'S NO. #6

Description of measuring point:

Date	Water Level Feet (below) Land Surface	DATE	WATER LEVEL	Date	Water Level Feet (below) Land Surface	Remarks
4-54	78	5 57	76	6-60	95	
10	95	9	82	8	85	
11	88	10	80	10	82	
12	85	11	72	3-61	97	
1-55	85	12	78	4	95	
2	82	1-58	80	11	100	
3	82	4	74	12	95	
4	78	9	85	1-62	100	
5	74	4-59	97	2-	98	
7	82	8	88	9	110	
12	86	9	85	11	105	
1-56	80	10	85	12	105	
2	76	11	84	1-63	100	
3	76	12	85	2	98	
4	73	1-60	87	5	110	
5	70	2	80	6	113	
8	80	3	100	8	119	
9	74	4	92			

REMARKS:

State Printing 89314

Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Well # 6

Date of Report Oct 7, 1952

1. Location of well: N.E.¼ - SW¼ of Section 2 Twp. 5N. Rge. 35 EW. M.
2. Name of nearest natural surface stream Little Walla Walla River
3. Distance from well to that stream: 3200 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: ______ feet.
5. Date of beginning drilling or digging. Aug. 11 1950
6. Date well was completed Dec. 22 1950

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
~~Soil & Dirty Gravel~~	At surface	6 ft.
Soil & Dirty Gravel	~~55~~ 6 ft.	55 ft.
Basalt (Broken)	55 ft.	20 ft.
" Black (Water 81)	81 ft.	120 ft.
" " Creviced	201 ft.	13 ft.
" Broken	214 ft.	63 ft.
" Broken - Yellow Clay	277 ft.	19 ft.
" Clean - Hard	296 ft.	55 ft.
" Broken Fault Zone Mat'l	351 ft.	601 ft.

Remarks:
Depth 952

WELL INFORMATION

8. Diameter of well ______ inches. Depth of well 952 feet.
9. Depth at which water was first encountered ______ feet.
10. Water level when completed: ~~71~~ 71 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.:

39. Test made by (weir, tank or other means): *Open Pipe.* Well # 6

40.

Pounds pressure	TOTAL HEAD	*Total lift in feet		Gallons per min.	°Feet to water level	¤Draw-down	+Time
0 lbs.,	Gauge at pump	Total 0 ft.	in.	0	71 ft.	0 ft.	0 M.
33 lbs.,	Gauge at pump	Total 79.5 ft.	in.	515	77.5 ft.	6.5 ft.	45 M.
36 lbs.,	Gauge at pump	Total 85.3 ft.	in.	840	83.3 ft.	12.3 ft.	30 M.
44 lbs.,	Gauge at pump	Total 102.6 ft.	in.	1410	100.6 ft.	29.6 ft.	240 M.
43 lbs.,	Gauge at pump	Total 101.5 ft.	in.	1400	99.5 ft.	28.5 ft.	15 M.
42 lbs.,	Gauge at pump	Total 101.0 ft.	in.	985	99.0 ft.	28.0 ft.	15 M.
37 lbs.,	Gauge at pump	Total 88.75 ft.	in.	565	87.0 ft.	16 ft.	15 M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.
lbs.,	Gauge at pump	Total ft.	in.		ft.	ft.	M.

* Difference in elevation between water level in well and outlet of pump test line.
° Distance from ground level to water surface in well.
¤ Distance water level is lowered during time interval.
\+ Hour and minute at which observation was made.

41. Installation will work efficiently under normal head of *56* ft.

42. Water is discharged into: *Reservoir via 8" discharge main*

43. Was water lowered to pump intake by test? *(?)*

44. Remarks: *In the installation we have head was 56 ft for 24 hrs.*

GENERAL INFORMATION

45. Name of contractor or other party who drilled or dug well: *George Scott* Address: *Milton-Freewater*

46. Pump and motor were installed by: *Pump, Pipe & Power Co* Address: *Box 7762 Portland Oregon*

47. Capacity test was made by: *Pump, Pipe & Power Co. (C. Garbe)* Address: *Box 7762 Portland Oregon*

48. General remarks:

13. Address: ~~301 W. Avenue 26~~ Los Angeles (31) Calif.

14. Data on name or base plate:

Well # 6

15. Data on pump bowl assembly:

16. Size of pump: 12"

17. Rated capacity: 1500 gallons per minute.

18. Rated speed: 1750 revolutions per minute.

19. Number of stages: 7

20. Size of intake pipe: 8

21. Size of discharge pipe: 10

22. Length of intake pipe: 20

23. Length of discharge pipe: 150

24. Suction lift: (difference in elevation between water surface in well and pump) 79

25. Discharge lift: (difference in elevation between pump and end of discharge line) 150

26. Depth of pump intake below ground surface: 177 feet.

27. Remarks:

MOTOR OR ENGINE INFORMATION

28. Name of manufacturer: General Electric Co

29. Address: Schenectady N.Y.

30. Type of motor or engine: K Code F.

31. Data on name or base plate:
Frame 505 P 3 Phase 440 Volt.
60 C.Y. Fl. Amp. 150
50 C.Y. Fl. Amp 162

32. Rated horsepower: 125

33. Rated speed of motor or engine: 1760 revolutions per minute.

34. Rated Capacity of Pump (with described motor)

____ g.p.m. at	____ ft. head
____ g.p.m. at	____ ft. head
____ g.p.m. at	____ ft. head
____ g.p.m. at	____ ft. head
____ g.p.m. at	____ ft. head

35. Remarks:

NO... WATER WELL CONTRACTOR: ...e original and first copy ...f this report are to be filed with the STATE ENGINEER, SALEM, OREGON 97310 within 30 days from the date of well completion.

RECEIVED APR 6 - 1972 STATE ENGINEER SALEM, OREGON

NC

Well # 6

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

UMAT 3923

State Well No. 5N/35-2ca

State Permit No. U-462

(1) OWNER:
Name City of Milton FREEWATER
Address PO. Box 108 Milton Frwtr. ORE 97862

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☐ Reconditioning ☒ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

CASING INSTALLED: Threaded ☐ Welded ☒
12" Diam. from +1 ft. to 232 ft. Gage .280
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

PERFORATIONS: Perforated? ☐ Yes ☒ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS: Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom?
Yield: 1500 gal./min. with 145 ft. drawdown after 10 hrs.
" " "
" " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 60° Depth artesian flow encountered ft.

(9) CONSTRUCTION:
Well seal—Material used 12" CASING, CEMENT
Well sealed from land surface to 232' ft.
Diameter of well bore to bottom of seal 12 in.
Diameter of well bore below seal 12 in.
Number of sacks of cement used in well seal 250 sacks
Number of sacks of bentonite used in well seal sacks
Brand name of bentonite
Number of pounds of bentonite per 100 gallons of water lbs./100 gals.
Was a drive shoe used? ☒ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL:
County Umatilla Driller's well number
NE ¼ SW ¼ Section 2 T. 5N R. 35 E W.M.
Bearing and distance from section or subdivision corner
~~[struck out]~~
S86°44'W 527' From Ctr. Sec.

(11) WATER LEVEL: Completed well.
Depth at which water was first found ft.
Static level 187 ft. below land surface. Date 2-29-72
Artesian pressure lbs. per square inch. Date

(12) WELL LOG: Diameter of well below casing 12
Depth drilled 915 ft. Depth of completed well 915 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. *Report each change in position of Static Water Level and indicate principal water-bearing strata.*

MATERIAL	From	To	SWL
SEE PREVIOUS LOG			

Work started 12-6 1971 Completed 2-29 1972
Date well drilling machine moved off of well 2-25 1972

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] [signature] Date 3-30 1972
(Drilling Machine Operator)
Drilling Machine Operator's License No. 361

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name CHARLES JUNGMANN DRILLING CO
(Person, firm or corporation) (Type or print)
Address 115 REES AVE. W. W. WASH.
[Signed] [signature]
(Water Well Contractor)
Contractor's License No. 236 Date 3-30, 1972

(USE ADDITIONAL SHEETS IF NECESSARY)

SP*45656-119

41311

N... 1962

Permit No. G- 2312

APPLICATION FOR A PERMIT

To Appropriate the Ground Waters of the State of Oregon

I, City of Milton-Freewater, a municipal corporation (Name of applicant)

of Box 108 Milton-Freewater (Postoffice Address), county of Umatilla,

state of Oregon, do hereby make application for a permit to appropriate the following described ground waters of the state of Oregon, SUBJECT TO EXISTING RIGHTS:

If the applicant is a corporation, give date and place of incorporation

December 27, 1950 at Milton-Freewater, Oregon

1. Give name of nearest stream to which the well, tunnel or other source of water development is situated Walla Walla River (Name of stream)

tributary of Columbia River

2. The amount of water which the applicant intends to apply to beneficial use is 6.6 cubic feet per second or 3000 gallons per minute.

3. The use to which the water is to be applied is Municipal Supply

4. The well or other source is located ... ft ... (N or S) and ... ft. ... (E or W) from the ... corner of ... (Section or subdivision)

The well lies N. 33°35' East a distance of 2143' from the S. W. corner (If preferable, give distance and bearing to section corner)

of Section 18, Township 5 North, Range 36 East of Willamet Meridian. (If there is more than one well each must be described. Use separate sheet if necessary)

being within the S. W. ¼ (NW¼ SW¼) of Sec. 18, Twp. 5 N., R. 36 E., W. M., in the county of Umatilla

5. The Pipeline (Canal or pipe line) to be 3.9 miles in length, terminating in the S. W. ¼ of S. E. ¼ (Smallest legal subdivision) of Sec. 12, Twp. 5N., R. 35 E., W. M., the proposed location being shown throughout on the accompanying map.

6. The name of the well or other works is Milton-Freewater Well No.8

DESCRIPTION OF WORKS

7. If the flow to be utilized is artesian, the works to be used for the control and conservation of the supply when not in use must be described.

Capped well with discharge tee and gate valve

8. The development will consist of a well (Give number of wells, tunnels, etc.) having a diameter of 16 inches and an estimated depth of 1000 feet. It is estimated that 30 feet of the well will require Steel (Kind) casing. Depth to water table is estimated 10 (Feet)

G-2312

CANAL SYSTEM OR PIPE LINE—

9. *(a) Give dimensions at each point of canal where materially changed in size, stating miles from headgate. At headgate: width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(b) At .... *miles from headgate: width on top (at water line)* .... *feet; width on bottom* .... *feet; depth of water* .... *feet; grade* .... *feet fall per one thousand feet.*

(c) Length of pipe, 4800 *ft.; size at intake,* 12" *in.; in size at* 2500 *ft. from intake* 12 *in.; size at place of use* 12 *in.; difference in elevation between intake and place of use,* 165 *ft. Is grade uniform?* Approximate *Estimated capacity,* 8 *sec. ft.*

10. *If pumps are to be used, give size and type* 3000 GPM vertical turbine

Give horsepower and type of motor or engine to be used 150 HP VHS squirrel cage electric

11. *If the location of the well, tunnel, or other development work is less than one-fourth mile from a natural stream or stream channel, give the distance to the nearest point on each of such channels and the difference in elevation between the stream bed and the ground surface at the source of development*

100 ft. from channel or Walla Walla River. Stream bed is approximately 10 ft. below elevation of ground at well site.

12. *Location of area to be irrigated, or place of use* City of Milton-Freewater

Township N. or S.	Range E. or W. of Willamette Meridian	Section	Forty-acre Tract	Number Acres To Be Irrigated
5 North	35 East	1, 2, 11, 12		2500
		1	NW¼ and SW¼	municipal
		2	NE¼ and SE¼	"
			E½ NW¼	"
			NE¼ SW¼	"
		11	NE¼ NE¼	"
		12	W½ NE¼	"
			NW¼	"
			E½ SW¼	"
			NW¼ SW¼	"
			SE¼	"

(If more space required, attach separate sheet)

Character of soil gravel

Kind of crops raised ....

G- 2312

MUNICIPAL SUPPLY—

13. To supply the city of Milton-Freewater

in Umatilla county, having a present population of 4110 per 1960 census

and an estimated population of 5654 in 1980

ANSWER QUESTIONS 14, 15, 16, 17 AND 18 IN ALL CASES

14. Estimated cost of proposed works, $50,000

15. Construction work will begin on or before July 1, 1963

16. Construction work will be completed on or before July 1, 1964

17. The water will be completely applied to the proposed use on or before July 1, 1964

18. If the ground water supply is supplemental to an existing water supply, identify any application for permit, permit, certificate or adjudicated right to appropriate water, made or held by the applicant. Permit #7830, #2391 - Well Permits: U-462, U-150, U-717, U-718 U-102, U-172.

(Signature of applicant) City Recorder

Remarks:

STATE OF OREGON,
County of Marion, } ss.

This is to certify that I have examined the foregoing application, together with the accompanying maps and data, and return the same for

In order to retain its priority, this application must be returned to the State Engineer, with corrections on or before ...., 19......

WITNESS my hand this .... day of ...., 19......

STATE ENGINEER

By ....
ASSISTANT

STATE OF OREGON, } ss.
County of Marion,

PERMIT

This is to certify that I have examined the foregoing application and do hereby grant the same, SUBJECT TO EXISTING RIGHTS and the following limitations and conditions:

The right herein granted is limited to the amount of water which can be applied to beneficial use and shall not exceed 6.6 *cubic feet per second measured at the point of diversion from the well or source of appropriation, or its equivalent in case of rotation with other water users, from* well No. 8

The use to which this water is to be applied is municipal

If for irrigation, this appropriation shall be limited to - - *of one cubic foot per second or its equivalent for each acre irrigated and shall be further limited to a diversion of not to exceed ...... acre feet per acre for each acre irrigated during the irrigation season of each year;*

and shall be subject to such reasonable rotation system as may be ordered by the proper state officer.

The well shall be cased as necessary in accordance with good practice and if the flow is artesian the works shall include proper capping and control valve to prevent the waste of ground water.

The works constructed shall include an air line and pressure gauge or an access port for measuring line, adequate to determine water level elevation in the well at all times.

The permittee shall install and maintain a weir, meter, or other suitable measuring device, and shall keep a complete record of the amount of ground water withdrawn.

The priority date of this permit is December 13, 1962

Actual construction work shall begin on or before March 15, 1964 *and shall thereafter be prosecuted with reasonable diligence and be completed on or before October 1, 19*64

*Complete application of the water to the proposed use shall be made on or before October 1, 19*65

WITNESS my hand this 15th *day of* March *, 19*63

[signature]
STATE ENGINEER

Application No. G- 2502
Permit No. G- 2312

PERMIT
TO APPROPRIATE THE GROUND WATERS OF THE STATE OF OREGON

This instrument was first received in the office of the State Engineer at Salem, Oregon, on the 13th *day of* December, *1962, at* 1:00 *o'clock* P. *M.*

Returned to applicant:

Approved:
March 15, 1963

Recorded in book No. 9 *of Ground Water Permits on page* 2312

CHRIS L. WHEELER
STATE ENGINEER

Drainage Basin No. 7 *page* 52

State Printing

Permit A—4M—7-70 SP*45035-119

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, That CITY OF MILTON-FREEWATER

of Box 108, Milton-Freewater , State of Oregon 97862 , has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of Well No. 8

a tributary of Walla Walla River for the purpose of municipal

under Permit No. G-2312 of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from December 13, 1962

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 3.90 cubic feet per second

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the NW¼ SW¼, Section 18, T. 5 N., R. 36 E., W. M., 1620 feet North and 1170 feet East from SW Corner, Section 18.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to -------------- of one cubic foot per second per acre,

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

W½
Section 1

N½
NE¼ SW¼
SE¼
Section 2

NE¼ NE¼
Section 11

W½ NE¼
NW¼
N½ SW¼
SE¼ SW¼
SE¼
Section 12
T. 5 N., R. 35 E., W. M.

NE¼ NE¼
Section 13
T. 5 N., R. 35 E., W. M.

SW¼ NW¼
NW¼ SW¼
Section 18
T. 5 N., R. 36 E., W. M.

SE¼ SW¼
SE¼
Section 35

SW¼ SW¼
Section 36
T. 6 N., R. 35 E., W. M.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this date. October 24, 1974

Chris L. Wheeler
State Engineer

Recorded in State Record of Water Right Certificates, Volume 33 , page 41011

#8

UMAT 4010

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the
STATE ENGINEER, SALEM, OREGON 97310
within 30 days from the date of well completion.

RECEIVED
JUN 4 1965
STATE ENGINEER
SALEM OREGON

WATER WELL REPORT
STATE OF OREGON
(Please type or print)

App# G-2502

State Well No. 5N/36-18 M

State Permit No. G-2312

(1) OWNER:

Name: CITY OF MILTON FREEWATER

Address: MILTON FREEWATER, ORE.

(2) LOCATION OF WELL:

County: UMATILLA Driller's well number: 4189

SW ¼ SW ¼ Section 18 T. 5N R. 36E W.M.

Bearing and distance from section or subdivision corner

(3) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐

If abandonment, describe material and procedure in Item 12.

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☒

Irrigation ☐ Test Well ☐ Other ☐

(5) TYPE OF WELL:

Rotary ☐ Driven ☐

Cable ☒ Jetted ☐

Dug ☐ Bored ☐

(6) CASING INSTALLED: Threaded ☐ Welded ☐

24" Diam. from 0 ft. to 315 ft. Gage .375

20" Diam. from 0 ft. to 76.5 ft. Gage .375

16" Diam. from 0 ft. to 480 ft. Gage .312

(7) PERFORATIONS: Perforated? ☐ Yes ☒ No

Type of perforator used

Size of perforations in. by in.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

(8) SCREENS: Well screen installed? ☐ Yes ☒ No

Manufacturer's Name

Type Model No.

Diam. Slot size Set from ft. to ft.

Diam. Slot size Set from ft. to ft.

(9) CONSTRUCTION:

Well seal—Material used in seal: CEMENT GROUT

Depth of seal 0-78 ft. Was a packer used? NO

Diameter of well bore to bottom of seal 24 in.

Were any loose strata cemented off? ☐ Yes ☒ No Depth

Was a drive shoe used? ☒ Yes ☐ No

Was well gravel packed? ☐ Yes ☒ No Size of gravel:

Gravel placed from ft. to ft.

Did any strata contain unusuable water? ☒ Yes ☐ No

Type of water? SURFACE depth of strata 31 FEET

Method of sealing strata off: CASING AND GROUT

(10) WATER LEVELS:

Static level 239 ft. below land surface Date NOV 1, 1963

Artesian pressure lbs. per square inch Date

(11) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? ☐ Yes ☐ No If yes, by whom? RJ STRASSER DRILLING Co

Yield: 1000 gal./min. with 67 ft. drawdown after 12 hrs.

" " " "

" " " "

Bailer test gal./min. with ft. drawdown after hrs.

Artesian flow g.p.m. Date

Temperature of water 60° Was a chemical analysis made? ☐ Yes ☒ No

(12) WELL LOG: Diameter of well below casing 12" AND 10"

Depth drilled 888 ft. Depth of completed well 888 ft.

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
SEE ATTACHED SHEET		

Work started FEB 21 1963 Completed APR 14 1965

Date well drilling machine moved off of well APR 15 1965

(13) PUMP:

Manufacturer's Name

Type: DEEP WELL TURBINE H.P.

Water Well Contractor's Certification:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME RJ STRASSER DRILLING Co
(Person, firm or corporation) (Type or print)

Address 8110 SE SUNSET LANE PORTLAND ORE.

Drilling Machine Operator's License No. 54

[Signed] Robert L. Strasser
(Water Well Contractor)

Contractor's License No. 10 Date JUNE 2 1965

(USE ADDITIONAL SHEETS IF NECESSARY)

STATE ENGINEER
Salem, Oregon

Well #8

State Well No. 5N/36-18M
County Umatilla
Application No. G-2502

Well Log

Owner: City of Milton-Freewater Owner's No. #8

Driller: R. J. Strasser, Portland, Oregon Date Drilled April 14, 1965

CHARACTER OF MATERIAL	(Feet below land surface) From	To	Thickness (feet)
Fill	0	9	9
Gravel and boulders	9	31	22
Weathered rock	31	38	7
Medium hard black rock	38	47	9
Broken rock	47	50	3
Hard black basalt	50	81	31
Medium hard basalt	81	83	2
Hard black basalt	83	96	13
Broken black rock	96	105	9
Hard black basalt	105	112	7
Broken gray basalt	112	121	9
Porous black rock	121	144	23
Porous dark brown rock	144	163	19
Broken black rock	163	180	17
Medium hard gray basalt	180	201	21
Black and reddish brown rock	201	209	8
Porous black basalt	209	316	7
Hard gray basalt	316	341	25
Medium hard dark gray basalt	341	352	11
Hard gray basalt	352	358	6
Porous black basalt	358	386	28
Medium hard gray basalt	386	398	12
Medium soft black basalt	398	437	39
Medium hard gray basalt	437	447	10

STATE ENGINEER
Salem, Oregon

State Well No. 5N/36-18M
County Umatilla
Application No. G-2502

Well #8

Well Log

Owner: City of Milton-Freewater Owner's No. #8

Driller: R. J. Strasser, Portland, Oregon Date Drilled April 14, 1965

CHARACTER OF MATERIAL	(Feet below land surface) From	To	Thickness (feet)
Black basalt with layers of black clay	447	463	26
Medium hard gray basalt	463	566	103
Porous black basalt with black clay	566	613	47
Medium hard gray basalt	613	679	59
Medium hard black basalt	679	723	44
Medium hard gray basalt	723	779	56
Hard gray basalt	779	787	8
Medium hard gray basalt with black clay	787	811	24
Medium hard black basalt	811	825	14
Medium hard gray basalt	825	827	2
Hard gray basalt	827	830	3
Medium hard gray basalt	830	836	6
Black and red basalt	836	841	5
Broken porous black and brown basalt	841	864	23
Porous black basalt	864	869	5
Porous black and brown basalt	869	883	14
Medium soft black basalt	883	888	5

STATE ENGINEER
Salem, Oregon

State Well No. 5N/36-18M(1)

County UMATILLA

Well #8

Application No.

Water Level Record

OWNER: MILTON-FREEWATER OWNER'S NO. #8

Description of measuring point:

Date	Water Level Feet ~~(above)~~ (below) Land Surface	Remarks	Date	Water Level Feet (above) (below) Land Surface	Remarks
3-19-64	239				
4-13	141.5				
6-15	193.5				
7-13	243				
8-24	245				
9-22	245.10				
10-26	245.40				
11-23	245				
12-21	245.50				

REMARKS:

State Printing 89314

RECEIVED
MAR 18 1970
STATE ENGINEER
SALEM, OREGON

NOTICE TO WATER WELL CONTRACTOR
The original and first copy of this report are to be filed with the STATE ENGINEER, SALEM, OREGON 97310 within 30 days from the date of well completion.

WATER WELL REPORT
STATE OF OREGON
(Please type or print)
(Do not write above this line)

nc

UMAT 4005

Well #8

5N/36-18cb

State Well No. G-2502

State Permit No. G-2312

(1) OWNER:
Name CITY OF MILTON-FREEWATER ORE.
Address MILTON-FREEWATER ORE.

(2) TYPE OF WORK (check):
New Well ☐ Deepening ☒ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☒
Irrigation ☐ Test Well ☐ Other ☐

(5) CASING INSTALLED:
Threaded ☐ Welded ☐
SEE PREVIOUS LOG
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

(6) PERFORATIONS:
Perforated? ☐ Yes ☐ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:
Well screen installed? ☐ Yes ☐ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

(8) WATER LEVEL: Completed well.
Static level 269 ft. below land surface Date 2/24/70
Artesian pressure lbs. per square inch Date

(9) WELL TESTS:
Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? CONTRACTOR
Yield: 1529 gal./min. with 197 ft. drawdown after 26 hrs.
" " " "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 68 Was a chemical analysis made? ☐ Yes ☒ No

(10) CONSTRUCTION: SEE PREVIOUS LOG
Well seal—Material used
Depth of seal ft.
Diameter of well bore to bottom of seal in.
Were any loose strata cemented off? ☐ Yes ☐ No Depth
Was a drive shoe used? ☐ Yes ☐ No
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☐ No Size of gravel:
Gravel placed from ft. to ft.

(11) LOCATION OF WELL:
County UMATILA Driller's well number 8
NW ¼ S.W. ¼ Section 18 T. 5N R. 36 E W.M.
Bearing and distance from section or subdivision corner

(12) WELL LOG:
Diameter of well below casing 12X10
Depth drilled 1051 ft. Depth of completed well 1051 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level as drilling proceeds. Note drilling rates.

MATERIAL	From	To	SWL
SEE PREVIOUS LOG	0	888	269
BLACK BASALT	888	963	269
BROWN-BLACK BASALT	963	965	269
BLACK BASALT	965	973	269
GREY BASALT	973	1021	269
RED BASALT	1021	1025	269
RED-BLACK BASALT	1025	1030	269
BLACK- BASALT	1030	1050	269
GREY- BASALT	1050	1051	269

Work started 12-1 1969 Completed 2-2 1970
Date well drilling machine moved off of well 2-2-70 19

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] (signature) (Drilling Machine Operator) Date 3-10, 1970
Drilling Machine Operator's License No. 361

Water Well Contractor's Certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME CHARLES SULLMANN DRILLING CO.
(Person, firm or corporation) (Type or print)
Address 115 REES AVE. W.W. WASH
[Signed] (signature)
(Water Well Contractor)
Contractor's License No. 256 Date 3-10-, 1970

(USE ADDITIONAL SHEETS IF NECESSARY)

Well #8

STATE OF OREGON

COUNTY OF UMATILLA

PERMIT TO APPROPRIATE THE PUBLIC WATERS

THIS PERMIT IS HEREBY ISSUED TO

CITY OF MILTON FREEWATER, DAVID BRADSHAW
722 S MAIN (541)938-5531
MILTON FREEWATER, OREGON 97862

The specific limits and conditions of the use are listed below.

APPLICATION FILE NUMBER: G-14665

SOURCE OF WATER: WELL 8 IN WALLA WALLA RIVER BASIN

PURPOSE OR USE: FROST PROTECTION AND IRRIGATION OF 10.2 ACRES

MAXIMUM RATE: 0.128 CUBIC FOOT PER SECOND

PERIOD OF USE: MARCH 15 THROUGH MAY 10 FOR FROST PROTECTION AND JUNE 1 THROUGH SEPTEMBER 30 FOR IRRIGATION

DATE OF PRIORITY: JANUARY 15, 1998

POINT OF DIVERSION LOCATION: NW 1/4 SW 1/4, SECTION 18, T5N, R36E, W.M.; 1113 FEET SOUTH & 1101 FEET EAST FROM W1/4 CORNER, SECTION 18

The amount of water used for irrigation under this right, together with the amount secured under any other right existing for the same lands, is limited to a diversion of ONE-EIGHTIETH of one cubic foot per second (or its equivalent) and 3.0 acre-feet for each acre irrigated during the irrigation season of each year.

THE PLACE OF USE IS LOCATED AS FOLLOWS:

NW 1/4 SW 1/4 10.2 ACRES & FROST PROTECTION
SECTION 18
TOWNSHIP 5 NORTH, RANGE 36 EAST, W.M.

Measurement, recording and reporting conditions:

A. Before water use may begin under this permit, the permittee shall install a meter or other suitable measuring device as approved by the Director. The permittee shall maintain the meter or measuring device in good working order.

B. The permittee shall allow the watermaster access to the meter or measuring device; provided however, where the meter or measuring device is located within a private structure, the watermaster shall request access upon reasonable notice.

C. The Director may require the permittee to keep and maintain a record of the amount (volume) of water used and may require the permittee to report water use on a periodic schedule as established by the Director. In addition, the Director may require the permittee to report general water use information, the periods of water use and the place and nature of use of water under the permit. The Director may provide an opportunity for the permittee to submit alternative reporting procedures for review and approval.

If substantial interference with a senior water right occurs due to withdrawal of water from any well listed on this permit, then use of water from the well(s) shall be discontinued or reduced and/or the schedule of withdrawal shall be regulated until or unless the Department approves or implements an alternative administrative action to mitigate the interference. The Department encourages junior and senior appropriators to jointly develop plans to mitigate interferences.

This right is limited to any deficiency in the available supply of any prior right existing for the same land.

STANDARD CONDITIONS

The wells shall be constructed in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon. The works shall be equipped with a usable access port, and may also include an air line and pressure gauge adequate to determine water level elevation in the well at all times.

The use shall conform to such reasonable rotation system as may be ordered by the proper state officer.

Prior to receiving a certificate of water right, the permit holder shall submit the results of a pump test meeting the department's standards, to the Water Resources Department. The Director may require water level or pump test results every ten years thereafter.

Failure to comply with any of the provisions of this permit may result in action including, but not limited to, restrictions on the use, civil penalties, or cancellation of the permit.

This permit is for the beneficial use of water without waste. The water user is advised that new regulations may require the use of best practical technologies or conservation practices to achieve this end.

By law, the land use associated with this water use must be in compliance with statewide land-use goals and any local acknowledged land-use plan.

The use of water shall be limited when it interferes with any prior surface or ground water rights.

The Director finds that the proposed use(s) of water described by this permit, as conditioned, will not impair or be detrimental to the public interest.

Actual construction of the well shall begin by September 30, 1999. Complete application of water to the use shall be made on or before October 1, 2002. Within one year after complete application of water to the proposed use, the permittee shall submit a claim of beneficial use, which includes a map and report, prepared by a Certified Water Rights Examiner (CWRE).

Issued September 30, 1998

Dwight French for
Martha O. Pagel, Director
Water Resources Department

Well No. 9

Permit A-1-1M-3-50 State Printing Dept.

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, *That* UMATILLA CANNING COMPANY

of 1000 Broadway, Milton *, State of* Oregon *, has made proof to the satisfaction of the STATE ENGINEER of Oregon, of a right to the use of the waters of* a well
a tributary of Walla Walla River *for the purpose of* Cleaning, fluming, washing, blanching, cooking & cooling fruits and vegetables
under Permit No. U-373 *of the State Engineer, and that said right to the use of said waters has been perfected in accordance with the laws of Oregon; that the priority of the right hereby confirmed dates from* December 22, 1950;

that the amount of water to which such right is entitled and hereby confirmed, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 2.23 cubic feet per second,

or its equivalent in case of rotation, measured at the point of diversion from the stream. The point of diversion is located in the SW¼ SE¼, Section 12, Township 5 North, Range 35 East, W. M.

The amount of water used for irrigation, together with the amount secured under any other right existing for the same lands, shall be limited to - - - - - - - - *of one cubic foot per second per acre,*

and shall conform to such reasonable rotation system as may be ordered by the proper state officer.

A description of the place of use under the right hereby confirmed, and to which such right is appurtenant, is as follows:

SW¼ SE¼
Section 12
NW¼ NE¼
Section 13
Township 5 North, Range 35 East, W. M.

Land on which water is to be used is a part of that more explicitly described by appropriator as follows:
All of Block 18 of Nichols Addition to the Town, now City, of Milton, by Deed Recorded in Book 169, Page 192 of Deed Records of Umatilla County, Oregon. Excepting that portion heretofore conveyed by Ephriam D. Hastings to Daniel E. Hastings, by Deed recorded in Book 62, Page 607 of the Deed Records of Umatilla County, Oregon. Also excepting that portion thereof heretofore conveyed to the State of Oregon by Deeds recorded in Book 160, Pages 70 and 71 of the said Deed Records. Excepting any and all water rights of way.

The right to the use of the water for the purposes aforesaid is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed

this 28th *day of* July *, 19*55.

LEWIS A. STANLEY *State Engineer*

Recorded in State Record of Water Right Certificates, Volume 15 *, page* 20806.

STATE OF OREGON

COUNTY OF UMATILLA

PERMIT TO APPROPRIATE THE PUBLIC WATERS

THIS PERMIT IS HEREBY ISSUED TO

CITY OF MILTON-FREEWATER
PO BOX 6 (541) 938-5531
MILTON-FREEWATER, OREGON 97862

The specific limits for the use are listed below along with conditions of use.

APPLICATION FILE NUMBER: G-13494

SOURCE OF WATER: A WELL IN WALLA WALLA RIVER BASIN

PURPOSE OR USE: MUNICIPAL USE

RATE OF USE: 3.34 CUBIC FEET PER SECOND

PERIOD OF USE: YEAR ROUND

DATE OF PRIORITY: FEBRUARY 27, 1996

POINT OF DIVERSION LOCATION: SW 1/4 SE 1/4, SECTION 12, T5N, R35E, W.M.; 840 FEET NORTH AND 2020 FEET WEST FROM THE SE CORNER OF SECTION 12

THE PLACE OF USE IS LOCATED AS FOLLOWS:

SERVICE AREA OF THE CITY OF MILTON-FREEWATER

Measurement, recording and reporting conditions:

A. Before water use may begin under this permit, the permittee shall install a meter or other suitable measuring device as approved by the Director. The permittee shall maintain the meter or measuring device in good working order, shall keep a complete record of the amount of water used each month and shall submit a report which includes the recorded water use measurements to the Department annually or more frequently as may be required by the Director. Further, the Director may require the permittee to report general water use information, including the place and nature of use of water under the permit.

B. The permittee shall allow the watermaster access to the meter or measuring device; provided however, where the meter or measuring device is located within a private structure, the watermaster shall request access upon reasonable notice.

The water user shall develop a plan to monitor and report the impact of water use under this permit on water levels within the aquifer that provides water to the permitted well(s). The plan shall be submitted to the Department within one year of the date the permit is issued and shall be subject to the approval of the Department. At a minimum, the plan shall include a program to periodically measure static water levels within the permitted well(s) or an adequate substitute such as water levels in nearby wells. The plan shall also stipulate a reference water level against which any water-level declines will be compared. If a well listed on this permit (or replacement well) displays a total static water-level decline of 25 or more feet over any period of years, as compared to the reference level, then the water user shall discontinue use of, or reduce the rate or volume of withdrawal from, the well(s). Such action shall be taken until the water level recovers to above the 25-foot decline level or until the Department determines, based on the water user's and/or the Department's data and analysis, that no action is necessary because the aquifer in question can sustain the observed declines without adversely impacting the resource or senior water rights. The water user shall in no instance allow excessive decline, as defined in Commission rules, to occur within the aquifer as a result of use under this permit.

Within TWO YEARS of permit issuance, the permittee shall submit a water management and conservation plan consistent with Oregon Administrative Rules Chapter 690, Division 86.

If at any time the well or its use:

a) acts as a conduit for groundwater contamination,
b) allows loss of artisan pressure,
c) allows waste of groundwater,
d) interferes with senior groundwater users or
e) interferes with surface water sources,

the Department may require that the well be repaired in accordance with current well construction standards.

STANDARD CONDITIONS

The wells shall be constructed in accordance with the General Standards for the Construction and Maintenance of Water Wells in Oregon. The works shall be equipped with a usable access port, and may also include an air line and pressure gauge adequate to determine water level elevation in the well at all times.

The use shall conform to such reasonable rotation system as may be ordered by the proper state officer.

Prior to receiving a certificate of water right, the permit holder shall submit the results of a pump test meeting the department's standards, to the Water Resources Department. The Director may require water level or pump test results every ten years thereafter.

Failure to comply with any of the provisions of this permit may result in action including, but not limited to, restrictions on the use, civil penalties, or cancellation of the permit.

This permit is for the beneficial use of water without waste. The water user is advised that new regulations may require the use of best practical technologies or conservation practices to achieve this end.

By law, the land use associated with this water use must be in compliance with statewide land-use goals and any local acknowledged land-use plan.

The use of water shall be limited when it interferes with any prior surface or ground water rights.

The Director finds that the proposed use(s) of water described by this permit, as conditioned, will not impair or be detrimental to the public interest.

Actual construction of the well shall begin within one year from permit issuance and shall be completed on or before October 1, 1998. Complete application of the water to the use shall be made on or before October 1, 1999.

Issued July 8, 1996

for Martha O. Pagel, Director
Water Resources Department

umat 51825

AUG 07 1998 WATER RESOURCES DEPT. SALEM, OREGON

Well #9

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

(START CARD) # 092107

(1) OWNER: Well Number #9

Name City Milton-Freewater

Address P.O. Box 6 722 S. Main

City Milton-Freewater State Ore. Zip 97862

(2) TYPE OF WORK

☐ New Well ☐ Deepening ☒ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:

☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger

☐ Other Reverse Rotary

(4) PROPOSED USE:

☐ Domestic ☒ Community ☒ Industrial ☐ Irrigation

☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:

Special Construction approval ☐ Yes ☒ No Depth of Completed Well 870 ft.

Explosives used ☐ Yes ☒ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
18"	+2	290	grout	+2	290	8 yds
Packer set at 290' to 18" x 12"						

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E

☐ Other

Backfill placed from ____ ft. to ____ ft. Material ____

Gravel placed from ____ ft. to ____ ft. Size of gravel ____

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Liner (Casing):	12"	+2	462	.375	☒	☐	☒	☐
	10"	462'	692	.365	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ____

(7) PERFORATIONS/SCREENS:

☒ Perforations Method Factory cut

☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
462'	692'	1/4 x 2.5	40/ft	10"		☐	☒
40 slots per foot						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour

☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
None Done			1 hr.

Temperature of water ____ Depth Artesian Flow Found ____

Was a water analysis done? ☐ Yes By whom ____

Did any strata contain water not suitable for intended use? ☐ Too little

☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ____

Depth of strata: ____

(9) LOCATION OF WELL by legal description:

County Umatilla Latitude ____ Longitude ____

Township 5 (N) or S Range 35 E or (W) WM.

Section 12 SW 1/4 SE 1/4

Tax Lot 1104 Lot ____ Block ____ Subdivision ____

Street Address of Well (or nearest address) Hwy 11

(10) STATIC WATER LEVEL:

292 ft. below land surface. Date 7-16-98

Artesian pressure ____ lb. per square inch. Date ____

(11) WATER BEARING ZONES:

Depth at which water was first found ____

From	To	Estimated Flow Rate	SWL
No Drilling			

(12) WELL LOG:

Ground Elevation ____

Material	From	To	SWL
Did No Drilling just Installed liner in existing well.			

Date started 7-10-98 Completed 7-28-98

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number ____

Signed ____ Date ____

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1506

Signed [signature] Date 8-5-98

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

RECEIVED AUG 24 1951 STATE ENGINEER SALEM. OREGON

Well #9 5/35 - 12 Q(4)

UMAT 3965

Application No. U -403
Permit No. U -373
Well No. 1, Umatilla Canning Co.
UMATILLA CO

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Date of Report August 22, 1951

1. Location of well: SW 1/4 of SE 1/4 of Section 12 Twp. 5N Rge. 35 E. W. M.
2. Name of nearest natural surface stream Walla Walla River
3. Distance from well to that stream: Approx. 4000 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: -- feet.
5. Date of beginning drilling or digging. January 11, 1951
6. Date well was completed June 22, 1951

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered		Thickness of stratum	
Yellow cement gravel	At surface 0	ft.	41	ft.
Broken Basalt & Blue Clay	41	ft.	285	ft.
Medium gray basalt & alternate clay & mud	285	ft.	421	ft.
Broken gray basalt	421	ft.	562	ft.
Black basalt & gray basalt	562	ft.	751	ft.
Medium black basalt -(2ft. Hard black basalt 816-818 ft)	751	ft.	878	ft.
Gray hard basalt	878	ft.	881	ft.
Medium black basalt	881	ft.	894	ft.
Hard black basalt	894	ft.	913	ft.
Remarks: Medium black basalt	913	ft.	918	ft.

WELL INFORMATION

8. Diameter of well see below inches. Depth of well 918 feet.
9. Depth at which water was first encountered 90 feet.
10. Water level when completed: 205 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.: Some caving - 321 ft to 500 ft.

8. 24" from 0 to 104 ft.
20" from 104 to 321 ft.
16" from 321 to 690 ft.
12" from 690 to 918 ft.

5N/35-12Q(A)
UMATILLA Co

RECEIVED
AUG 24 1951
STATE ENGINEER
SALEM. OREGON

Well #9

PUMP INFORMATION

12. Manufacturer of pump: A. D. Cook, Inc.
13. Address: Lawrenceburg, Indiana
14. Data on name or base plate: Serial No. 13254
Cook Rotation Pump

15. Data on pump bowl assembly: TR 5107 12 TR 527
26 12 TR 5280

16. Size of pump: 8" Turbine
17. Rated capacity: 950 gallons per minute.
18. Rated speed: 1765 revolutions per minute.
19. Number of stages: 8
20. Size of intake pipe: 8"
21. Size of discharge pipe: 8"
22. Length of intake pipe: 290 feet column, 25 feet bowl assembly, suction and strainer
23. Length of discharge pipe: 161.65 ft.
24. Suction lift: (difference in elevation between water surface in well and pump) 205 feet
25. Discharge lift: (difference in elevation between pump and end of discharge line) Hardly any -- pipe runs slightly downhill
26. Depth of pump intake below ground surface: 310 feet.
27. Remarks: This pump will be exchanged or worked over to that we can pump between 1400 and 1500 g.p.m. next season.

MOTOR OR ENGINE INFORMATION

28. Name of manufacturer: General Electric
29. Address: ~~XXXX~~ Schenectady, N. Y.
30. Type of motor or engine: Electric Induction Motor

31. Data on name or base plate: Model 5K445A1A Service Factor 1.15 at Rated Volts
60 cycles 220/440 volts Type K Code F Frame 445 3 phase 60 cy
FL AMP 181/90.5 FL Speed 1765 No. WGJ6873648 TRYCLAD INDUCTION MOTOR

32. Rated horsepower: 75 H.P.
33. Rated speed of motor or engine: 1765 revolutions per minute.

34. Rated Capacity of Pump (with described motor)

950 g.p.m. at	205 ft. head
800 g.p.m. at	300 ft. head
700 g.p.m. at	350 ft. head
g.p.m. at	ft. head
g.p.m. at	ft. head

35. Remarks: We intend to trade this pump and motor or have it worked over next year (before June 1952) so that we can pump 1400-1500 g.p.m.

RECEIVED
AUG 24 1951
STATE ENGINEER
SALEM. OREGON

5N/25-12Q(4)

Well #9

CAPACITY TEST

36. Date of test: 8/16 & 8/17, 1951 37. Temperature of water 60 °F. or ____ °C.
38. Motor speed during test: From 1250 - 1800 R.P.M.
39. Test made by (weir, tank or other means): Weir

40.

DIRECT READING GAUGE	TOTAL HEAD		*Total lift in feet	Gallons per min.	°Feet to water level	▫Draw-down	+Time	
205	___ lbs.,	Gauge at pump	Total 205 ft. ___ in.	Static water level	ft.	___ ft.	___ M.	8/16
215	___ lbs.,	Gauge at pump	Total 215 ft. ___ in.	336	215 ft.	10 ft.	7:15 AM.	
244	___ lbs.,	Gauge at pump	Total 244 ft. ___ in.	795	244 ft.	39 ft.	8:30 AM.	
266	___ lbs.,	Gauge at pump	Total 266 ft. ___ in.	1220	266 ft.	61 ft.	10:30 AM.	
287	___ lbs.,	Gauge at pump	Total 287 ft. ___ in.	1407	287 ft.	82 ft.	12:30 PM.	
287	___ lbs.,	Gauge at pump	Total 287 ft. ___ in.	1407	287 ft.	82 ft.	5:30 PM.	
270	___ lbs.,	Gauge at pump	Total 270 ft. ___ in.	1220	270 ft.	65 ft.	7:30 PM.	
285	___ lbs.,	Gauge at pump	Total 285 ft. ___ in.	1407	285 ft.	80 ft.	9:00 PM.	
285	___ lbs.,	Gauge at pump	Total 285 ft. ___ in.	1407	285 ft.	80 ft.	12:00 M.	Midnight
285	___ lbs.,	Gauge at pump	Total 285 ft. ___ in.	1407	285 ft.	80 ft.	4:00 AM.	8/17
270	___ lbs.,	Gauge at pump	Total 270 ft. ___ in.	1312	270 ft.	65 ft.	4:10 AM.	
263	___ lbs.,	Gauge at pump	Total 263 ft. ___ in.	1220	263 ft.	58 ft.	4:20 AM.	
264	___ lbs.,	Gauge at pump	Total 264 ft. ___ in.	1220	264 ft.	59 ft.	6:00 AM.	
295	___ lbs.,	Gauge at pump	Total 295 ft. ___ in.	1501	295 ft.	90 ft.	6:10 AM.	
295	___ lbs.,	Gauge at pump	Total 295 ft. ___ in.	1501	295 ft.	90 ft.	6:18 AM.	
209	___ lbs.,	Gauge at pump	Total ___ ft. ___ in.	(RECOVERY)	ft.	___ ft.	6:23 aM.	
	___ lbs.,	Gauge at pump	Total ___ ft. ___ in.		ft.	___ ft.	___ M.	

* Difference in elevation between water level in well and outlet of pump test line.
° Distance from ground level to water surface in well.
▫ Distance water level is lowered during time interval.
\+ Hour and minute at which observation was made.

41. Installation will work efficiently under normal head of 325 ft.
42. Water is discharged into: Main lines, Umatilla Canning Company Plant.
43. Was water lowered to pump intake by test? Yes - deliberately.
44. Remarks: Didn't have enough column on to go beyond 1501 G.P.M. on test. Had only 90 feet of column beyond static water level of 205 feet. Well recovered to static water level from 6:18 a.m. to 6:23 a.m. 8/17/51. Recovery rate of 5 minutes.

GENERAL INFORMATION

45. Name of contractor or other party who drilled or dug well: A. A. Durand & Son
Address: 115 Rees Avenue, Walla Walla, Washington
46. Pump and motor were installed by: Pump, Pipe, & Power Co., Portland, Oregon
Address: ____
47. Capacity test was made by: A. A. Durand & Son, Walla Walla, Washington
Address: ____
48. General remarks: ____

UMAT 3908

STATE ENGINEER
Salem, Oregon

OBSERVATION WELL
Well Record
Key Well

STATE WELL NO. 5N/35-1E(1)
COUNTY Umatilla
APPLICATION NO. U-165

OWNER: Key Equipment Co. (Utah Can) MAILING ADDRESS: Milton Freewater

LOCATION OF WELL: Owner's No. #1 CITY AND STATE:

SW ¼ NW ¼ Sec. 1 T. 5 N. ~~S.~~, R. 35 E. ~~W.~~, W.M.

Bearing and distance from section or subdivision corner

Altitude at well

TYPE OF WELL: Drilled Date Constructed 2-16-45

Depth drilled 528' Depth cased 109' 3"

Section 1

CASING RECORD:
16 inch

FINISH:

AQUIFERS:
Basalt

WATER LEVEL:
49' (2-16-45)

PUMPING EQUIPMENT: Type H.P.
Capacity G.P.M.

WELL TESTS: See pump test info
Drawdown ft. after hours G.P.M.
Drawdown ft. after hours G.P.M.

USE OF WATER Municipal Temp. °F. , 19
SOURCE OF INFORMATION U-158
DRILLER or DIGGER A. A. Durand & Son
ADDITIONAL DATA:
Log ✓ Water Level Measurements ✓ Chemical Analysis ✓ Aquifer Test

REMARKS:

State Printing 89316

STATE ENGINEER
Salem, Oregon

UMAT 3908

Key Well

State Well No. 5N/35-1E(1)

County UMATILLA

Application No. U-165

Water Level Record

OWNER: KEY EQUIPMENT CO. (UTAH CANNING CO.) OWNER'S NO.

Description of measuring point: OWNERS AIRLINE & GAGE (147' LINE)

Date	Water Level Feet (above) (below) Land Surface	Remarks	Date	Water Level Feet (above) (below) Land Surface	Remarks
11-9-61	105'	RD & WSB.			
11-4-63	12[illegible]				
11-18	120				
12-2	120				
12-21	112				
1-6-64	112				
1-20	114				
2-3	113				
2-17	112				
3-3	107				
3-17	107				
4-7	105				
4-27	105				
5-4	103				
6-1	103				
9-29	132				
10-12	132				
11-16	130				

REMARKS:

State Printing 89314

UMAT 3908

RECEIVED
MAR 5 1945
STATE ENGINEER
SALEM, OREGON

Key Well

5N/35-1E(1)

Application No. U-165
Permit No. U - 158
Well No. 1

UMAT
3908

REPORT ON COMPLETION OF WELL

(Note: This report should be submitted to the State Engineer, Salem, Oregon, as soon as possible after the well is completed. If more than one well is covered by this permit, a separate report shall be filed for each)

Utah Canning Co.

Date of Report Feb. 28, 1945

1. Location of well: SW¼ of NW¼ of Section 1 Twp. 5N Rge. 35 E, W. M.
2. Name of nearest natural surface stream Walla Walla River
3. Distance from well to that stream: 1800 feet.
4. If the well is less than 1300 feet from a natural surface stream, give the difference in elevation between the ground surface at the well and the lowest point in stream channel: ------ feet.
5. Date of beginning drilling or digging Nov. 21, 1944
6. Date well was completed Feb. 16, 1945

7. LOG OF MATERIALS ENCOUNTERED

Character of Material	Depth at which encountered	Thickness of stratum
	At surface	ft.
	ft.	ft.
	ft.	ft.
See attached Chronology of	ft.	ft.
Well.	ft.	ft.
	ft.	ft.
	ft.	ft.
	ft.	ft.
	ft.	ft.

Remarks:

WELL INFORMATION

8. Diameter of well 16 inches. Depth of well 528 feet.
9. Depth at which water was first encountered ± 22 feet.
10. Water level when completed: 49 feet below ground surface.
11. Additional information regarding well; such as soil conditions, quick sand, caves, obstructions, rock, etc.:

Note: You will find attached Test Pumping Record of this well.

The Utah Canning Company
By [signature]
Geo. M. Martin

UMAT 3908 Key Well

1"135-1E(1)-

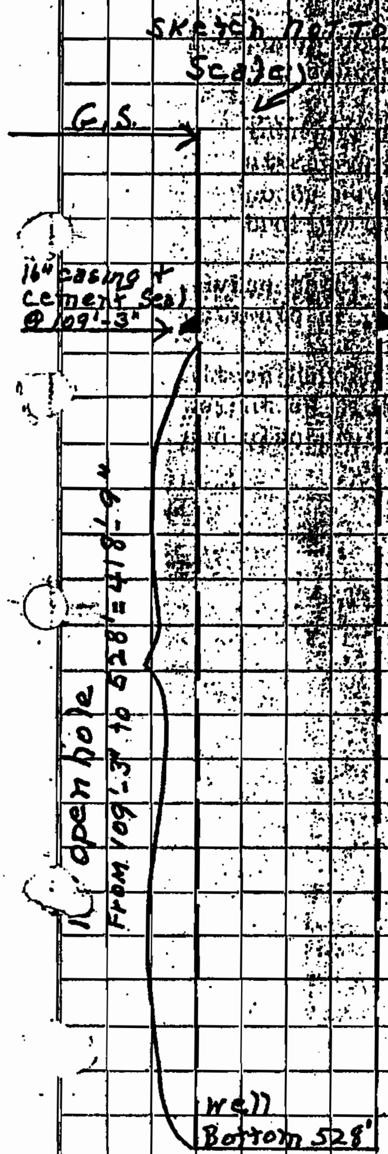
ENGINEERING DEPARTMENT DU PONT COMPUTATION SHEET

Sheet No.
Proj. No.
Works

A. A. DURAND & SON
WELL DRILLING CONTRACTORS
215 Reese Avenue
WALLA WALLA, WASHINGTON

Computer P.A.D. Date March 1, 1945

Utah Canning Company, Freewater, Oregon. Plant Well No. 1
Drilled during period November 21, 1944 to February 16, 1945 Located in SW¼ of NW¼ of Sec. 1, T5N, R35E



WELL CHRONOLOGY

Depth From	Depth To	Formation	S.W.L.	Comments
Ground Surface	20'	Gravel & boulders		
20'	30'	Gravel	22'	
30'	55'	Clay & Gravel		
55'	64'	Pure Gravel		
64'	92'	Yellow Clay & Gravel		
92'	107'	Solid Black Basalt		End of 20" Drilling.
107'	114'	Black Basalt & Blue shale		16" O.D. casing sealed at 109' 3".
114'	118'	Black Basalt		
118'	125'	Gray & Brown Basalt and Blue Shale		
125'	145'	Gray Basalt & Blue Shale		
145'	156'	Gray, Red & Brown Basalt and Blue Shale	23'	
156'	168'	Gray & Brown Basalt with Blue Clay	18'	
168'	186'	Black Basalt		
186'	193'	Black & Red Basalt with little Yellow Clay		
193'	198'	Black Basalt		
198'	205'	Black Basalt & Blue Shale		
205'	213'	Black & Red Basalt with Yellow Clay		
213'	221'	Hard Black Basalt		
221'	228'	Black Basalt with little Yellow Clay		
228'	233'	Hard Black Basalt	15'	
233'	285'	Gray Basalt	16' 6"	
285'	292'	Hard Blue Basalt		
292'	401'	Hard Gray Basalt		
401'	437'	Hard Black Basalt		
437'	468'	Hard Gray Basalt		
468'	528'	Soft & Hard Black Basalt		Cement seal (1504#) set at the bottom of 16" by bridging below 16" pipe, filling same with cement and driving wood plug down and forcing cement around behind 16" casing. Was done when well was drilled to 496' level then cement & cement bridge drilled out at which time S.W.L. changed from 16' 6" to 41' 5"

Pump Test #1 conducted Feb. 16 and 17, 1945, 24 hours continuous. S.W.L. 49'.

Mean Pumping Points as follows:

Dynamic W.L.	G.P.M.
70'	1029
73½'	1040
79½'	1265
81'	1550

UMAT 3908

Key Well

STATE ENGINEER
Salem, Oregon

State Well No. 5/35-1E1

County Umatilla

Application No.

Chemical Analysis

OWNER Utah Canning Co. OWNER'S NO.

ANALYST Ore. State Board of Health Address

Date of Collection 1945

Point of Collection

	P.P.M.	E.P.M.
Silica (SiO_2)		
Iron (Fe) Total		
Manganese (Mn)		
Calcium (Ca)	16.	
Magnesium (Mg)	8.5	
Sodium (Na)	14.	
Potassium (K)		
Bicarbonate (HCO_3)	90.	
Carbonate (CO_3)		
Sulfate (SO_4)		
Chloride (Cl)		
Fluoride (F)		
Nitrate (NO_3)		
Boron (B)		
Dissolved Solids		
Hardness as $CaCO_3$	74.	
Specific Conductance (Micromhos at 25°C)		
pH		
Percent Sodium		
Sodium Absorption Ratio (S.A.R.)		
CLASS		

State Printing 89313

UMAT 3908

Key Well

The Utah Canning Company

GENERAL OFFICE
OGDEN, UTAH

PLANTS AT
OGDEN, UTAH
FREEWATER, OREGON

Freewater, Oregon
May 24, 1950

RECEIVED
MAY 26 1950
STATE ENGINEER
SALEM, OREGON

Mr. Chas. E. Stricklin, State Engineer
State of Oregon,
Salem, Oregon

Dear Sir: Re: File No. 165

We are holder of Water Right Certificate No. 1551 under Permit No. U-158.

Due to the drop in water tables in this area last year we have been checking the water level in our well for depth below ground level weekly since Feb. 13, 1950 and find the following;

Feb. 13 -70'	Mar. 20 -65'	Apr. 17 -59'	May 15 -63
Feb. 27 -70	Mar. 27 -62	Apr. 24 -59	May 22 -65
Mar. 6 -68	Apr. 3 -62	May 1 -57'	
Mar. 13 -65	Apr. 10 -60	May 8 -57	

You will note that we had a build up for awhile and now the table is lowering.

When we started using our well in the 1949 season about June 10th the level was 59' below ground level and after pumping for 8 hours we had dropped somewhere below 100', how far below that we do not know as our gauge is only set for 100'.

It is very evident that there are too many wells on the same basin that we are on.

What we would like to know is, does a well that was proven at a certain time have priority over wells that were proven at later dates.

Very truly yours,

Utah Canning Company

Geo. M. Martin
Manager

UMAT 3908

Key Well

5N/35-1E1
UMATILLA

Water level from ground surface. Utah Canning Company, Freewater, Oregon well - Permit No. U-~~165~~ 158

Date	Feet
Feb. 13, 1950	70 - Not Pumping
Feb. 27, 1950	70 - Not Pumping
March 6, 1950	68 - Not Pumping
March 13, 1950	65 - Not Pumping
March 20, 1950	65 - Not Pumping
March 27, 1950	62 - Not Pumping
April 3, 1950	62 - Not Pumping
April 10, 1950	60 - Not Pumping
April 17, 1950	59 - Not Pumping
April 24, 1950	59 - Not Pumping
May 1, 1950	57 - Not Pumping
May 8, 1950	57 - Not Pumping
May 15, 1950	63 - Not Pumping
May 16, 1950	63 - Not Pumping
May 17, 1950	63 - Not Pumping
May 22, 1950	65 - Not Pumping
May 31, 1950	70 - Not Pumping
June 5, 1950	70 - Not Pumping
June 12, 1950	74 - Not Pumping
June 13, 1950	73 - Not Pumping
June 14, 1950	75 - Not Pumping
June 15, 1950	73 - Not Pumping
June 16, 1950	73 - Not Pumping
June 19, 1950	73 - Not Pumping
June 20, 1950	74 - Started Pumping
June 21, 1950	95 - Pumping
June 22, 1950	93 - Pumping
June 23, 1950	93 - Pumping
June 24, 1950	94 - Pumping
June 25, 1950	98 - Pumping
June 26, 1950	100 - Pumping
June 27, 1950	100 - Pumping
June 28, 1950	98 - Pumping
June 29, 1950	99 - Pumping
June 30, 1950	103 - Pumping
July 1, 1950	100 - Pumping
July 2, 1950	103 - Pumping
July 3, 1950	105 - Pumping
July 4, 1950	107 - Pumping
July 5, 1950	109 - Pumping
July 6, 1950	106 - Pumping
July 7, 1950	110 - Pumping
July 8, 1950	103 - Pumping
July 9, 1950	105 - Pumping
July 10, 1950	105 - Pumping
July 11, 1950	102 - Pumping
July 12, 1950	103 - Pumping
July 13, 1950	110 - Pumping
July 14, 1950	110 - Pumping

RECEIVED
JAN 9 1951
STATE ENGINEER
SALEM, OREGON

UMAT 3908

Key Well

5N/35-1E1
UMATILLA

Water level from ground surface. Utah Canning Company, Freewater, Oregon well - Permit No. U-~~165~~ 159

Date	Feet
July 15, 1950	105 - Pumping
July 16, 1950	103 - Pumping
July 17, 1950	103 - Pumping
July 18, 1950	100 - Stopped Pumping
July 19, 1950	105 - Not Pumping
July 20, 1950	100 - Not Pumping
July 21, 1950	98 - Not Pumping
July 24, 1950	95 - Not Pumping
July 25, 1950	88 - Not Pumping
July 26, 1950	88 - Not Pumping
July 27, 1950	87 - Not Pumping
Aug. 3, 1950	87 - Not Pumping
Aug. 9, 1950	85 - Not Pumping
Aug. 11, 1950	85 - Not Pumping
Aug. 14, 1950	84 - Not Pumping
Aug. 18, 1950	83 - Not Pumping
Aug. 22, 1950	82 - Not Pumping
Aug. 30, 1950	78 - Not Pumping
Sept. 7, 1950	78 - Not Pumping
Sept. 12, 1950	79 - Not Pumping
Sept. 20, 1950	80 - Not Pumping
Sept. 26, 1950	80 - Not Pumping
Oct. 2, 1950	76 - Not Pumping
Oct 12, 1950	73 - Not Pumping
Oct. 17, 1950	73 - Not Pumping
Oct. 24, 1950	72 - Not Pumping
Nov. 1, 1950	72 - Not Pumping
Nov. 8, 1950	72 - Not Pumping
Nov. 20, 1950	72 - Not Pumping
Nov. 27, 1950	71 - Not Pumping
Dec. 6, 1950	69 - Not Pumping
Dec. 11, 1950	68 - Not Pumping
Dec. 19, 1950	67 - Not Pumping
Dec. 26, 1950	66 - Not Pumping

RECEIVED
JAN 9 1951
STATE ENGINEER
SALEM, OREGON

5N/35-1E(1)
UMATILLA CO.

Water level from ground surface. Utah Canning Company, Milton-Freewater, Oregon well - PERMIT No. U-158, for the year 1951

Date	Feet
1/2	66 - Not Pumping
1/8	66 - " "
1/16	66 " "
1/22	65 " "
1/29	67 " "
2/5	68 " "
2/13	71 " "
2/20	73 " "
2/28	74 " "
3/5	76 " "
3/12	76 " "
3/19	76 " "
3/26	74 " "
4/3	62 " "
4/10	63 " "
4/17	64 " "
4/23	64 " "
4/30	63 " "
5/8	63 " "
5/14	61 " "
5/23	63 " "
6/4/	64 - Started Pumping
6/5	85 - Pumping
6/9	85NotPumping
6/11	88 " "
6/15	84 " "
6/17	95 Pumping
6/18	98 "
6/19	100 "
6/20	100 "
6/21	100 "
6/22	102 "
6/23	100 "
6/24	105 "
6/25	102 "
6/26	108 "
6/27	105 "
6/28	105 "
6/29	105 "
6/30	107 "
7/1	107 "
7/2	107 "
7/3	105 "
7/4	105 "
7/5	107 "
7/6	109 "
7/7	101 "
7/8	107 "
7/9	107 "
7/10	103 "
7/11	109 "
7/12	107 - Pumping
7/13	102 "
7/14	105 "
7/15	103 - " (Last Day)
7/18	92 Not Pumping
7/25	89 " "
7/31	87 " "
8/8	85 " "
8/15	83 " "
8/23	83 " "
8/31	82 " "
9/7	80 " "
9/14	78 " "
9/21	78 " "
9/28	77 " "
10/5	75 " "
10/11	77 " "
10/18	75 " "
10/22	75 " "
10/30	75 " "
11/9	74 " "
11/16	74 " "
11/19	74 " "
11/29	75 " "
12/3	75 " "
12/10	75 " "
12/17	74 " "
12/27	73 " "
12/31	73 " "

RECEIVED
JAN 14 1952
STATE ENGINEER
SALEM, OREGON

UMAT 3908

Key Well

RECEIVED
FEB 5 1954
STATE ENGINEER
SALEM, OREGON

5N/35 -1E(1)
UMATILLA CO

Water level from ground surface. Utah Canning Company, Milton-Freewater Oregon - Well #1 - Permit No. U-158, for the year 1953.

1953	Ft.	
1/8	74	Not Pumping
1/15	75	" "
1/22	77	" "
1/26	77	" "
2/2	79	" "
2/16	78	" "
2/23	81	" "
3/2	83	" "
3/9	79	" "
3/16	79	" "
3/23	78	" "
3/30	78	" "
4/6	78	" "
4/27	73	" "
5/4	73	" "
5/11	77	" "
5/18	81	" "
5/25	83	" "
6/2	76	" "
6/8	74	" "
6/15	78	" "
6/22	83	" "
6/30	110	Pumping
7/1	115	"
7/2	112	"
7/3	115	"
7/4	113	"
7/5	114	"
7/6	112	"
7/7	114	"
7/8	114	"
7/9	114	"
7/10	115	"

1953	Ft.	
7/11	119	Pumping
7/12	117	"
7/13	116	"
7/14	117	"
7/15	117	"
7/16	115	"
7/17	118	"
7/18	110	"
7/20	111	"
7/27	93	Not Pumping
8/5	91	" "
8/10	89	" "
8/17	86	" "
8/24	84	" "
8/31	82	" "
9/8	80	" "
9/15	83	" "
9/22	84	" "
9/28	76	" "
10/5	74	" "
10/12	72	" "
10/19	73	" "
10/26	70	" "
11/2	69	" "
11/9	67	" "
11/16	71	" "
11/23	73	" "
11/30	78	" "
12/7	78	" "
12/14	80	" "
12/21	80	" "
12/28	81	" "

UMAT 3908

Key Well

3N/35-1E(H)
Umatilla Co

Water level from ground surface. Utah Canning Company, Milton-Freewater Oregon - Well #1 - Permit No. U-158, for the year 1954.

1954	Ft.		
1/4	81	Not	Pumping
1/11	83	"	"
1/18	83	"	"
1/25	83	"	"
2/1	84	"	"
2/8	80	"	"
2/15	77	"	"
2/22	78	"	"
3/1	76	"	"
3/8	76	"	"
3/15	76	"	"
3/22	76	"	"
3/29	75	"	"
4/5	75	"	"
4/12	75	"	"
4/19	78	"	"
4/26	74	"	"
5/3	74	"	"
5/10	73	"	"
5/17	73	"	"
5/24	73	"	"
6/1	73	"	"
6/7	68	"	"
6/14	67	"	"
6/21	69	"	"
6/24	74	Pumping	
6/25	101	"	
6/26	105	"	
6/27	107	"	
6/28	97	Not	Pumping
6/29	104	Pumping	
6/30	105	"	
7/1	97	Not	Pumping
7/3	108	Pumping	
7/4	108	"	
7/5	111	"	
7/6	110	"	
7/7	113	"	
7/8	112	"	

1954	Ft.		
7/9	112	Pumping	
7/10	112	"	
7/11	112	"	
7/12	112	"	
7/13	109	"	
7/14	113	"	
7/15	117	"	
7/16	114	"	
7/17	95	Not	Pumping
7/18	96	"	"
7/19	95	"	"
7/20	96	"	"
7/21	110	Pumping	
7/22	110	"	
7/23	114	"	
7/26	96	Not	Pumping
8/2	95	"	"
8/9	92	"	"
8/16	90	"	"
8/23	80	"	"
8/30	77	"	"
9/6	74	"	"
9/13	73	"	"
9/20	71	"	"
9/27	71	"	"
10/4	69	"	"
10/11	67	"	"
10/18	67	"	"
10/25	66	"	"
11/1	67	"	"
11/8	68	"	"
11/15	70	"	"
11/22	72	"	"
11/29	74	"	"
12/6	75	"	"
12/13	76	"	"
12/20	73	"	"
12/27	71	"	"

Walla Walla River

Court--1000--2-40

STATE OF OREGON

COUNTY OF UMATILLA

CERTIFICATE OF WATER RIGHT

This Is to Certify, That MILTON CITY, a Municipal Corporation,

of Milton, State of Oregon, has a right to the use of

the waters of Walla Walla River

for the purpose of Domestic and Municipal

and that said right has been confirmed by decree of the Circuit Court of the State of Oregon for Umatilla County, and the said decree entered of record at Salem, in the Order Record of the STATE ENGINEER, in Volume 12, at page 9; that the priority of the right thereby confirmed dates from 1890;

that the amount of water to which such right is entitled, for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 7.24 cubic feet per second.

A description of the lands irrigated under such right, and to which the water is appurtenant (or, if for other purposes, the place where such water is put to beneficial use), is as follows:

PLACE OF USE: Within the boundaries of the CITY OF MILTON, Oregon.

AND said right shall be subject to all other conditions and limitations contained in said decree.

The right to the use of the water for irrigation purposes is restricted to the lands or place of use herein described.

WITNESS the signature of the State Engineer, affixed this 5th day of April, 1940.

CHAS. E. STRICKLIN
State Engineer.

Recorded in State Record of Water Right Certificates, Volume 11, page 12920

Appendix B

Site Visit Photographs

Well #1 eastside

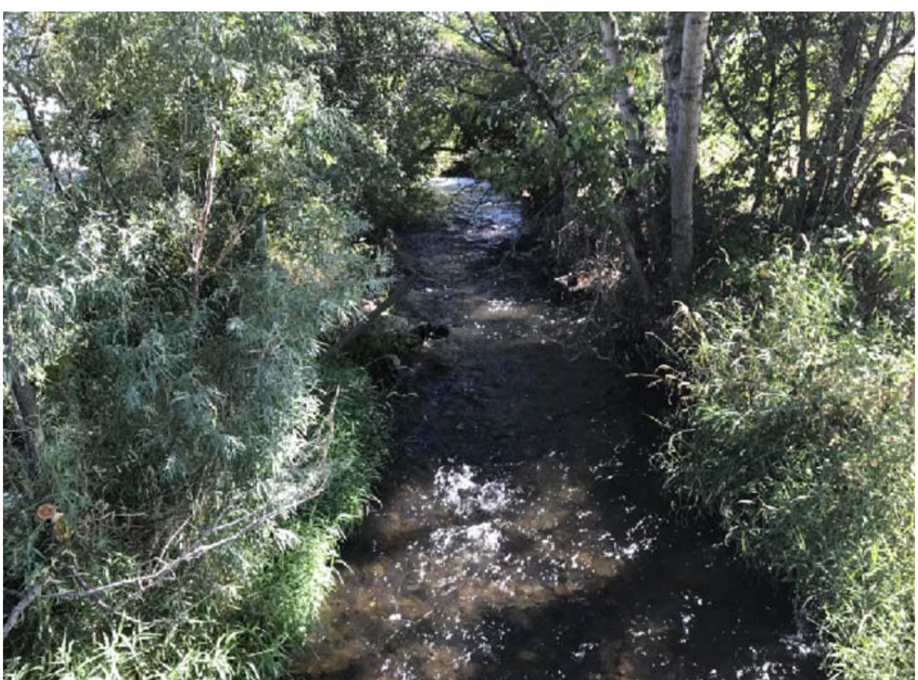
Well #1 inside looking west

Well #1 inside looking east

Well #1 southside

Well #5 southside

Little Walla Walla River at Well #5



Diversion at Little Walla Walla River

Diversion at Little Walla Walla River

Marie Dorion Park and well #8 looking south

Well #8 westside

Well #8 inside north end

Well #8 inside south end pump

Well #8 east side

Old Milton-Freewater powerplant

Well #9 northside

Well #9 inside looking east

Technical Memorandum

Date: November 9, 2018

Project: 17-2076

To: Mr. Kevin Lindsay, PhD, LHg – Principal Hydrogeologist
GeoEngineers, Inc.

From: Brian Ginter, PE – Murraysmith
Phil Brown, RG, LHg – Northwest Groundwater Services, LLC

Re: Milton-Freewater Aquifer Storage and Recovery Feasibility Study Project - Investigation of Water Treatment Alternatives (Task 3)

Introduction

This memorandum documents work completed under Task 3 of the Milton-Freewater Aquifer Storage and Recovery (ASR) Feasibility Study Project. Work under this task involves developing a water treatment alternative recommendation for meeting the requirements of ORS-690-350, and the Oregon Health Authority treatment technique requirements.

This memorandum also documents the water quality data for the proposed surface water supply to be used for ASR recharge and presents a comparison of it to City of Walla Walla surface water and groundwater data to assess whether there are indications that geochemical compatibility will differ from Walla Walla's successful ASR project. The purpose of the comparison is to assess whether the samples are sufficiently similar to allow an opinion that geochemistry is, or is not, a significant issue with respect to ASR feasibility in Milton-Freewater.

Groundwater and Surface Water Comparison

Purpose

In support of Task 3 of the Milton-Freewater Aquifer Storage and Recovery Feasibility Study Project (ASR/FS), the source waters and receiving waters for the project were compared to the source waters and receiving waters of the Walla Walla ASR project, which has been operating successfully. The comparison was done to determine whether there is in obvious risk for geochemical compatibility issues to arise in the Milton-Freewater ASR project.

The analytical program selected for this phase of the project was designed to facilitate two elements of this phase of the feasibility study:

1. Allow comparison of the general geochemistry of source and receiving waters in Milton-Freewater with a nearby operating ASR project to allow an assessment of the potential for geochemical reactions that may require treatment to mitigate, and;
2. Assess the potential for the presence of common agricultural chemicals in surface water that may require additional treatment prior to injection.

The need for additional treatment is completed early as it may influence the determination of feasibility. The geochemical analyte list is the typical suite of cations, anions, physical parameters and some metals that are used in comparison of waters and geochemical compatibility modeling. The semi-volatile organic compounds (SVOCs) were selected in consultation with Oregon DEQ to identify the most common agricultural chemicals that would indicate influence from agricultural runoff. The actual geochemical modeling will be completed in later project phases when the complete suite of analyses required for source and receiving water characterization by OAR 690-350 (ASR Rule) is conducted.

Two methods were used to compare the cation and anion chemistry for the surface water which is the source water and groundwater for the AR project. Stiff diagrams were prepared to visually demonstrate the similarity of the waters. Piper plots were also prepared to compare some of the finer details of the chemistry in the water samples that are not easily seen in the stiff diagrams.

Methods

Laboratory results used for comparison were from the Milton-Freewater ASR sampling event conducted between March and April 2018, have been provided in Appendix 1 and summarized in Table 1. Source water or surface water samples for the Milton-Freewater ASR project are from the Walla Walla River at the point of diversion (sample ID: MF-ASR-WWR-030118) and the Little Walla Walla River (sample IDs: MF-ASR-LWWR-1 and MF-ASR-LWWR-2). Receiving water or groundwater samples for the Milton Free Water ASR project are from Well No. 5 (sample ID: MF-ASR-W5-030118). Historical source water results were collected on February 24, 1999, and the historical receiving (groundwater) sample results used for comparison were collected on April 15, 1999 for Well No. 1 and Well No. 2. Both historical source and receiving waters were reported in the 1999 Walla Walla Baseline Source Water and Native Groundwater Quality Report, and the report tables have been provided in Appendix 2. Field forms for these events have been provided in Appendix 3. The hydrographs for the Walla Walla River showing flow rates at the time of sample collection are provided in Appendix 4. Because of the proximity—both the source waters (with headwaters relatively close to each other in the Blue Mountains) and the same basalt aquifer are only 12 miles apart—the Walla Walla project appears to be a good geochemical analog for the project considered by Milton-Freewater.

A comparison of receiving waters was done by comparing general ion chemistry from Milton-Freewater Well No. 5 to Walla Walla ASR Wells No. 1 and No. 2, and a comparison for the source waters was done by comparing the samples collected from the Walla Walla and Little Walla Walla

Rivers for Milton-Freewater to the Mill Creek characterization sample used for the source water for the Walla Walla ASR project. The Walla Walla ASR project at Well No. 1 did not exhibit geochemical stability issues and has been operating successfully for nearly 2 decades. Therefore, if the source water and receiving waters for Milton-Freewater ASR project closely resemble those for the Walla Walla ASR project, then speciation or stability problems associated with ion chemistry in the Milton-Freewater ASR project are unlikely. Although geochemical compatibility will be modeled as part of the permitting process, this early assessment was used to inform the water treatment assessment whether additional source water modification was needed to avoid a detrimental reaction.

The Stiff diagrams were created using Zeta Stiff Version 1.0, a stiff diagram generating software produced by ZetaWare (1998). GW-Chart Version 1.29.0.0 was used for creating the Piper plots. GW_Chart is a free USGS software that generates calibration plots and operated as a graphing tool for Model Analysis but also contains a Piper plotting feature.

Assumptions

Total alkalinity was reported for all samples as mg/L $CaCO_3$. To construct the stiff diagrams and piper plots this needed to be converted to mg/L bicarbonate (HCO_3^-) and mg/L carbonate (CO_3^{2-}). Since the pH of all samples was reported to be below 8.5, the assumption was made that all of the total alkalinity is bicarbonate. This assumption is supported by the fact that carbonate was reported as non-detect for Walla Walla ASR Wells No. 1 and No. 2. To adjust between total alkalinity below pH 8.5 and bicarbonate a simple 1.22 conversion factor was used, and is justified as follows:

- $CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$
- $CaCO_3$ has a molecular weight of 100 g/mol
- HCO_3 has a molecular weight of 61 g/mol
- Each mol of $Ca(HCO_3)_2$ corresponds to one mol of $CaCO_3$ and contains two HCO_3 which is 2x61 grams = 122 grams of HCO_3^-. The final conversion is as follows:
- 1.22 x Total Alkalinity as $CaCO_3$ (mg/L) = Bicarbonate Alkalinity as HCO_3^-.

Results

Receiving Water – Groundwater

The stiff diagram for the groundwater comparison is provided in Figure 1. Visual inspection of the stiff diagram shows three very similar polygons. Milton-Freewater Well No. 5 (blue) closely resembles historical results from Walla Walla ASR Wells No. 1 and No. 2 (purple); however, the details in the piper diagram (Figure 2) indicate that chloride and sulfate are slightly elevated in Milton-Freewater ASR Well No. 5 compared to Walla Walla. The actual concentrations of chloride for these wells are 6.46 mg/L for Milton-Freewater Well No. 5 and 1.4 mg/L and 1.9 mg/L in Walla Wall ASR wells No. 1 and No. 2, respectively. All other ions are tightly grouped in similar positions on the piper diagram.

Source Water – Surface Water

The stiff diagram for the surface water comparison is provided in Figure 3. The three surface water samples for the Milton-Freewater ASR (point of diversion on the Walla Walla River and two Little Walla Walla River samples in blue) appear to closely resemble the historical Mill Creek sample from the Walla Walla ASR project (purple). The polygons for the Little Walla Walla appear most like the Mill Creek sample. However, inspection of the piper diagram (Figure 4) shows that chloride is slightly lower in the Milton-Freewater source water samples when compared to the Mill Creek sample. The actual concentrations for the Milton-Freewater ASR source waters range from 0.416 mg/L in the Little Walla Walla RIver to 0.500 mg/L in the Walla Walla River at the point of diversion. The concentration of chloride in Mill Creek was 2.9 mg/L in February 1999. All other ions are tightly grouped on the piper diagram.

Conclusion

This limited initial look at the potential for geochemical compatibility issues for the Milton-Freewater ASR finds that there is sufficient similarity to the Walla Walla water qualities that feasibility-limiting speciation reaction (precipitation/dissolution) do not appear likely. Although chloride varies slightly in both the receiving and source waters from those of the Walla Walla ASR, a speciation or stability problem related to this difference is not expected to occur because all other ions in the receiving and sources waters are nearly identical to those found in the Walla Walla ASR project. Consequently, modifying source water to mitigate reactivity prior to injection should not be considered at this phase of the Feasibility Study. A complete geochemical compatibility analysis will be completed as part of the Limited License application.

Review of Identified Diversion Locations and Water Treatment Alternatives

Overview

Under current State of Oregon rules for ASR, OAR 690-350-0020, the source water to be used for ASR recharge must be treated to meet drinking water standards. The Task 2 memorandum presented an analysis of potential diversion locations for supply of recharge water at potential ASR well sites and an assessment of available treatment techniques that may be applied to meet Oregon Health Authority regulations for treatment of surface water to drinking water standards prior to recharge. Four primary mechanical treatment alternatives were identified: Slow Sand Filtration, Conventional Rapid Sand Filtration, Packaged Treatment Units, and Membrane Filtration. In addition, Riverbank Filtration may be feasible, either as a primary treatment technique or in tandem with one of the 4 mechanical treatment options. This memorandum will focus on confirming the findings from Task 2, that membrane filtration is the preferred treatment methodology for treatment of Little Walla Walla River (or Walla Walla River) surface water for ASR injection. This conclusion is based on the following:

- Membrane filtration is a robust treatment alternative that can be adapted to a wide range of treatment requirements which may not fully be defined prior to pilot testing.
- Membrane treatment systems are most readily scaled for a variety of treatment capacity demands ranging from pilot testing for a single well to a centralized surface water treatment facility for transmission of finished water to a build-out ASR system with multiple wells.
- It may be feasible to rent/lease modular and mobile membrane treatment systems for ASR pilot testing to reduce risk of capital investment prior to validation of ASR feasibility.

A brief description of the key findings from the water quality testing results, presented early in this document, for the purposes of defining surface water treatment requirements is presented below.

Water Quality Results

Table 1 summarized the results from the water quality sampling of surface water in the Walla Walla River and Little Walla Walla River. For the purposes of this analysis, the water quality samples from the Little Walla River will be used as the basis for evaluation of feasible treatment techniques. In general, the results indicate the following:

- Samples were non-detect for all primary Safe Drinking Water Act (SDWA) regulated contaminants including SOCs and VOCs, and well below the Maximum Contaminant Level (MCL) for all secondary contaminants.

- Under low and high flow conditions in March, turbidity levels were consistently low (less than 10 NTUs) in the Little Walla Walla River.

- All samples were positive for the presence of Total Coliform and E.coli.

Treatment Requirements and Performance Standards

Oregon Administrative Rules Division 333, Chapter 61, establishes criteria under which filtration and treatment technique requirements are prescribed in lieu of MCLs for the following contaminants: Giardia lamblia, viruses, heterotrophic plate count bacteria, Legionella, Cryptosporidium, and turbidity. At every public water system with a surface water source or a groundwater source under the direct influence of surface water, water suppliers must provide treatment of source water that complies with these treatment technique requirements. Recharge water for ASR is required to meet these criteria prior to injection into the ASR well.

Of primary concern for selection of appropriate treatment techniques for this feasibility study is the removal of turbidity, Cryptosporidium, giardia and virus inactivation). A brief description of each is presented below.

Turbidity

The presence and levels of turbidity in the raw water limits the feasibility of use of the Little Walla Walla River as an unfiltered source. If turbidity levels routinely exceed, 5 NTUs, which the 2 samples collected in March indicate that it is likely to occur, the reliable operation of a surface water intake on the Little Walla Walla River will require filtration. Each of the identified treatment alternatives will effectively reduce turbidity levels to meet drinking water standards. Depending on actual peak turbidity levels in the river during high flow events, additional treatment processes, including sedimentation and flocculation prior to filtration, may be required. One advantage of membrane filtration as the selected treatment technique is that increased levels of turbidity during higher flows may increase backwash requirements and reduce filtration efficiency, but overall filtered water quality can be expected to remain high. This would likely be more challenging with conventional or packaged filtration treatment systems that do not include pretreatment processes.

Collection of additional raw water quality turbidity at the proposed diversion locations should continue through the next year to obtain a better understanding of the range of turbidity levels that will need to be addressed by the selected treatment process.

Cryptosporidium and Giardia

All surface water sources are classified into one of four categories, or bins, based on the likely presence of cryptosporidium in the water. The classification process is part of routine water quality monitoring required by the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The bin classification of the surface water defines the level of removal (on a $\log_{10}$ scale) of Cryptosporidium that must be achieved through treatment techniques. Since the diversion location will be a new surface water supply for the City, a conservative assumption is that the bin classification of the source will be Bin 4 requiring a 5.5-log removal of Cryptosporidium.

A source water monitoring plan, approved by the Oregon Heath Authority, should be conducted in order to determine the Bin classification for this new surface water source.

If the source water is classified as Bin 1, which is unlikely given the nature of the Walla Walla River watershed, then no additional treatment would be required specifically for Cryptosporidium and Giardia. A Bin classification of 2 or greater would trigger a requirement for filtration.

Membrane filtration provides a robust level of removal for cryptosporidium. In Oregon, challenge studies have been performed multiple membrane units resulting in verified cryptosporidium removal performance. All of these membrane units achieve a 4-log removal of cryptosporidium. In addition, they meet the required 3-log removal of giardia. As long as the source is not classified into Bin 3 or 4, no additional treatment processes will be required for Cryptosporidium removal.

Viruses

4-log removal or inactivation of viruses is required for a surface water source. This is most typically achieved through inactivation, either through disinfection by ultraviolet light (UV) or chlorine disinfection. If additional cryptosporidium removal is required because of the LT2ESWTR Bin classification described above (Bin 3 or 4), then UV disinfection may effectively achieve both the required Cryptosporidium inactivation and 4-log inactivation of viruses.

Maintenance of a chlorine residual, achieved through the addition of liquid sodium hypochlorite post-filtration, is also recommended for finished water to be sued for ASR recharge. A chlorine disinfectant residual will help limit bio-fouling potential in the well.

For the purposes of this study, it should be assumed that the treatment system will include both UV and chlorine disinfection.

Consideration of Riverbank Filtration

Riverbank filtration, if determined feasible, may be considered as a pre-treatment option to achieve some reduction in Cryptosporidium log-removal required through membrane filtration and UV disinfection. Riverbank filtration may provide up to 1-log removal (with a 50-foot setback) of Cryptosporidium. For a Bin 3 or 4 classification, Riverbank Filtration could avoid the need for UV disinfection. Further study would be needed to determine if Riverbank Filtration could be successfully implemented for this surface water source at the planned point of diversion.

Summary of Treatment Requirements

Based on the water quality data collected to date and a review of Oregon and EPA rules for treatment of surface water for drinking water systems, membrane filtration with chlorine disinfection is the minimum treatment requirement that can be expected. Additionally, raw water turbidity and LT@ESWTR Bin classification could require the addition of pre-filtration sedimentation processes and UV disinfection post-filtration. Alternately, if these additional processes are required, riverbank filtration may present an alternative to implementing additional treatment processes beyond membrane filtration.

For the purposes of pilot testing, a modular membrane treatment unit with UV disinfection will effectively meet drinking water standards using the most conservative assumptions regarding raw water quality.

BMG:bmg

Table 1: Milton-Freewater ASR Receiving and Source Water Analytical Results

		Sample Location:	**Well #5 Groundwater**				**Surface Water @ Point of Diversion on Walla Walla River**				**Surface Water @ Little Walla Walla River behind Well #5**				**Surface Water @ Little Walla Walla River behind Well #5**				**Notes**
		Sample ID:	*MF-ASR-W5-030118*				*MF-ASR-WWR-030118*				*MF-ASR-LWWR-1*				*MF-ASR-LWWR-2*				
		Sample Date/Time:	3/1/18 9:45 AM				3/1/18 11:20 AM				3/15/18 10:55 AM				4/5/2018 14:40:00 PM [1]				
		Batch:	180302017				180302020				180316032				180410059				
		Lab Name:	*Anatek Laboratorties*				*Anatek Laboratorties*				*Anatek Laboratorties*				*Anatek Laboratorties*				
ANALYTE GROUP / Analyte	**Units**	**Drinking Water Standard MCL/SMCL**	**MDL**	**RDL**	**Result**	**Q**	**MDL**	**RDL**	**Result**	**Q**	**MDL**	**RDL**	**Result**	**Q**	**MDL**	**RDL**	**Result**	**Q**	
GENERAL CHEMISTRY (GC)																			Groundwater & Surface water
Alkalinity (total)	mg CaCO3/L	NA	2	2	**80**		2	2	**30.0**		2	2	**26.0**		2	2	**28**		[b]
Temperature	degrees Fahrenheit		–––	–––	–––		–––	–––	–––		–––	–––	–––		–––	–––	–––		
Chloride	mg/L	/250	0.01	0.1	**6.46**		0.01	0.1	**0.500**		0.01	0.1	**0.420**		0.01	0.1	**0.416**		
Fluoride	mg/L	4.0/2.0	0.071	0.1	**0.123**		0.071	0.1	ND		0.071	0.1	ND		0.071	0.1	ND		
Hardness	mg CaCO3/L	/250	0.1	1	**82.2**		0.1	1	**23.8**		0.1	1	**21.0**		0.1	1	**22.1**		
Nitrate+Nitrite (total N)	mg/L as N	10	0.01	0.1	**0.493**		0.01	0.1	ND		0.01	0.1	ND		0.01	0.1	ND		
Nitrate-N	mg/L as N	10	0.076	0.1	**0.493**		0.076	0.1	ND		0.076	0.1	ND		0.076	0.1	ND		
Nitrite-N	mg/L as N	1	0.063	0.1	ND		0.063	0.1	ND		0.063	0.1	ND		0.063	0.1	ND		
Orthophosphate as P	mg/L	NA	0.042	0.1	ND		0.042	0.1	ND		0.042	0.1	ND		0.042	0.1	ND		
Oxidation-Reduction Potential	millivolts	NA	–––	–––	-41		–––	–––	-18.5		–––	–––	-38.3		–––	–––	-28.6		
pH	pH units	/6.5-8.5	1	–––	7.85		1	–––	7.29		1	–––	7.30		1		7.41		
Specific Conductance	µS/cm	/700	1	1	**235**		1	1	**65.0**		1	1	**55.2**		1	1	**63.8**		
Sulfate	mg/L	/250	0.057	0.1	**10.6**		0.057	0.1	**0.822**		0.057	0.1	**0.648**		0.057	0.1	**0.609**		
Total Dissolved Solids	mg/L	/500	30	50	**129**		30	50	**47**		30	50	**76.0**		30	50	**74.0**		
Turbidity	NTU	1	0.01	0.1	**0.56**		0.01	0.1	**1.30**		0.01	0.1	**5.11**		0.01	0.1	**1.99**		
Total Kjeldahl nitrogen	mg/L	NA	0.357	0.5	ND		0.357	0.5	ND		0.464	0.5	ND		0.464	0.5	ND		
TOTAL METALS (M)																			Groundwater & Surface water
Arsenic	mg/L	0.010	0.001	0.001	ND		0.001	0.001	ND		0.001	0.001	ND		0.001	0.001	ND		[a]
Calcium	mg/L	NA	0.03	0.1	**19.6**		0.01	0.1	**5.71**		0.03	0.1	**5.12**		0.03	0.1	**5.37**		[c]
Copper	mg/L	1.3*	0.001	0.001	0.00100		0.001	0.001	ND		0.001	0.001	**0.00125**		0.001	0.001	ND		[a,c]
Iron	mg/L	/0.3	0.0018	0.01	ND		0.0018	0.01	**0.168**		0.0018	0.01	**0.941**		0.0018	0.01	**0.241**		[c]
Iron (dissolved)	mg/L	NA	0.01	0.01	ND		0.01	0.01	**0.0315**		0.01	0.01	**0.138**		0.01	0.01	**0.0176**		[c]
Lead	mg/L	0.015 (AL)	0.001	0.001	ND		0.001	0.001	ND		0.001	0.001	ND		0.001	0.001	ND		[a,b,c]
Magnesium	mg/L	NA	0.001	0.1	**8.06**		0.001	0.1	**2.24**		0.001	0.1	**1.99**		0.001	0.1	**2.11**		[c]
Manganese	mg/L	/0.05	0.01	0.01	ND		0.01	0.01	ND		0.01	0.01	**0.0121**		0.01	0.01	ND		[c]
Manganese (dissolved)	mg/L	NA	0.01	0.01	ND		0.01	0.01	ND		0.01	0.01	ND		0.01	0.01	ND		[c]
Mercury	mg/L	0.002	0.00001	0.0001	ND		0.00001	0.0001	ND		0.00001	0.0001	ND		0.00001	0.0001	ND		[a,b,c]
Potassium	mg/L	NA	0.05	0.1	**3.70**		0.05	0.1	**1.48**		0.05	0.1	**1.37**		0.05	0.1	**1.49**		[c]
Sodium	mg/L	20**	0.05	0.1	**8.96**		0.05	0.1	**2.7**		0.05	0.1	**2.15**		0.05	0.1	**2.64**		[c]
Zinc	mg/L	/5	0.001	0.001	**0.00372**		0.001	0.001	**0.00128**		0.001	0.001	**0.00198**		0.001	0.001	ND		[c]
MISCELLANEOUS (MISC)																			Groundwater & Surface water
Corrosivity	Standard units	/non-corrosive	–––	–––	-0.134		–––	–––	-1.07		–––	–––	-1.14		–––	–––	-0.994		
BACTERIOLOGICALS (BAC)																			Surface water only
Total Coliform (Presence/Absence)	cfu/100mL		–––	–––	–––		1	1	Present	[4]	1	1	Present	[5]	1	1	Present	[5]	
SYNTHETIC ORGANIC CHEMICALS (SOC)																			Surface water only
Chlordane, Technical	µg/L	2	–––	–––	–––		0.0288	0.2	ND		0.0288	0.2	ND		0.0288	0.2	ND		[a,b]
Glyphosate [2]	µg/L	700	–––	–––	–––		3.2	5	ND		3.2	5	ND		3.2	5	ND		[a]
Heptachlor Epoxide	µg/L	0.2	–––	–––	–––		0.0165	0.02	ND		0.0165	0.02	ND		0.0165	0.02	ND		[a,b]
Hexachlorobenzene	µg/L	1	–––	–––	–––		0.0066	0.1	ND		0.0066	0.1	ND		0.0066	0.1	ND		[a,b]
Hexachlorocyclopentadiene	µg/L	50	–––	–––	–––		0.011	0.1	ND		0.011	0.1	ND		0.011	0.1	ND		[a,b]
Lindane (BHC - GAMMA)	µg/L	0.2 as total PAH's	–––	–––	–––		0.0152	0.04	ND		0.0152	0.04	ND		0.0152	0.04	ND		[a,c]
Aroclor 1016 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.08	0.08	ND		0.08	0.08	ND		0.08	0.08	ND		[a,b]
Aroclor 1221 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.5	1	ND		0.5	1	ND		0.5	1	ND		[a,b]
Aroclor 1232 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.1	0.5	ND		0.1	0.5	ND		0.1	0.5	ND		[a,b]
Aroclor 1242 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.1	0.3	ND		0.1	0.3	ND		0.1	0.3	ND		[a,b]

Table 1: Milton-Freewater ASR Receiving and Source Water Analytical Results

Sample Location:			Well #5 Groundwater				Surface Water @ Point of Diversion on Walla Walla River				Surface Water @ Little Walla Walla River behind Well #5				Surface Water @ Little Walla Walla River behind Well #5				Notes
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Sample Date/Time:			3/1/18 9:45 AM				3/1/18 11:20 AM				3/15/18 10:55 AM				4/5/2018 14:40:00 PM [1]				
Batch:			180302017				180302020				180316032				180410059				
Lab Name:			*Anatek Laboratorties*				*Anatek Laboratorties*				*Anatek Laboratorties*				*Anatek Laboratorties*				
ANALYTE GROUP / Analyte	**Units**	**Drinking Water Standard MCL/SMCL**	**MDL**	**RDL**	**Result**	**Q**	**MDL**	**RDL**	**Result**	**Q**	**MDL**	**RDL**	**Result**	**Q**	**MDL**	**RDL**	**Result**	**Q**	
Aroclor 1248 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.1	0.1	ND		0.1	0.1	ND		0.1	0.1	ND		a,b
Aroclor 1254 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.1	0.1	ND		0.1	0.1	ND		0.1	0.1	ND		a,b
Aroclor 1260 (PCB)	µg/L	0.5 as total PCB's	–––	–––	–––		0.1	0.2	ND		0.1	0.2	ND		0.1	0.2	ND		a,b
Total PCB	µg/L		–––	–––	–––		0.095	0.5	ND		0.095	0.5	ND		0.095	0.5	ND		
Pentachlorophenol	µg/L	1	–––	–––	–––		0.04	0.04	ND		0.04	0.04	ND		0.04	0.04	ND		a,b
Malathion [3]	µg/L		–––	–––	–––		0.1	0.2	ND		0.1	0.2	ND		0.1	0.2	ND		
Chlorpyrifos [3]	µg/L		–––	–––	–––		0.0165	0.2	ND		0.0165	0.2	ND		0.0165	0.2	ND		
Azinphos-methyl [3]	µg/L		–––	–––	–––		0.1	0.1	ND		0.1	0.1	ND		0.1	0.1	ND		
VOLATILE ORGANIC CHEMICALS (VOC)																			Surface water only
Benzene	µg/L	5	–––	–––	–––		0.1	0.5	ND		0.1	0.5	ND		0.1	0.5	ND		
Ethylbenzene	µg/L	700	–––	–––	–––		0.1	0.5	ND		0.1	0.5	ND		0.1	0.5	ND		
Toluene	µg/L	1000	–––	–––	–––		0.1	0.5	ND		0.1	0.5	ND		0.1	0.5	ND		
Total Xylenes	µg/L	10000	–––	–––	–––		0.1	0.5	ND		0.1	0.5	ND		0.1	0.5	ND		

Notes:

[1] - Chain of custody has the wrong date written on it. Sample was collected on 4/5/2018.

[2] - Glyphosphate was chosen as a herbicide proxy.

[3] - Chosen as a pesticide proxy as it is a common organophosphate based on conversation with WA DEQ, will analyzed using EPA Method 8141 for water, not drinking water.

[4] - Anatek Lab analyzed this sample accidentally and are not certified in Oregon to meet drinking water standards.

[5] - Table Rock Analytical Laboratories analyzed for total coliform as they are certified to meet drinking water standards in Oregon.

BOLD = Result detected above method RDL.

Data Sources used to reduce analytical list:

[a] - Listed in OAR 330-061-0030.

[b] - Anderson Petty & Associates, 2011. City of Milton-Freewater, Oregon Water Management and Conservation Plan Update Addendum. May. p.16.

[c] - GeoSystems Analysis, Inc., 2016. Surface Water and Groundwater Monitoring and Reporting Plan. May. Table 5.

* Action Level set by the EPA

** Guideline level recommended by the EPA

MCL = Maxiumim Contaminant Level

SMCL = Secondary Maximum Contaminant Level

MDL = Method Detection Limit

RDL = Representative Detection Limit

Q = Qualifier

pCi/L = Picocuries per liter

PCB = Polychlinated biphenyl

mg CaCO3/L = milligram of calcium carbonate per liter

µg/L = Micrograms per liter

µS/cm = Micro-Siemens per centimeter

mg/L = Milligrams per liter

NTU = Nephelometric turbidity unit

MV = Millivolts

ND = Not detected

Figure 1: Milton-Freewater Stiff Diagram Groundwater Comparison

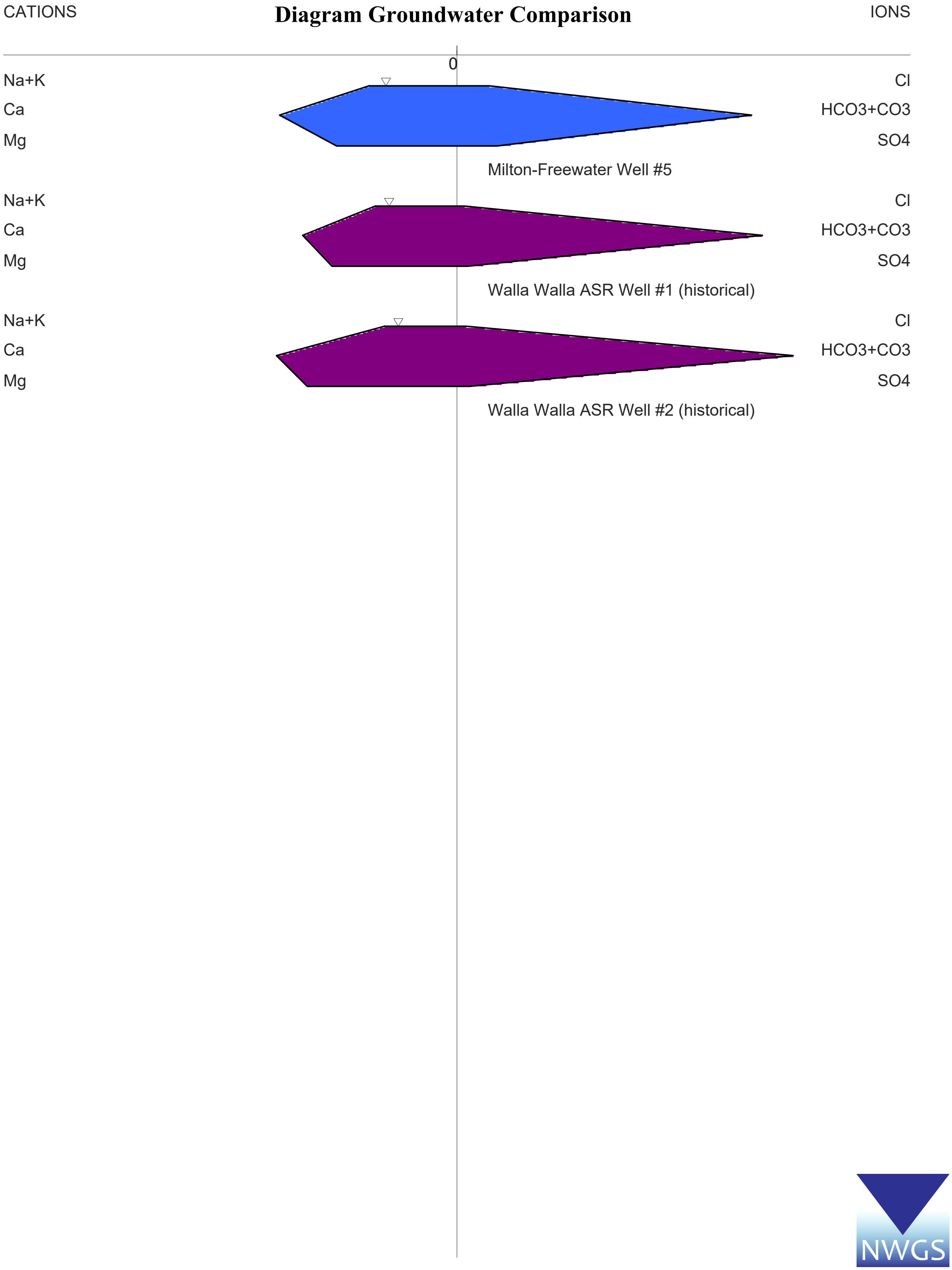


Figure 2: Milton-Freewater Piper Diagram Groundwater Comparison

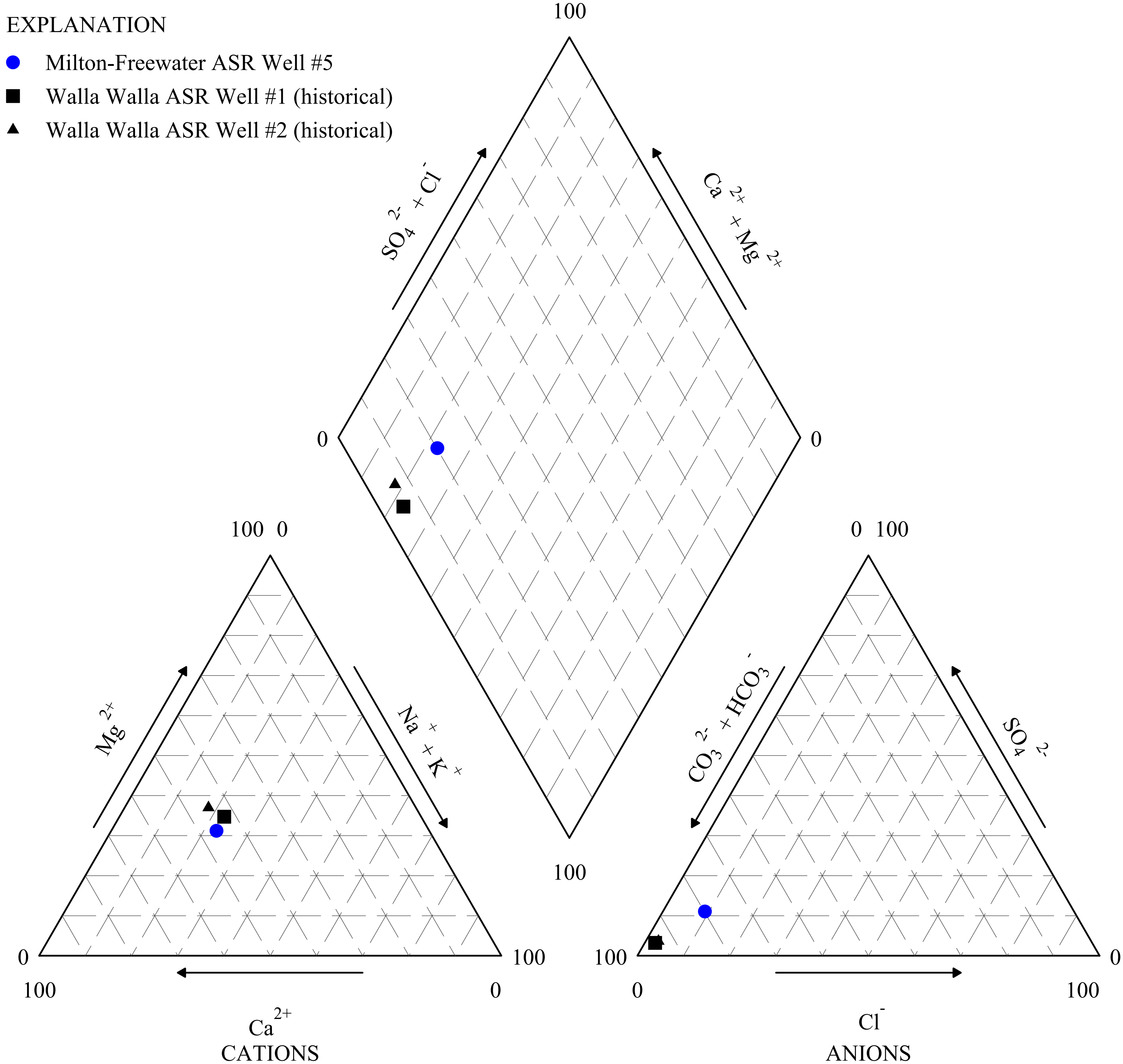
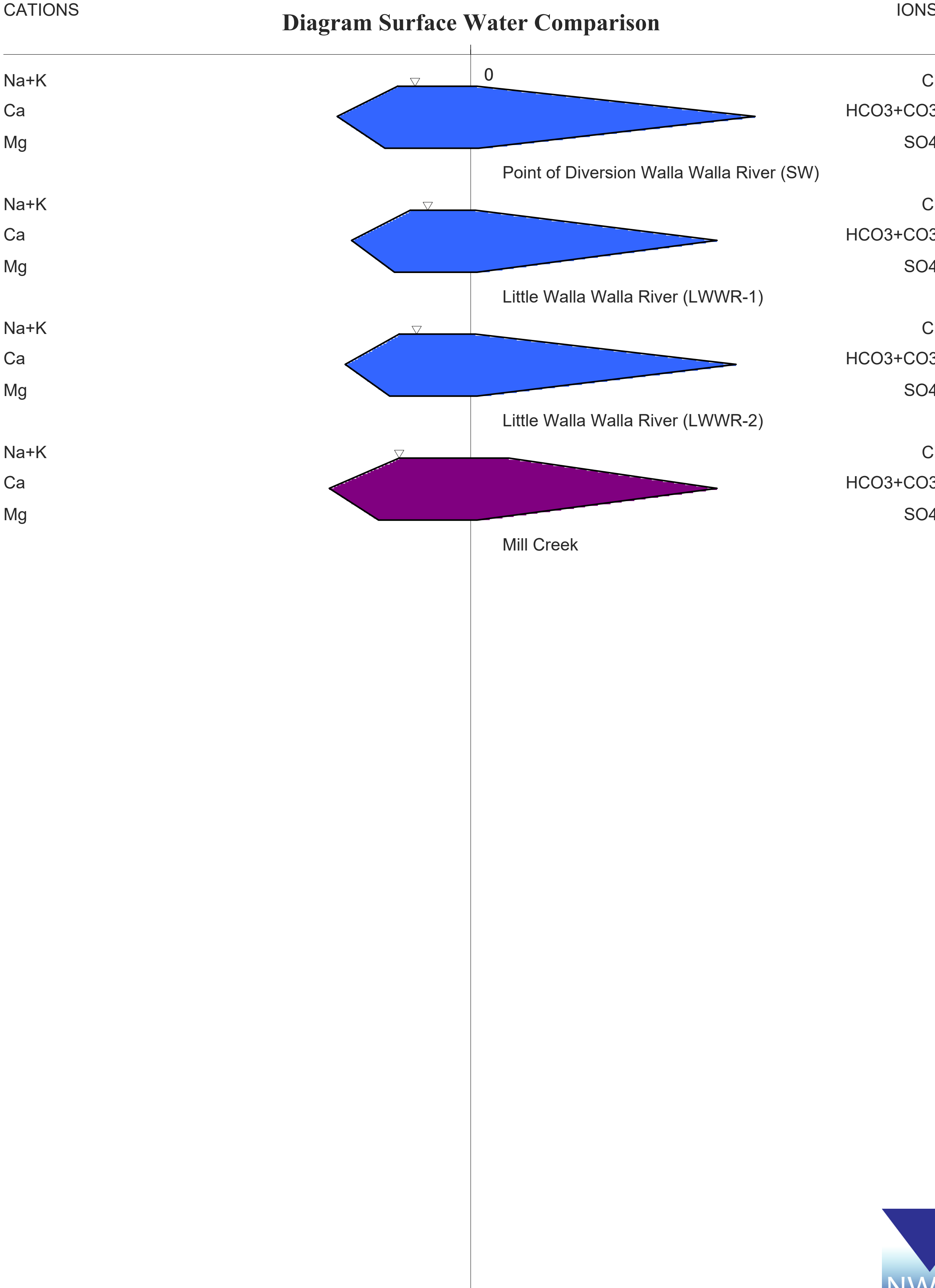
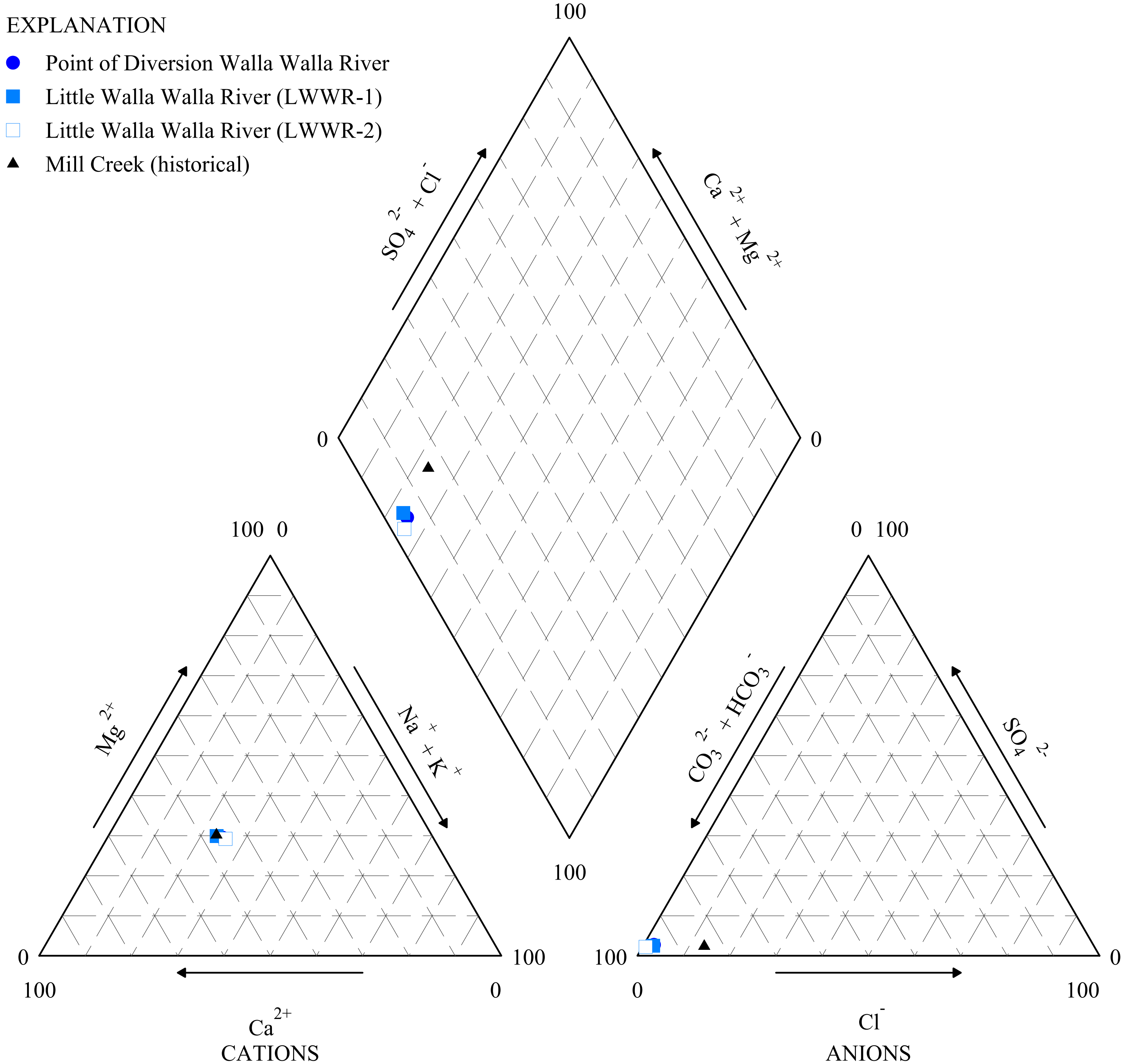


Figure 3: Milton-Freewater Stiff Diagram Surface Water Comparison



NWGS

Figure 4: Milton-Freewater Piper Diagram Surface Water Comparison



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504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Client: EA ENGINEERING
Address: 8019 W QUINAULT AVE, STE D
KENNEWICK, WA 99336
Attn: KEVIN LINDSEY

Batch #: 180302017
Project Name: MILTON-FREEWATER ASR 1556301

Analytical Results Report

Sample Number 180302017-001
Client Sample ID MF-ASR-W5-030118
Matrix Drinking Water
Comments

Sampling Date 3/1/2018
Sampling Time 9:45 AM
Sample Location

Date/Time Received 3/2/2018 11:02 AM
Extraction Date

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Alkalinity	80.0	mg CaCO3/L	2	3/6/2018	RPU	SM2320B	
Arsenic	ND	mg/L	0.001	3/7/2018	ETL	EPA 200.8	
Chloride	6.46	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
Conductivity	235	µmhos/cm	1	3/6/2018	RPU	SM 2510B	
Copper	0.00100	mg/L	0.001	3/7/2018	ETL	EPA 200.8	
Corrosivity	-0.134			3/14/2018	ETL	Calculation	
Dissolved Iron	ND	mg/L	0.01	3/6/2018	SDR	EPA 200.7	
Dissolved Manganese	ND	mg/L	0.01	3/6/2018	SDR	EPA 200.7	
Fluoride	0.123	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
Calcium	19.6	mg CaCO3/L	0.1	3/6/2018	SDR	EPA 200.7	
Hardness	82.2	mg CaCO3/L	1	3/6/2018	SDR	EPA 200.7	
Magnesium	8.06	mg CaCO3/L	0.1	3/6/2018	SDR	EPA 200.7	
Iron	ND	mg/L	0.01	3/6/2018	SDR	EPA 200.7	
Lead	ND	mg/L	0.001	3/7/2018	ETL	EPA 200.8	
Manganese	ND	mg/L	0.01	3/6/2018	SDR	EPA 200.7	
Mercury-ICPMS	ND	mg/L	0.0001	3/7/2018	ETL	EPA 200.8	
NO3/N	0.493	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
NO3/N+NO2/N	0.493	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
NO2/N	ND	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
Oxidation-Reduction Potential	-41.0	millivolts		3/6/2018	RPU	SM 2580B	
pH	7.85	ph Units		3/6/2018	RPU	SM 4500pH-B	
PO4/P	ND	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
Potassium	3.70	mg/L	0.1	3/6/2018	SDR	EPA 200.7	
Sodium	8.96	mg/L	0.1	3/6/2018	SDR	EPA 200.7	
TDS	129	mg/L	50	3/8/2018 6:00:00 PM	RPU	SM 2540C	
Sulfate	10.6	mg/L	0.1	3/2/2018 8:03:00 PM	MER	EPA 300.0	
TKN	ND	mg/L	0.5	3/6/2018	RPU	SM4500NORGC	
Turbidity	0.56	NTU	0.1	3/6/2018	RPU	EPA 180.1	H1
Zinc	0.00372	mg/L	0.001	3/7/2018	ETL	EPA 200.8	

Authorized Signature

Todd Taruscio, Lab Manager

H1 Sample analysis performed past holding time.
MCL EPA's Maximum Contaminant Level
ND Not Detected
PQL Practical Quantitation Limit

The results reported relate only to the samples indicated.
Soil/solid results are reported on a dry-weight basis unless otherwise noted.

Certifications held by Anatek Labs ID: EPA:ID00013; AZ:0701; FL(NELAP):E87893; ID:ID00013; MT:CERT0028; NM: ID00013;NV:ID00013; OR:ID200001-002; WA:C595
Certifications held by Anatek Labs WA: EPA:WA00169; ID:WA00169; WA:C585; MT:Cert0095; FL(NELAP): E871099

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Login Report

Customer Name: EA ENGINEERING
8019 W QUINAULT AVE, STE D
KENNEWICK WA 99336

Order ID: 180302017
Order Date: 3/2/2018

Contact Name: KEVIN LINDSEY
Project Name: MILTON-FREEWATER ASR 1556301
Comment:

Sample #: 180302017-001 **Customer Sample #:** MF-ASR-W5-030118

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** PATTY NEWMAN **Date Collected:** 3/1/2018
Quantity: 4 **Date Received:** 3/2/2018 11:02:00 AM **Time Collected:** 9:45 AM
Comment:

Test	Lab	Method	Due Date	Priority
ALKALINITY	M	SM2320B	3/14/2018	Normal (~10 Days)
ARSENIC	M	EPA 200.8	3/14/2018	Normal (~10 Days)
CHLORIDE	M	EPA 300.0	3/14/2018	Normal (~10 Days)
CONDUCTIVITY	M	SM 2510B	3/14/2018	Normal (~10 Days)
COPPER	M	EPA 200.8	3/14/2018	Normal (~10 Days)
Corrosivity	M	Calculation	3/14/2018	Normal (~10 Days)
DISSOLVED IRON BY ICP	M	EPA 200.7	3/14/2018	Normal (~10 Days)
DISSOLVED MANGANESE BY ICP	M	EPA 200.7	3/14/2018	Normal (~10 Days)
FLUORIDE	M	EPA 300.0	3/14/2018	Normal (~10 Days)
HARDNESS by EPA 200.7	M	EPA 200.7	3/14/2018	Normal (~10 Days)
IRON ICP	M	EPA 200.7	3/14/2018	Normal (~10 Days)
LEAD	M	EPA 200.8	3/14/2018	Normal (~10 Days)
MANGANESE ICP	M	EPA 200.7	3/14/2018	Normal (~10 Days)
MERCURY-ICPMS	M	EPA 200.8	3/14/2018	Normal (~10 Days)
NITRATE/N	M	EPA 300.0	3/14/2018	Normal (~10 Days)
NITRATE+ NITRITE AS N	M	EPA 300.0	3/14/2018	Normal (~10 Days)
NITRITE/N	M	EPA 300.0	3/14/2018	Normal (~10 Days)
OXIDATION-REDUCTION POTENTIAL	M	SM 2580B	3/14/2018	Normal (~10 Days)
pH	M	SM 4500pH-B	3/14/2018	Normal (~10 Days)
PHOSPHATE/P	M	EPA 300.0	3/14/2018	Normal (~10 Days)
POTASSIUM ICP	M	EPA 200.7	3/14/2018	Normal (~10 Days)
SODIUM ICP	M	EPA 200.7	3/14/2018	Normal (~10 Days)
SOLIDS - TDS	M	SM 2540C	3/14/2018	Normal (~10 Days)

Customer Name:	EA ENGINEERING	**Order ID:**	180302017
	8019 W QUINAULT AVE, STE D	**Order Date:**	3/2/2018
	KENNEWICK WA 99336		
Contact Name:	KEVIN LINDSEY	**Project Name:**	MILTON-FREEWATER ASR 1556301
Comment:			

SULFATE	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
TKN	M	SM4500NORGC	3/14/2018	***Normal (~10 Days)***
TURBIDITY	M	EPA 180.1	3/14/2018	***Normal (~10 Days)***
ZINC	M	EPA 200.8	3/14/2018	***Normal (~10 Days)***

SAMPLE CONDITION RECORD

Samples received in a cooler?	Yes
Samples received intact?	Yes
What is the temperature of the sample(s)? (°C)	3.9
Samples received with a COC?	Yes
Samples received within holding time?	Yes
Are all sample bottles properly preserved?	Yes
Are VOC samples free of headspace?	N/A
Is there a trip blank to accompany VOC samples?	N/A
Labels and chain agree?	Yes
Total number of containers?	4

180302 017 EENG Last Due 3/14/2018
1st SAMP 3/1/2018 1st RCVD 3/2/2018
MILTON-FREEWATER ASR 1556301

Anatek Labs, Inc.

Chain of Custody Record

1282 Alturas Drive, Moscow ID 83843 (208) 883-2839 FAX 882-9246
504 E Sprague Ste D, Spokane WA 99202 (509) 838-3999 FAX 838-4433

Company Name: EA Engineering, Inc., PBC	Project Manager: Kevin Lindsey		
Address: 8019 W Quinault Ave., Suite 201	Project Name & #: Milton-Freewater ASR 1556301		
City: Kennewick State: WA Zip: 99336	Email Address: PNEWMAN@EAEST.COM		
Phone: (509) 591-0264	Purchase Order #:		
Fax:	Sampler Name & phone: Patty Newman 509-591-0876		

Turn Around Time & Reporting

Please refer to our normal turn around times at: http://www.anateklabs.com/services/guidelines/reporting.asp

✓ Normal
__Next Day*
__2nd Day*
__Other*______

*All rush order requests must be prior approved.

__Phone
__Mail
__Fax
__Email

Provide Sample Description / **List Analyses Requested** (Preservative:)

Lab ID	Sample Identification	Sampling Date/Time	Matrix	# of Containers	Sample Volume	See Attached
	MF-ASR-W5-030118	03/01/2018 0945	W	4	2L	x

Note Special Instructions/Comments

****SEE ATTACHED****

SEE ATTTACHED TABLE FOR ANALYTES

MWB?

	Printed Name	Signature	Company	Date	Time
Relinquished by	Patty Newman	[signature]	EA	3/1/18	1436
Received by	Leigham Corritt	Leigham Corritt	Anatek	3/2/18	1102
Relinquished by					
Received by					
Relinquished by					
Received by					

Inspection Checklist

Received Intact?	(Y)	N
Labels & Chains Agree?	(Y)	N
Containers Sealed?	(Y)	N
VOC Head Space?	Y	N

UPS
Temperature (°C): 3.9 IR-2
Preservative: H_2SO_4, HCl

Date & Time:______
Inspected By:______

Table 1 Full Analytical Suite

ANALYTE GROUP / Analyte	Units	Drinking Water Standard / Criteria	Notes
GENERAL CHEMISTRY (GC)			Groundwater & Surface water
Alkalinity (total)	mg CaCO3/L		b
Temperature	degrees Fahrenheit		
Chloride	mg/L	250 (SMCL)	
Fluoride	mg/L	2.0 (SMCL), 4.0 (MCL)	
Hardness	mg CaCO3/L	250 (SMCL)	
Nitrate+Nitrite (total N)	mg/L as N	10	
Nitrate-N	mg/L as N	10	
Nitrite-N	mg/L as N	1	
Orthophosphate as P	mg/L		
Oxidation-Reduction Potential	millivolts		
pH	pH units	6.5 to 8.5 (SMCL)	
Specific Conductance	µS/cm	700 (SMCL)	
Sulfate	mg/L	250 (SMCL)	
Total Dissolved Solids	mg/L	500 (SMCL)	
Turbidity	NTU	1	
Total Kjeldahl nitrogen			
TOTAL METALS (M)			Groundwater & Surface water
Arsenic	mg/L	0.010	a
Calcium	mg/L		c
Copper	mg/L	1.3*	a,c
Iron	mg/L	0.3 (SMCL)	c
Iron (dissolved)	mg/L		c
Lead	mg/L	0.015*	a,b,c
Magnesium	mg/L		c
Manganese	mg/L	0.05 (SMCL)	c
Manganese (dissolved)	mg/L		c
Mercury	mg/L	0.002	a,b,c
Potassium	mg/L		c
Sodium	mg/L	20**	c
Zinc	mg/L	5	c
MISCELLANEOUS (MISC)			Groundwater & Surface water
Corrosivity	Standard units	Non-corrosive	
BACTERIOLOGICALS (BAC)			Surface water only
Total Coliform (Presence/Absence)	cfu/100mL	absent	Method SM 9221 B, C per the proposal Will be analyzed by Table Rock but Anatek will bill EA directly
SYNTHETIC ORGANIC CHEMICALS (SOC)			Surface water only
Chlordane, Technical	µg/L	2	a,b
Glyphosate [1]	µg/L	700	a
Heptachlor Epoxide	µg/L	0.2	a,b
Hexachlorobenzene	µg/L	1	a,b
Hexachlorocyclopentadiene	µg/L	50	a,b
Lindane (BHC - GAMMA)	µg/L	0.2 as total PAH's	a,c
Aroclor 1016 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1221 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1232 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1242 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1248 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1254 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1260 (PCB)	µg/L	0.5 as total PCB's	a,b
Pentachlorophenol	µg/L	1	a,b
Malathion [2]	µg/L		
Chlorpyrifos [2]	µg/L		
Azinphos-methyl [2]	µg/L		
VOLATILE ORGANIC CHEMICALS (VOC)			Surface water only
Benzene	µg/L	5	
Ethylbenzene	µg/L	700	
Toluene	µg/L	1000	
Total Xylenes	µg/L	10000	

Notes:

[1] - Glyphosphate was chosen as a herbicide proxy.

[2] - Chosen as a pesticide proxy as it is a common organophosphate based on conversation with WA DEQ, will analyzed using EPA Method 8141 for water, not drinking water.

Data Sources used to reduce analytical list:

[a] - Listed in OAR 330-061-0030.

[b] - Anderson Petty & Associates, 2011. City of Milton-Freewater, Oregon Water Management and Conservation Plan Update Addendum. May. p.16.

[c] - GeoSystems Analysis, Inc., 2016. Surface Water and Groundwater Monitoring and Reporting Plan. May. Table 5.

* Action Level set by the EPA
** Guideline level recommended by the EPA
MCL = Maxiumim Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MDL = Method Detection Limit
RL = Reporting Limit
µg/L = Micrograms per liter
µS/cm = Micro-Siemens per centimeter
mg/L = Milligrams per liter
NTU = Nephelometric turbidity unit
MV = Millivolts

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504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Client:	EA ENGINEERING	**Batch #:**	180302020
Address:	8019 W QUINAULT AVE, STE D KENNEWICK, WA 99336	**Project Name:**	MILTON-FREEWATER ASR 1556301
Attn:	KEVIN LINDSEY		

Analytical Results Report

Sample Number	180302020-001	**Sampling Date**	3/1/2018	**Date/Time Received**	3/2/2018	11:06 AM
Client Sample ID	MF-ASR-WWR-030118	**Sampling Time**	11:20 AM			
Matrix	Drinking Water					
Comments						

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Alkalinity	30.0	mg CaCO3/L	2	3/6/2018	RPU	SM2320B	
Arsenic	ND	mg/L	0.001	3/12/2018	HSW	EPA 200.8	
E. Coli	PRESENT	cfu/100ml	1	3/2/2018	LAC	SM9223B	
Total Coliform	PRESENT	cfu/100ml	1	3/2/2018	LAC	SM9223B	
Chloride	0.500	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
Conductivity	65.0	µmhos/cm	1	3/6/2018	RPU	SM 2510B	
Copper	ND	mg/L	0.001	3/12/2018	HSW	EPA 200.8	
Corrosivity	-1.07			3/14/2018	ETL	Calculation	
Dissolved Iron	0.0315	mg/L	0.01	3/6/2018	SDR	EPA 200.7	
Dissolved Manganese	ND	mg/L	0.01	3/6/2018	SDR	EPA 200.7	
Fluoride	ND	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
Glyphosate	ND	ug/L	5	3/6/2018 9:06:00 PM	MER	EPA 547	
Calcium	5.81	mg CaCO3/L	0.1	3/9/2018	SDR	EPA 200.7	
Hardness	23.8	mg CaCO3/L	1	3/9/2018	SDR	EPA 200.7	
Magnesium	2.24	mg CaCO3/L	0.1	3/9/2018	SDR	EPA 200.7	
Pentachlorophenol	ND	ug/L	0.04	3/7/2018 4:11:00 AM	MAH	EPA 515.4	
Iron	0.168	mg/L	0.01	3/14/2018	SDR	EPA 200.7	
Lead	ND	mg/L	0.001	3/12/2018	HSW	EPA 200.8	
Manganese	ND	mg/L	0.01	3/9/2018	SDR	EPA 200.7	
Mercury-ICPMS	ND	mg/L	0.0001	3/12/2018	HSW	EPA 200.8	
NO3/N	ND	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
NO3/N+NO2/N	ND	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
NO2/N	ND	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
Oxidation-Reduction Potential	-18.5	millivolts		3/6/2018	RPU	SM 2580B	
Aroclor 1016 (PCB-1016)	ND	ug/L	0.08	3/7/2018 9:18:00 PM	MAH	EPA 505	
Aroclor 1221 (PCB-1221)	ND	ug/L	1	3/7/2018 9:18:00 PM	MAH	EPA 505	
Aroclor 1232 (PCB-1232)	ND	ug/L	0.5	3/7/2018 9:18:00 PM	MAH	EPA 505	
Aroclor 1242 (PCB-1242)	ND	ug/L	0.3	3/7/2018 9:18:00 PM	MAH	EPA 505	
Aroclor 1248 (PCB-1248)	ND	ug/L	0.1	3/7/2018 9:18:00 PM	MAH	EPA 505	
Aroclor 1254 (PCB-1254)	ND	ug/L	0.1	3/7/2018 9:18:00 PM	MAH	EPA 505	
Aroclor 1260 (PCB-1260)	ND	ug/L	0.2	3/7/2018 9:18:00 PM	MAH	EPA 505	
Chlordane	ND	ug/L	0.2	3/7/2018 9:18:00 PM	MAH	EPA 505	
PCBs	ND	ug/L	0.5	3/7/2018 9:18:00 PM	MAH	EPA 505	
pH	7.29	ph Units		3/6/2018	RPU	SM 4500pH-B	

Certifications held by Anatek Labs ID: EPA:ID00013; AZ:0701; FL(NELAP):E87893; ID:ID00013; MT:CERT0028; NM: ID00013;NV:ID00013; OR:ID200001-002; WA:C595
Certifications held by Anatek Labs WA: EPA:WA00169; ID:WA00169; WA:C585; MT:Cert0095; FL(NELAP): E871099

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Client:	EA ENGINEERING	**Batch #:**	180302020
Address:	8019 W QUINAULT AVE, STE D KENNEWICK, WA 99336	**Project Name:**	MILTON-FREEWATER ASR 1556301
Attn:	KEVIN LINDSEY		

Analytical Results Report

Sample Number	180302020-001	**Sampling Date**	3/1/2018	**Date/Time Received**	3/2/2018	11:06 AM
Client Sample ID	MF-ASR-WWR-030118	**Sampling Time**	11:20 AM			
Matrix	Drinking Water					
Comments						

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
PO4/P	ND	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
Potassium	1.48	mg/L	0.1	3/9/2018	SDR	EPA 200.7	
Chlorpyrifos	ND	ug/L	0.2	3/15/2018 7:04:00 PM	BMM	EPA 525.2	
gamma-BHC (Lindane)	ND	ug/L	0.04	3/15/2018 7:04:00 PM	BMM	EPA 525.2	
Heptachlor epoxide	ND	ug/L	0.02	3/15/2018 7:04:00 PM	BMM	EPA 525.2	
Hexachlorobenzene	ND	ug/L	0.1	3/15/2018 7:04:00 PM	BMM	EPA 525.2	
Hexachlorocyclopentadiene	ND	ug/L	0.1	3/15/2018 7:04:00 PM	BMM	EPA 525.2	
Malathion	ND	ug/L	0.2	3/15/2018 7:04:00 PM	BMM	EPA 525.2	
Azinphos-methyl	ND	ug/L	0.2	3/17/2018	BMM	EPA 525.2	
Sodium	2.77	mg/L	0.1	3/9/2018	SDR	EPA 200.7	
TDS	47	mg/L	50	3/8/2018 6:00:00 PM	RPU	SM 2540C	
Sulfate	0.822	mg/L	0.1	3/2/2018 8:46:00 PM	MER	EPA 300.0	
TKN	ND	mg/L	0.5	3/6/2018	RPU	SM4500NORGC	
Turbidity	1.30	NTU	0.1	3/6/2018	RPU	EPA 180.1	H1
Benzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Ethylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Toluene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Total Xylene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Zinc	0.00128	mg/L	0.001	3/12/2018	HSW	EPA 200.8	

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KENNEWICK, WA 99336
Attn: KEVIN LINDSEY

Batch #: 180302020
Project Name: MILTON-FREEWATER ASR 1556301

Analytical Results Report

Sample Number 180302020-001A **Sampling Date** 3/1/2018 **Date/Time Received** 3/2/2018 11:06 AM
Client Sample ID MF-ASR-WWR-030118A **Sampling Time** 11:20 AM
Matrix Drinking Water
Comments

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Calcium	5.71	mg/L	0.1	3/14/2018	SDR	EPA 200.7	
1,1,1,2-Tetrachloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,1,1-Trichloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,1,2,2-Tetrachloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,1,2-Trichloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,1-Dichloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,1-Dichloroethene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,1-dichloropropene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2,3-Trichlorobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2,3-Trichloropropane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2,4-Trichlorobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2,4-Trimethylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2-Dibromo-3-chloropropane(	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2-Dibromoethane (EDB)	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2-Dichlorobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2-Dichloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,2-Dichloropropane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,3,5-Trimethylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,3-Dichlorobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,3-Dichloropropane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,3-Dichloropropene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
1,4-Dichlorobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
2,2-Dichloropropane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
2-Chlorotoluene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
4-Chlorotoluene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Acetone	ND	ug/L	2.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Benzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Bromobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Bromochloromethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Bromodichloromethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Bromoform	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Bromomethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Carbon Tetrachloride	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Chlorobenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Chloroethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	

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Client: EA ENGINEERING
Address: 8019 W QUINAULT AVE, STE D
KENNEWICK, WA 99336
Attn: KEVIN LINDSEY

Batch #: 180302020
Project Name: MILTON-FREEWATER ASR 1556301

Analytical Results Report

Sample Number 180302020-001A **Sampling Date** 3/1/2018 **Date/Time Received** 3/2/2018 11:06 AM
Client Sample ID MF-ASR-WWR-030118A **Sampling Time** 11:20 AM
Matrix Drinking Water
Comments

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Chloroform	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Chloromethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
cis-1,2-dichloroethene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
cis-1,3-Dichloropropene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Dibromochloromethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Dibromomethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Dichlorodifluoromethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Ethylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Hexachlorobutadiene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Isopropylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
m+p-Xylene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Methylene chloride	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
methyl-t-butyl ether (MTBE)	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Naphthalene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
n-Butylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
n-Propylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
o-Xylene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
p-isopropyltoluene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
sec-Butylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Styrene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
tert-Butylbenzene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Tetrachloroethene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Toluene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Total Xylene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
trans-1,2-Dichloroethene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
trans-1,3-Dichloropropene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Trichloroethene	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Trichlorofluoromethane	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	
Vinyl Chloride	ND	ug/L	0.5	3/9/2018 1:26:00 PM	SAT	EPA 524.3	

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Client: EA ENGINEERING
Address: 8019 W QUINAULT AVE, STE D
KENNEWICK, WA 99336
Attn: KEVIN LINDSEY

Batch #: 180302020
Project Name: MILTON-FREEWATER ASR 1556301

Analytical Results Report

Sample Number 180302020-002
Client Sample ID TRIP BLANK
Matrix Drinking Water
Comments

Sampling Date 3/1/2018
Sampling Time

Date/Time Received 3/2/2018 11:06 AM

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Benzene	ND	ug/L	0.5	3/9/2018 2:07:00 PM	SAT	EPA 524.3	
Ethylbenzene	ND	ug/L	0.5	3/9/2018 2:07:00 PM	SAT	EPA 524.3	
Toluene	ND	ug/L	0.5	3/9/2018 2:07:00 PM	SAT	EPA 524.3	
Total Xylene	ND	ug/L	0.5	3/9/2018 2:07:00 PM	SAT	EPA 524.3	

Authorized Signature

Todd Taruscio, Lab Manager

H1 Sample analysis performed past holding time.
MCL EPA's Maximum Contaminant Level
ND Not Detected
PQL Practical Quantitation Limit

The results reported relate only to the samples indicated.
Soil/solid results are reported on a dry-weight basis unless otherwise noted.

Certifications held by Anatek Labs ID: EPA:ID00013; AZ:0701; FL(NELAP):E87893; ID:ID00013; MT:CERT0028; NM: ID00013;NV:ID00013; OR:ID200001-002; WA:C595
Certifications held by Anatek Labs WA: EPA:WA00169; ID:WA00169; WA:C585; MT:Cert0095; FL(NELAP): E871099

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Login Report

Customer Name: EA ENGINEERING
8019 W QUINAULT AVE, STE D
KENNEWICK WA 99336

Order ID: 180302020
Order Date: 3/2/2018

Contact Name: KEVIN LINDSEY

Project Name: MILTON-FREEWATER ASR 1556301

Comment:

Sample #: 180302020-001 **Customer Sample #:** MF-ASR-WWR-030118

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** PATTY NEWMAN **Date Collected:** 3/1/2018

Quantity: 16 **Date Received:** 3/2/2018 11:06:00 AM **Time Collected:** 11:20 AM

Comment:

Test	Lab	Method	Due Date	Priority
ALKALINITY	M	SM2320B	3/14/2018	***Normal (~10 Days)***
ARSENIC	M	EPA 200.8	3/14/2018	***Normal (~10 Days)***
BACT - TOTAL/ECOLI COLILERT	M	SM9223B	3/14/2018	***Normal (~10 Days)***
CHLORIDE	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
CONDUCTIVITY	M	SM 2510B	3/14/2018	***Normal (~10 Days)***
COPPER	M	EPA 200.8	3/14/2018	***Normal (~10 Days)***
Corrosivity	M	Calculation	3/14/2018	***Normal (~10 Days)***
DISSOLVED IRON BY ICP	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
DISSOLVED MANGANESE BY ICP	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
FLUORIDE	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
GLYPHOSATE 547	M	EPA 547	3/14/2018	***Normal (~10 Days)***
HARDNESS by EPA 200.7	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
HERBICIDES 515.4	M	EPA 515.4	3/14/2018	***Normal (~10 Days)***
IRON ICP	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
LEAD	M	EPA 200.8	3/14/2018	***Normal (~10 Days)***
MANGANESE ICP	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
MERCURY-ICPMS	M	EPA 200.8	3/14/2018	***Normal (~10 Days)***
NITRATE/N	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
NITRATE+ NITRITE AS N	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
NITRITE/N	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
OXIDATION-REDUCTION POTENTIAL	M	SM 2580B	3/14/2018	***Normal (~10 Days)***
PESTICIDES 505	M	EPA 505	3/14/2018	***Normal (~10 Days)***
pH	M	SM 4500pH-B	3/14/2018	***Normal (~10 Days)***

Customer Name: EA ENGINEERING
8019 W QUINAULT AVE, STE D
KENNEWICK WA 99336

Order ID: 180302020
Order Date: 3/2/2018

Contact Name: KEVIN LINDSEY

Project Name: MILTON-FREEWATER ASR 1556301

Comment:

PHOSPHATE/P	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
POTASSIUM ICP	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
SEMIVOLATILES 525.2	M	EPA 525.2	3/14/2018	***Normal (~10 Days)***
SEMIVOLATILES 525.2 EXTENDED	M	EPA 525.2	3/14/2018	***Normal (~10 Days)***
SODIUM ICP	M	EPA 200.7	3/14/2018	***Normal (~10 Days)***
SOLIDS - TDS	M	SM 2540C	3/14/2018	***Normal (~10 Days)***
SULFATE	M	EPA 300.0	3/14/2018	***Normal (~10 Days)***
TKN	M	SM4500NORGC	3/14/2018	***Normal (~10 Days)***
TURBIDITY	M	EPA 180.1	3/14/2018	***Normal (~10 Days)***
VOLATILES 524.3	M	EPA 524.3	3/14/2018	***Normal (~10 Days)***
ZINC	M	EPA 200.8	3/14/2018	***Normal (~10 Days)***

Sample #: 180302020-002 **Customer Sample #:** TRIP BLANK

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** **Date Collected:** 3/1/2018
Quantity: 1 **Date Received:** 3/2/2018 11:06:00 AM **Time Collected:**
Comment:

Test	Lab	Method	Due Date	Priority
VOLATILES 524.3	M	EPA 524.3	3/14/2018	***Normal (~10 Days)***

SAMPLE CONDITION RECORD

Samples received in a cooler?	Yes
Samples received intact?	Yes
What is the temperature of the sample(s)? (°C)	5.5
Samples received with a COC?	Yes
Samples received within holding time?	Yes
Are all sample bottles properly preserved?	Yes
Are VOC samples free of headspace?	Yes
Is there a trip blank to accompany VOC samples?	Yes
Labels and chain agree?	Yes
Total number of containers?	16

180302 020 **EENG** Last Due 3/14/2018
1st SAMP 3/1/2018 1st RCVD 3/2/2018
Anatek Log-In # MILTON-FREEWATER ASR 1556301

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Chain of Custody Record

Company Name: EA Engineering, Inc., PBC	Project Manager: Kevin Lindsey
Address: 8019 W Quinault Ave., Suite 201	Project Name & #: Milton-Freewater ASR 1556301
City: Kennewick State: WA Zip: 99336	Email Address: PNEWMAN@EAEST.COM
Phone: (509) 591-0264	Purchase Order #:
Fax:	Sampler Name & phone: Patty Newman 509-591-0876

Turn Around Time & Reporting

Please refer to our normal turn around times at: http://www.anateklabs.com/services/guidelines/reporting.asp

✓ Normal
__Next Day*
__2nd Day*
__Other*______

*All rush order requests must be prior approved.

__Phone
__Mail
__Fax
__Email

Provide Sample Description				List Analyses Requested											
				Preservative:											
Lab ID	Sample Identification	Sampling Date/Time	Matrix	# of Containers	Sample Volume	See Attached									
-01	MF-ASR-WWR-030118	03/01/2018 1120	W	16	5L	×									
-02	Trip Blank														

Note Special Instructions/Comments

****SEE ATTACHED****

MWB?

SEE ATTTACHED TABLE FOR ANALYTES

Analyze bacteria per Patty N. -[illegible] 3/5/18

	Printed Name	Signature	Company	Date	Time
Relinquished by	Patty Newman	[illegible]	EA	3/1/18	1436
Received by	Leighann Conitt	Leighann Conitt	Anatek	3/2/18	1100
Relinquished by					
Received by					
Relinquished by					
Received by					

Inspection Checklist

Received Intact?	(Y)	N
Labels & Chains Agree?	(Y)	N
Containers Sealed?	(Y)	N
VOC Head Space?	Y	(N)

UPS
Temperature (°C): 5.5 IR-2
Preservative: Hcl, SS, NaThio, MA/AA H2SO4
Date & Time:
Inspected By:

Table 1 Full Analytical Suite

ANALYTE GROUP / Analyte	Units	Drinking Water Standard / Criteria	Notes
GENERAL CHEMISTRY (GC)			Groundwater & Surface water
Alkalinity (total)	mg CaCO3/L		b
Temperature	degrees Fahrenheit		
Chloride	mg/L	250 (SMCL)	
Fluoride	mg/L	2.0 (SMCL), 4.0 (MCL)	
Hardness	mg CaCO3/L	250 (SMCL)	
Nitrate+Nitrite (total N)	mg/L as N	10	
Nitrate-N	mg/L as N	10	
Nitrite-N	mg/L as N	1	
Orthophosphate as P	mg/L		
Oxidation-Reduction Potential	millivolts		
pH	pH units	6.5 to 8.5 (SMCL)	
Specific Conductance	µS/cm	700 (SMCL)	
Sulfate	mg/L	250 (SMCL)	
Total Dissolved Solids	mg/L	500 (SMCL)	
Turbidity	NTU	1	
Total Kjeldahl nitrogen			
TOTAL METALS (M)			Groundwater & Surface water
Arsenic	mg/L	0.010	a
Calcium	mg/L		c
Copper	mg/L	1.3*	a,c
Iron	mg/L	0.3 (SMCL)	c
Iron (dissolved)	mg/L		c
Lead	mg/L	0.015*	a,b,c
Magnesium	mg/L		c
Manganese	mg/L	0.05 (SMCL)	c
Manganese (dissolved)	mg/L		c
Mercury	mg/L	0.002	a,b,c
Potassium	mg/L		c
Sodium	mg/L	20**	c
Zinc	mg/L	5	c
MISCELLANEOUS (MISC)			Groundwater & Surface water
Corrosivity	Standard units	Non-corrosive	
BACTERIOLOGICALS (BAC)			Surface water only
Total Coliform (Presence/Absence)	cfu/100mL	absent	Method SM 9221 B, C per the proposal Will be analyzed by Table Rock but Anatek will bill EA directly
SYNTHETIC ORGANIC CHEMICALS (SOC)			Surface water only
Chlordane, Technical	µg/L	2	a,b
Glyphosate [1]	µg/L	700	a
Heptachlor Epoxide	µg/L	0.2	a,b
Hexachlorobenzene	µg/L	1	a,b
Hexachlorocyclopentadiene	µg/L	50	a,b
Lindane (BHC - GAMMA)	µg/L	0.2 as total PAH's	a,c
Aroclor 1016 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1221 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1232 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1242 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1248 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1254 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1260 (PCB)	µg/L	0.5 as total PCB's	a,b
Pentachlorophenol	µg/L	1	a,b
Malathion [2]	µg/L		
Chlorpyrifos [2]	µg/L		
Azinphos-methyl [2]	µg/L		
VOLATILE ORGANIC CHEMICALS (VOC)			Surface water only
Benzene	µg/L	5	
Ethylbenzene	µg/L	700	
Toluene	µg/L	1000	
Total Xylenes	µg/L	10000	

Notes:

[1] - Glyphosphate was chosen as a herbicide proxy.

[2] - Chosen as a pesticide proxy as it is a common organophosphate based on conversation with WA DEQ, will analyzed using EPA Method 8141 for water, not drinking water.

Data Sources used to reduce analytical list:

[a] - Listed in OAR 330-061-0030.

[b] - Anderson Petty & Associates, 2011. City of Milton-Freewater, Oregon Water Management and Conservation Plan Update Addendum. May. p.16.

[c] - GeoSystems Analysis, Inc., 2016. Surface Water and Groundwater Monitoring and Reporting Plan. May. Table 5.

* Action Level set by the EPA
** Guideline level recommended by the EPA
MCL = Maxiumim Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MDL = Method Detection Limit
RL = Reporting Limit
µg/L = Micrograms per liter
µS/cm = Micro-Siemens per centimeter
mg/L = Milligrams per liter
NTU = Nephelometric turbidity unit
MV = Millivolts

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504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Client:	EA ENGINEERING	**Batch #:**	180316032
Address:	8019 W QUINAULT AVE, STE D KENNEWICK, WA 99336	**Project Name:**	MILTON-FREEWATER ASR 1556301
Attn:	KEVIN LINDSEY		

Analytical Results Report

Sample Number	180316032-001	**Sampling Date**	3/15/2018	**Date/Time Received**	3/16/2018	9:45 AM
Client Sample ID	MF-ASR-LWWR-1	**Sampling Time**	10:55 AM			
Matrix	Drinking Water					
Comments						

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Alkalinity	26.0	mg CaCO3/L	2	3/21/2018 1:15:00 PM	RPU	SM2320B	
Arsenic	ND	mg/L	0.001	3/20/2018	HSW	EPA 200.8	
Chloride	0.420	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
Conductivity	55.2	µmhos/cm	1	3/21/2018 1:15:00 PM	RPU	SM 2510B	
Copper	0.00125	mg/L	0.001	3/20/2018	HSW	EPA 200.8	
Corrosivity	-1.14			3/27/2018	ETL	Calculation	
Dissolved Iron	0.138	mg/L	0.01	3/19/2018	SDR	EPA 200.7	
Dissolved Manganese	ND	mg/L	0.01	3/19/2018	SDR	EPA 200.7	
Fluoride	ND	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
Glyphosate	ND	ug/L	5	3/29/2018 11:02:00 AM	MER	EPA 547	
Calcium	5.12	mg CaCO3/L	0.1	3/19/2018	SDR	EPA 200.7	
Hardness	21.0	mg CaCO3/L	1	3/19/2018	SDR	EPA 200.7	
Magnesium	1.99	mg CaCO3/L	0.1	3/19/2018	SDR	EPA 200.7	
Pentachlorophenol	ND	ug/L	0.04	3/22/2018 2:00:00 AM	MAH	EPA 515.4	
Iron	0.941	mg/L	0.01	3/19/2018	SDR	EPA 200.7	
Lead	ND	mg/L	0.001	3/20/2018	HSW	EPA 200.8	
Manganese	0.0121	mg/L	0.01	3/19/2018	SDR	EPA 200.7	
Mercury-ICPMS	ND	mg/L	0.0001	3/20/2018	HSW	EPA 200.8	
NO3/N	ND	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
NO3/N+NO2/N	ND	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
NO2/N	ND	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
Oxidation-Reduction Potential	-38.3	millivolts		3/21/2018 1:15:00 PM	RPU	SM 2580B	
Aroclor 1016 (PCB-1016)	ND	ug/L	0.08	3/23/2018 12:09:00 AM	MAH	EPA 505	
Aroclor 1221 (PCB-1221)	ND	ug/L	1	3/23/2018 12:09:00 AM	MAH	EPA 505	
Aroclor 1232 (PCB-1232)	ND	ug/L	0.5	3/23/2018 12:09:00 AM	MAH	EPA 505	
Aroclor 1242 (PCB-1242)	ND	ug/L	0.3	3/23/2018 12:09:00 AM	MAH	EPA 505	
Aroclor 1248 (PCB-1248)	ND	ug/L	0.1	3/23/2018 12:09:00 AM	MAH	EPA 505	
Aroclor 1254 (PCB-1254)	ND	ug/L	0.1	3/23/2018 12:09:00 AM	MAH	EPA 505	
Aroclor 1260 (PCB-1260)	ND	ug/L	0.2	3/23/2018 12:09:00 AM	MAH	EPA 505	
Chlordane	ND	ug/L	0.2	3/23/2018 12:09:00 AM	MAH	EPA 505	
PCBs	ND	ug/L	0.5	3/23/2018 12:09:00 AM	MAH	EPA 505	
pH	7.30	ph Units		3/21/2018 1:15:00 PM	RPU	SM 4500pH-B	
PO4/P	ND	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
Potassium	1.37	mg/L	0.1	3/19/2018	SDR	EPA 200.7	

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Client:	EA ENGINEERING	**Batch #:**	180316032
Address:	8019 W QUINAULT AVE, STE D KENNEWICK, WA 99336	**Project Name:**	MILTON-FREEWATER ASR 1556301
Attn:	KEVIN LINDSEY		

Analytical Results Report

Sample Number	180316032-001	**Sampling Date**	3/15/2018	**Date/Time Received**	3/16/2018 9:45 AM
Client Sample ID	MF-ASR-LWWR-1	**Sampling Time**	10:55 AM		
Matrix	Drinking Water				
Comments					

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Chlorpyrifos	ND	ug/L	0.2	3/21/2018 11:03:00 PM	BMM	EPA 525.2	
gamma-BHC (Lindane)	ND	ug/L	0.04	3/21/2018 11:03:00 PM	BMM	EPA 525.2	
Heptachlor epoxide	ND	ug/L	0.02	3/21/2018 11:03:00 PM	BMM	EPA 525.2	
Hexachlorobenzene	ND	ug/L	0.1	3/21/2018 11:03:00 PM	BMM	EPA 525.2	
Hexachlorocyclopentadiene	ND	ug/L	0.1	3/21/2018 11:03:00 PM	BMM	EPA 525.2	
Malathion	ND	ug/L	0.2	3/21/2018 11:03:00 PM	BMM	EPA 525.2	
Azinphos-methyl	ND	ug/L	0.1	3/26/2018 3:49:00 PM	BMM	EPA 525.2	
Sodium	2.15	mg/L	0.1	3/19/2018	SDR	EPA 200.7	
TDS	76.0	mg/L	50	3/21/2018 5:00:00 PM	RPU	SM 2540C	
Sulfate	0.648	mg/L	0.1	3/16/2018 6:41:00 PM	MER	EPA 300.0	
TKN	ND	mg/L	0.5	4/4/2018 9:00:00 AM	MER	SM4500NORGC	
Turbidity	5.11	NTU	0.1	3/16/2018 3:00:00 PM	RPU	EPA 180.1	
Benzene	ND	ug/L	0.5	3/21/2018 11:11:00 AM	SAT	EPA 524.3	
Ethylbenzene	ND	ug/L	0.5	3/21/2018 11:11:00 AM	SAT	EPA 524.3	
Toluene	ND	ug/L	0.5	3/21/2018 11:11:00 AM	SAT	EPA 524.3	
Total Xylene	ND	ug/L	0.5	3/21/2018 11:11:00 AM	SAT	EPA 524.3	
Zinc	0.00198	mg/L	0.001	3/20/2018	HSW	EPA 200.8	

Authorized Signature

Todd Taruscio, Lab Manager

MCL EPA's Maximum Contaminant Level
ND Not Detected
PQL Practical Quantitation Limit

Certifications held by Anatek Labs ID: EPA:ID00013; AZ:0701; FL(NELAP):E87893; ID:ID00013; MT:CERT0028; NM: ID00013;NV:ID00013; OR:ID200001-002; WA:C595
Certifications held by Anatek Labs WA: EPA:WA00169; ID:WA00169; WA:C585; MT:Cert0095; FL(NELAP): E871099

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Login Report

Customer Name: EA ENGINEERING
8019 W QUINAULT AVE, STE D
KENNEWICK WA 99336

Order ID: 180316032
Order Date: 3/16/2018

Contact Name: KEVIN LINDSEY

Project Name: MILTON-FREEWATER ASR 1556301

Comment:

Sample #: 180316032-001 **Customer Sample #:** MF-ASR-LWWR-1

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** PATTY NEWMAN **Date Collected:** 3/15/2018
Quantity: 16 **Date Received:** 3/16/2018 9:45:00 AM **Time Collected:** 10:55 AM
Comment:

Test	Lab	Method	Due Date	Priority
ALKALINITY	M	SM2320B	3/28/2018	***Normal (~10 Days)***
ARSENIC	M	EPA 200.8	3/28/2018	***Normal (~10 Days)***
CHLORIDE	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***
CONDUCTIVITY	M	SM 2510B	3/28/2018	***Normal (~10 Days)***
COPPER	M	EPA 200.8	3/28/2018	***Normal (~10 Days)***
Corrosivity	M	Calculation	3/28/2018	***Normal (~10 Days)***
DISSOLVED IRON BY ICP	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
DISSOLVED MANGANESE BY ICP	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
FLUORIDE	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***
GLYPHOSATE 547	M	EPA 547	3/28/2018	***Normal (~10 Days)***
HARDNESS by EPA 200.7	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
HERBICIDES 515.4	M	EPA 515.4	3/28/2018	***Normal (~10 Days)***
IRON ICP	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
LEAD	M	EPA 200.8	3/28/2018	***Normal (~10 Days)***
MANGANESE ICP	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
MERCURY-ICPMS	M	EPA 200.8	3/28/2018	***Normal (~10 Days)***
NITRATE/N	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***
NITRATE+ NITRITE AS N	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***
NITRITE/N	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***
OXIDATION-REDUCTION POTENTIAL	M	SM 2580B	3/28/2018	***Normal (~10 Days)***
PESTICIDES 505	M	EPA 505	3/28/2018	***Normal (~10 Days)***
pH	M	SM 4500pH-B	3/28/2018	***Normal (~10 Days)***
PHOSPHATE/P	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***

Customer Name:	EA ENGINEERING	**Order ID:**	180316032
	8019 W QUINAULT AVE, STE D	**Order Date:**	3/16/2018
	KENNEWICK WA 99336		
Contact Name:	KEVIN LINDSEY	**Project Name:**	MILTON-FREEWATER ASR 1556301
Comment:			

POTASSIUM ICP	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
SEMIVOLATILES 525.2	M	EPA 525.2	3/28/2018	***Normal (~10 Days)***
SEMIVOLATILES 525.2 EXTENDED	M	EPA 525.2	3/28/2018	***Normal (~10 Days)***
SODIUM ICP	M	EPA 200.7	3/28/2018	***Normal (~10 Days)***
SOLIDS - TDS	M	SM 2540C	3/28/2018	***Normal (~10 Days)***
SULFATE	M	EPA 300.0	3/28/2018	***Normal (~10 Days)***
TKN	M	SM4500NORGC	3/28/2018	***Normal (~10 Days)***
TURBIDITY	M	EPA 180.1	3/28/2018	***Normal (~10 Days)***
VOLATILES 524.3	M	EPA 524.3	3/28/2018	***Normal (~10 Days)***
ZINC	M	EPA 200.8	3/28/2018	***Normal (~10 Days)***

Sample #: 180316032-002 **Customer Sample #:** TRIP BLANK

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** **Date Collected:** 3/15/2018

Quantity: 1 **Date Received:** 3/16/2018 9:45:00 AM **Time Collected:**

Comment:

Test	Lab	Method	Due Date	Priority
VOLATILES 524.3	M	EPA 524.3	3/28/2018	***Normal (~10 Days)***

SAMPLE CONDITION RECORD

Samples received in a cooler?	Yes
Samples received intact?	No
What is the temperature of the sample(s)? (°C)	1.9
Samples received with a COC?	Yes
Samples received within holding time?	Yes
Are all sample bottles properly preserved?	Yes
Are VOC samples free of headspace?	Yes
Is there a trip blank to accompany VOC samples?	Yes
Labels and chain agree?	Yes
Total number of containers?	15

180316 032 **EENG** Last Due 3/28/2018
1st SAMP 3/15/2018 1st RCVD 3/16/2018
MILTON-FREEWATER ASR 1556301

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Chain of Custody Record

1282 Alturas Drive, Moscow ID 83843 (208) 883-2839 FAX 882-9246
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Company Name:	EA Engineering, Inc., PBC	Project Manager:	Kevin Lindsey
Address:	8019 W Quinault Ave., Suite 201	Project Name & #:	Milton-Freewater ASR 1556301
City: Kennewick	State: WA Zip: 99336	Email Address:	PNEWMAN@EAEST.COM
Phone:	(509) 591-0264	Purchase Order #:	
Fax:		Sampler Name & phone:	Patty Newman 509-591-0876

Turn Around Time & Reporting

Please refer to our normal turn around times at: http://www.anateklabs.com/services/guidelines/reporting.asp

✓ Normal
__Next Day*
__2nd Day*
__Other*______

*All rush order requests must be prior approved.

__Phone
__Mail
__Fax
__Email

Provide Sample Description / **List Analyses Requested**

Lab ID	Sample Identification	Sampling Date/Time	Matrix	# of Containers	Sample Volume	See Attached
	MF-ASR-LWWR-1	03/15/2018 1055	W	15	5L	x

Preservative:

Note Special Instructions/Comments

****SEE ATTACHED****

MWBS

SEE ATTTACHED TABLE FOR ANALYTES

One pesticide + Glyphosate vial arrived broke

	Printed Name	Signature	Company	Date	Time
Relinquished by	Patty Newman	[signature]	EA	3/15/18	1430
Received by	Justin Doty	[signature]	Anatek	3/16/18	0945
Relinquished by					
Received by					
Relinquished by					
Received by					

Inspection Checklist

Received Intact?	(Y)	(N)
Labels & Chains Agree?	Y	N
Containers Sealed?	(Y)	N
VOC Head Space?	Y	(N)

UPS
Temperature (°C): 1.9 IR-1
Preservative: HCL, H2SO4, SS, NaThio, MCAA, NaThio-PDC
Date & Time:
Inspected By:

Appendix 1
Laboratory Results
Northwest Groundwater Services, Inc

Table 1 Full Analytical Suite

ANALYTE GROUP / Analyte	Units	Drinking Water Standard / Criteria	Notes
GENERAL CHEMISTRY (GC)			Groundwater & Surface water
Alkalinity (total)	mg CaCO3/L		b
Temperature	degrees Fahrenheit		
Chloride	mg/L	250 (SMCL)	
Fluoride	mg/L	2.0 (SMCL), 4.0 (MCL)	
Hardness	mg CaCO3/L	250 (SMCL)	
Nitrate+Nitrite (total N)	mg/L as N	10	
Nitrate-N	mg/L as N	10	
Nitrite-N	mg/L as N	1	
Orthophosphate as P	mg/L		
Oxidation-Reduction Potential	millivolts		
pH	pH units	6.5 to 8.5 (SMCL)	
Specific Conductance	µS/cm	700 (SMCL)	
Sulfate	mg/L	250 (SMCL)	
Total Dissolved Solids	mg/L	500 (SMCL)	
Turbidity	NTU	1	
Total Kjeldahl nitrogen			
TOTAL METALS (M)			Groundwater & Surface water
Arsenic	mg/L	0.010	a
Calcium	mg/L		c
Copper	mg/L	1.3*	a,c
Iron	mg/L	0.3 (SMCL)	c
Iron (dissolved)	mg/L		c
Lead	mg/L	0.015*	a,b,c
Magnesium	mg/L		c
Manganese	mg/L	0.05 (SMCL)	c
Manganese (dissolved)	mg/L		c
Mercury	mg/L	0.002	a,b,c
Potassium	mg/L		c
Sodium	mg/L	20**	c
Zinc	mg/L	5	c
MISCELLANEOUS (MISC)			Groundwater & Surface water
Corrosivity	Standard units	Non-corrosive	
BACTERIOLOGICALS (BAC)			Surface water only
Total Coliform (Presence/Absence)	cfu/100mL	absent	Method SM 9221 B, C per the proposal Will be analyzed by Table Rock but Anatek will bill EA directly
SYNTHETIC ORGANIC CHEMICALS (SOC)			Surface water only
Chlordane, Technical	µg/L	2	a,b
Glyphosate [1]	µg/L	700	a
Heptachlor Epoxide	µg/L	0.2	a,b
Hexachlorobenzene	µg/L	1	a,b
Hexachlorocyclopentadiene	µg/L	50	a,b
Lindane (BHC - GAMMA)	µg/L	0.2 as total PAH's	a,c
Aroclor 1016 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1221 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1232 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1242 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1248 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1254 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1260 (PCB)	µg/L	0.5 as total PCB's	a,b
Pentachlorophenol	µg/L	1	a,b
Malathion [2]	µg/L		
Chlorpyrifos [2]	µg/L		
Azinphos-methyl [2]	µg/L		
VOLATILE ORGANIC CHEMICALS (VOC)			Surface water only
Benzene	µg/L	5	
Ethylbenzene	µg/L	700	
Toluene	µg/L	1000	
Total Xylenes	µg/L	10000	

—* sent to Table Rock

Notes:

[1] - Glyphosphate was chosen as a herbicide proxy.

[2] - Chosen as a pesticide proxy as it is a common organophosphate based on conversation with WA DEQ, will analyzed using EPA Method 8141 for water, not drinking water.

Data Sources used to reduce analytical list:

[a] - Listed in OAR 330-061-0030.

[b] - Anderson Petty & Associates, 2011. City of Milton-Freewater, Oregon Water Management and Conservation Plan Update Addendum. May. p.16.

[c] - GeoSystems Analysis, Inc., 2016. Surface Water and Groundwater Monitoring and Reporting Plan. May. Table 5.

* Action Level set by the EPA

** Guideline level recommended by the EPA

MCL = Maxiumim Contaminant Level

SMCL = Secondary Maximum Contaminant Level

MDL = Method Detection Limit

RL = Reporting Limit

µg/L = Micrograms per liter

µS/cm = Micro-Siemens per centimeter

mg/L = Milligrams per liter

NTU = Nephelometric turbidity unit

MV = Millivolts

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Client:	EA ENGINEERING	**Batch #:**	180410059
Address:	8019 W QUINAULT AVE, STE D KENNEWICK, WA 99336	**Project Name:**	MILTON-FREEWATER ASR 1556301
Attn:	KEVIN LINDSEY		

Analytical Results Report

Sample Number	180410059-001	**Sampling Date**	4/8/2018	**Date/Time Received**	4/10/2018 11:24 AM
Client Sample ID	MF-ASR-LWWR-2	**Sampling Time**	2:40 PM		
Matrix	Drinking Water				
Comments					

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Alkalinity	28	mg CaCO3/L	2	4/18/2018 2:30:00 PM	RPU	SM2320B	
Arsenic	ND	mg/L	0.001	4/16/2018 12:32:00 PM	HSW	EPA 200.8	
Chloride	0.416	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
Conductivity	63.8	µmhos/cm	1	4/13/2018 5:00:00 PM	RPU	SM 2510B	
Copper	ND	mg/L	0.001	4/16/2018 12:32:00 PM	HSW	EPA 200.8	
Corrosivity	-0.994			4/24/2018	ETL	Calculation	
Dissolved Iron	0.0176	mg/L	0.01	4/17/2018 12:00:44 PM	SDR	EPA 200.7	
Dissolved Manganese	ND	mg/L	0.01	4/17/2018 12:00:44 PM	SDR	EPA 200.7	
Fluoride	ND	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
Glyphosate	ND	ug/L	5	4/10/2018 10:52:00 PM	MER	EPA 547	
Calcium	5.37	mg CaCO3/L	0.1	4/17/2018 12:52:30 PM	SDR	EPA 200.7	
Hardness	22.1	mg CaCO3/L	1	4/17/2018 12:52:30 PM	SDR	EPA 200.7	
Magnesium	2.11	mg CaCO3/L	0.1	4/17/2018 12:52:30 PM	SDR	EPA 200.7	
Pentachlorophenol	ND	ug/L	0.04	4/20/2018 1:31:00 AM	MAH	EPA 515.4	
Iron	0.241	mg/L	0.01	4/17/2018 12:52:30 PM	SDR	EPA 200.7	
Lead	ND	mg/L	0.001	4/18/2018 3:32:00 PM	HSW	EPA 200.8	
Manganese	ND	mg/L	0.01	4/17/2018 12:52:30 PM	SDR	EPA 200.7	
Mercury-ICPMS	ND	mg/L	0.0001	4/16/2018 12:32:00 PM	HSW	EPA 200.8	
NO3/N	ND	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
NO3/N+NO2/N	ND	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
NO2/N	ND	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
Oxidation-Reduction Potential	-28.6	millivolts		4/13/2018	RPU	SM 2580B	
Aroclor 1016 (PCB-1016)	ND	ug/L	0.08	4/18/2018 12:23:00 AM	MAH	EPA 505	
Aroclor 1221 (PCB-1221)	ND	ug/L	1	4/18/2018 12:23:00 AM	MAH	EPA 505	
Aroclor 1232 (PCB-1232)	ND	ug/L	0.5	4/18/2018 12:23:00 AM	MAH	EPA 505	
Aroclor 1242 (PCB-1242)	ND	ug/L	0.3	4/18/2018 12:23:00 AM	MAH	EPA 505	
Aroclor 1248 (PCB-1248)	ND	ug/L	0.1	4/18/2018 12:23:00 AM	MAH	EPA 505	
Aroclor 1254 (PCB-1254)	ND	ug/L	0.1	4/18/2018 12:23:00 AM	MAH	EPA 505	
Aroclor 1260 (PCB-1260)	ND	ug/L	0.2	4/18/2018 12:23:00 AM	MAH	EPA 505	
Chlordane	ND	ug/L	0.2	4/18/2018 12:23:00 AM	MAH	EPA 505	
PCBs	ND	ug/L	0.5	4/18/2018 12:23:00 AM	MAH	EPA 505	
pH	7.41	ph Units		4/13/2018 5:00:00 PM	RPU	SM 4500pH-B	
PO4/P	ND	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
Potassium	1.49	mg/L	0.1	4/17/2018 12:52:30 PM	SDR	EPA 200.7	

Certifications held by Anatek Labs ID: EPA:ID00013; AZ:0701; FL(NELAP):E87893; ID:ID00013; MT:CERT0028; NM: ID00013;NV:ID00013; OR:ID200001-002; WA:C595
Certifications held by Anatek Labs WA: EPA:WA00169; ID:WA00169; WA:C585; MT:Cert0095; FL(NELAP): E871099

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Client: EA ENGINEERING
Address: 8019 W QUINAULT AVE, STE D
KENNEWICK, WA 99336
Attn: KEVIN LINDSEY

Batch #: 180410059
Project Name: MILTON-FREEWATER ASR 1556301

Analytical Results Report

Sample Number 180410059-001
Client Sample ID MF-ASR-LWWR-2
Matrix Drinking Water
Comments

Sampling Date 4/8/2018
Sampling Time 2:40 PM

Date/Time Received 4/10/2018 11:24 AM

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Chlorpyrifos	ND	ug/L	0.2	4/25/2018 1:45:00 AM	BMM	EPA 525.2	
gamma-BHC (Lindane)	ND	ug/L	0.04	4/25/2018 1:45:00 AM	BMM	EPA 525.2	
Heptachlor epoxide	ND	ug/L	0.02	4/25/2018 1:45:00 AM	BMM	EPA 525.2	
Hexachlorobenzene	ND	ug/L	0.1	4/25/2018 1:45:00 AM	BMM	EPA 525.2	
Hexachlorocyclopentadiene	ND	ug/L	0.1	4/25/2018 1:45:00 AM	BMM	EPA 525.2	
Malathion	ND	ug/L	0.2	4/25/2018 1:45:00 AM	BMM	EPA 525.2	
Azinphos-methyl	ND	ug/L	0.1	4/26/2018 7:21:00 AM	BMM	EPA 525.2	
Sodium	2.64	mg/L	0.1	4/17/2018 12:52:30 PM	SDR	EPA 200.7	
TDS	74.0	mg/L	50	4/11/2018 4:00:00 PM	RPU	SM 2540C	
Sulfate	0.609	mg/L	0.1	4/10/2018 11:19:00 PM	MER	EPA 300.0	
TKN	ND	mg/L	0.5	4/20/2018	RPU	SM4500NORGC	
Turbidity	1.99	NTU	0.1	4/10/2018 4:00:00 PM	RPU	EPA 180.1	
Benzene	ND	ug/L	0.5	4/12/2018 3:16:00 PM	SAT	EPA 524.3	
Ethylbenzene	ND	ug/L	0.5	4/12/2018 3:16:00 PM	SAT	EPA 524.3	
Toluene	ND	ug/L	0.5	4/12/2018 3:16:00 PM	SAT	EPA 524.3	
Total Xylene	ND	ug/L	0.5	4/12/2018 3:16:00 PM	SAT	EPA 524.3	
Zinc	ND	mg/L	0.001	4/16/2018 12:32:00 PM	HSW	EPA 200.8	

Anatek Labs, Inc.

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504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Client:	EA ENGINEERING	**Batch #:**	180410059
Address:	8019 W QUINAULT AVE, STE D KENNEWICK, WA 99336	**Project Name:**	MILTON-FREEWATER ASR 1556301
Attn:	KEVIN LINDSEY		

Analytical Results Report

Sample Number	180410059-002	**Sampling Date**	4/8/2018	**Date/Time Received**	4/10/2018 11:24 AM
Client Sample ID	TRIP BLANK	**Sampling Time**			
Matrix	Drinking Water				
Comments					

Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Benzene	ND	ug/L	0.5	4/12/2018 3:57:00 PM	SAT	EPA 524.3	
Ethylbenzene	ND	ug/L	0.5	4/12/2018 3:57:00 PM	SAT	EPA 524.3	
Toluene	ND	ug/L	0.5	4/12/2018 3:57:00 PM	SAT	EPA 524.3	
Total Xylene	ND	ug/L	0.5	4/12/2018 3:57:00 PM	SAT	EPA 524.3	

Authorized Signature

Todd Taruscio, Lab Manager

MCL EPA's Maximum Contaminant Level
ND Not Detected
PQL Practical Quantitation Limit

This report shall not be reproduced except in full, without the written approval of the laboratory.
The results reported relate only to the samples indicated.
Soil/solid results are reported on a dry-weight basis unless otherwise noted.

Certifications held by Anatek Labs ID: EPA:ID00013; AZ:0701; FL(NELAP):E87893; ID:ID00013; MT:CERT0028; NM: ID00013;NV:ID00013; OR:ID200001-002; WA:C595
Certifications held by Anatek Labs WA: EPA:WA00169; ID:WA00169; WA:C585; MT:Cert0095; FL(NELAP): E871099

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504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Login Report

Customer Name: EA ENGINEERING
8019 W QUINAULT AVE, STE D
KENNEWICK WA 99336

Order ID: 180410059
Order Date: 4/10/2018

Contact Name: KEVIN LINDSEY
Project Name: MILTON-FREEWATER ASR 1556301
Comment:

Sample #: 180410059-001 **Customer Sample #:** MF-ASR-LWWR-2

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** PATTY NEWMAN **Date Collected:** 4/8/2018
Quantity: 14 **Date Received:** 4/10/2018 11:24:00 AM **Time Collected:** 2:40 PM
Comment:

Test	Lab	Method	Due Date	Priority
ALKALINITY	M	SM2320B	4/20/2018	Normal (~10 Days)
ARSENIC	M	EPA 200.8	4/20/2018	Normal (~10 Days)
CHLORIDE	M	EPA 300.0	4/20/2018	Normal (~10 Days)
CONDUCTIVITY	M	SM 2510B	4/20/2018	Normal (~10 Days)
COPPER	M	EPA 200.8	4/20/2018	Normal (~10 Days)
Corrosivity	M	Calculation	4/20/2018	Normal (~10 Days)
DISSOLVED IRON BY ICP	M	EPA 200.7	4/20/2018	Normal (~10 Days)
DISSOLVED MANGANESE BY ICP	M	EPA 200.7	4/20/2018	Normal (~10 Days)
FLUORIDE	M	EPA 300.0	4/20/2018	Normal (~10 Days)
GLYPHOSATE 547	M	EPA 547	4/20/2018	Normal (~10 Days)
HARDNESS by EPA 200.7	M	EPA 200.7	4/20/2018	Normal (~10 Days)
HERBICIDES 515.4	M	EPA 515.4	4/20/2018	Normal (~10 Days)
IRON ICP	M	EPA 200.7	4/20/2018	Normal (~10 Days)
LEAD	M	EPA 200.8	4/20/2018	Normal (~10 Days)
MANGANESE ICP	M	EPA 200.7	4/20/2018	Normal (~10 Days)
MERCURY-ICPMS	M	EPA 200.8	4/20/2018	Normal (~10 Days)
NITRATE/N	M	EPA 300.0	4/20/2018	Normal (~10 Days)
NITRATE+ NITRITE AS N	M	EPA 300.0	4/20/2018	Normal (~10 Days)
NITRITE/N	M	EPA 300.0	4/20/2018	Normal (~10 Days)
OXIDATION-REDUCTION POTENTIAL	M	SM 2580B	4/20/2018	Normal (~10 Days)
PESTICIDES 505	M	EPA 505	4/20/2018	Normal (~10 Days)
pH	M	SM 4500pH-B	4/20/2018	Normal (~10 Days)
PHOSPHATE/P	M	EPA 300.0	4/20/2018	Normal (~10 Days)

Customer Name:	EA ENGINEERING
	8019 W QUINAULT AVE, STE D
	KENNEWICK WA 99336
Order ID:	180410059
Order Date:	4/10/2018
Contact Name:	KEVIN LINDSEY
Project Name:	MILTON-FREEWATER ASR 1556301
Comment:	

POTASSIUM ICP	M	EPA 200.7	4/20/2018	***Normal (~10 Days)***
SEMIVOLATILES 525.2	M	EPA 525.2	4/20/2018	***Normal (~10 Days)***
SEMIVOLATILES 525.2 EXTENDED	M	EPA 525.2	4/20/2018	***Normal (~10 Days)***
SODIUM ICP	M	EPA 200.7	4/20/2018	***Normal (~10 Days)***
SOLIDS - TDS	M	SM 2540C	4/20/2018	***Normal (~10 Days)***
SULFATE	M	EPA 300.0	4/20/2018	***Normal (~10 Days)***
TKN	M	SM4500NORGC	4/20/2018	***Normal (~10 Days)***
TURBIDITY	M	EPA 180.1	4/20/2018	***Normal (~10 Days)***
VOLATILES 524.3	M	EPA 524.3	4/20/2018	***Normal (~10 Days)***
ZINC	M	EPA 200.8	4/20/2018	***Normal (~10 Days)***

Sample #: 180410059-002 **Customer Sample #:** TRIP BLANK

Recv'd: ☑ **Matrix:** Drinking Water **Collector:** **Date Collected:** 4/8/2018

Quantity: 1 **Date Received:** 4/10/2018 11:24:00 AM **Time Collected:**

Comment:

Test	Lab	Method	Due Date	Priority
VOLATILES 524.3	M	EPA 524.3	4/20/2018	***Normal (~10 Days)***

SAMPLE CONDITION RECORD

Samples received in a cooler?	Yes
Samples received intact?	Yes
What is the temperature of the sample(s)? (°C)	5.6
Samples received with a COC?	Yes
Samples received within holding time?	No
Are all sample bottles properly preserved?	Yes
Are VOC samples free of headspace?	Yes
Is there a trip blank to accompany VOC samples?	Yes
Labels and chain agree?	Yes
Total number of containers?	14

180410 059 **EENG** Last Due 4/20/2018
1st SAMP 4/8/2018 1st RCVD 4/10/2018
MILTON-FREEWATER ASR 1556301

Anatek Labs, Inc.

Chain of Custody Record

1282 Alturas Drive, Moscow ID 83843 (208) 883-2839 FAX 882-9246
504 E Sprague Ste D, Spokane WA 99202 (509) 838-3999 FAX 838-4433

Company Name:	EA Engineering, Inc., PBC	Project Manager:	Kevin Lindsey
Address:	8019 W Quinault Ave., Suite 201	Project Name & #:	Milton-Freewater ASR 1556301
City:	Kennewick State: WA Zip: 99336	Email Address:	PNEWMAN@EAEST.COM
Phone:	(509) 591-0264	Purchase Order #:	
Fax:		Sampler Name & phone:	Patty Newman 509-591-0876

Turn Around Time & Reporting

Please refer to our normal turn around times at: http://www.anateklabs.com/services/guidelines/reporting.asp

✓ Normal
__Next Day*
__2nd Day*
__Other*______

*All rush order requests must be prior approved.

__Phone
__Mail
__Fax
__Email

Provide Sample Description / **List Analyses Requested** (Preservative:)

Lab ID	Sample Identification	Sampling Date/Time	Matrix	# of Containers	Sample Volume	See Attached
	MF-ASR-LWWR-2	04/8/2018 14:40	W	14	5L	x

Note Special Instructions/Comments

****SEE ATTACHED****

MWB3

SEE ATTTACHED TABLE FOR ANALYTES

Nitrate will be out of hold time, analyze anyway

	Printed Name	Signature	Company	Date	Time
Relinquished by	Jon Travis	[signature]	EA	4/9/18	15:00
Received by	Leighann Conn'A	Leighann Conn'A	Anatek	4/10/18	1124
Relinquished by					
Received by					
Relinquished by					
Received by					

Inspection Checklist

Received Intact? (Y) N
Labels & Chains Agree? (Y) N
Containers Sealed? (Y) N
VOC Head Space? Y (N)

UB
Temperature (°C): 5.6 IR-3
Preservative: MA/AA, Hcl, SS, Nathio #2504
Date & Time:
Inspected By:

Table 1 Full Analytical Suite

ANALYTE GROUP / Analyte	Units	Drinking Water Standard / Criteria	Notes
GENERAL CHEMISTRY (GC)			Groundwater & Surface water
Alkalinity (total)	mg CaCO3/L		b
Temperature	degrees Fahrenheit		
Chloride	mg/L	250 (SMCL)	
Fluoride	mg/L	2.0 (SMCL), 4.0 (MCL)	
Hardness	mg CaCO3/L	250 (SMCL)	
Nitrate+Nitrite (total N)	mg/L as N	10	
Nitrate-N	mg/L as N	10	
Nitrite-N	mg/L as N	1	
Orthophosphate as P	mg/L		
Oxidation-Reduction Potential	millivolts		
pH	pH units	6.5 to 8.5 (SMCL)	
Specific Conductance	µS/cm	700 (SMCL)	
Sulfate	mg/L	250 (SMCL)	
Total Dissolved Solids	mg/L	500 (SMCL)	
Turbidity	NTU	1	
Total Kjeldahl nitrogen			
TOTAL METALS (M)			Groundwater & Surface water
Arsenic	mg/L	0.010	a
Calcium	mg/L		c
Copper	mg/L	1.3*	a,c
Iron	mg/L	0.3 (SMCL)	c
Iron (dissolved)	mg/L		c
Lead	mg/L	0.015*	a,b,c
Magnesium	mg/L		c
Manganese	mg/L	0.05 (SMCL)	c
Manganese (dissolved)	mg/L		c
Mercury	mg/L	0.002	a,b,c
Potassium	mg/L		c
Sodium	mg/L	20**	c
Zinc	mg/L	5	c
MISCELLANEOUS (MISC)			Groundwater & Surface water
Corrosivity	Standard units	Non-corrosive	
BACTERIOLOGICALS (BAC)			Surface water only
~~Total Coliform (Presence/Absence)~~	~~cfu/100mL~~	~~absent~~	Method SM 9221 B, C per the proposal ~~Will be analyzed~~ by Table Rock but ~~Anatek will bill EA directly~~
SYNTHETIC ORGANIC CHEMICALS (SOC)			~~Surface water only~~
Chlordane, Technical	µg/L	2	a,b
Glyphosate [1]	µg/L	700	a
Heptachlor Epoxide	µg/L	0.2	a,b
Hexachlorobenzene	µg/L	1	a,b
Hexachlorocyclopentadiene	µg/L	50	a,b
Lindane (BHC - GAMMA)	µg/L	0.2 as total PAH's	a,c
Aroclor 1016 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1221 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1232 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1242 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1248 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1254 (PCB)	µg/L	0.5 as total PCB's	a,b
Aroclor 1260 (PCB)	µg/L	0.5 as total PCB's	a,b
Pentachlorophenol	µg/L	1	a,b
Malathion [2]	µg/L		
Chlorpyrifos [2]	µg/L		
Azinphos-methyl [2]	µg/L		
VOLATILE ORGANIC CHEMICALS (VOC)			Surface water only
Benzene	µg/L	5	
Ethylbenzene	µg/L	700	
Toluene	µg/L	1000	
Total Xylenes	µg/L	10000	

Notes:

[1] - Glyphosphate was chosen as a herbicide proxy.

[2] - Chosen as a pesticide proxy as it is a common organophosphate based on conversation with WA DEQ, will analyzed using EPA Method 8141 for water, not drinking water.

Data Sources used to reduce analytical list:

[a] - Listed in OAR 330-061-0030.

[b] - Anderson Petty & Associates, 2011. City of Milton-Freewater, Oregon Water Management and Conservation Plan Update Addendum. May. p.16.

[c] - GeoSystems Analysis, Inc., 2016. Surface Water and Groundwater Monitoring and Reporting Plan. May. Table 5.

* Action Level set by the EPA

** Guideline level recommended by the EPA

MCL = Maxiumim Contaminant Level

SMCL = Secondary Maximum Contaminant Level

MDL = Method Detection Limit

RL = Reporting Limit

µg/L = Micrograms per liter

µS/cm = Micro-Siemens per centimeter

mg/L = Milligrams per liter

NTU = Nephelometric turbidity unit

MV = Millivolts

DHS

State of Oregon - Drinking Water Program
Microbiological Analysis (Coliform) Reporting Form for Public Water Supplies (v3.2)

PWS# 41 ____________
PWS Name: ____________
City, County: ____________
Phone: ____________ Fax: ____________

Return address for report:
Name: E A Engineering
Address: ____________
City, State, Zip: ____________

TABLE ROCK ANALYTICAL LABORATORY
PO Box 746 / 419 SW 5th St. Pendleton, OR 97801
Phone 541-276-0385 Fax 541-276-2041
ORELAP #OR100061

Bottle#: ____________
☐ Results do not meet NELAC Standards-See below
Lab Sample ID#: 180405N1

Sample Collected Date/Time: 04 / 05 / 2018 (MM/DD/YYYY) 14 : 40 (Hour : Min) ☐ AM ☐ PM
Chlorinated: ☐ No ☐ Yes
Collected By: JT
Free Chlorine: ______ mg/L

DISTRIBUTION Sample Type: ☐ Routine ☐ *Repeat ☐ Temporary Routine ☒ Special
*Date of Initial Positive: ___/___/____ (MM/DD/YYYY) *Original Positive ID#: ____________
Address: MF-ASR-LWWR-2 Sampled at (ex. "SINK"): ____________

SOURCE Sample Type: ☐ *Triggered ☐ *Confirmation ☐ Assessment ☐ Special
*Date of Initial Positive: ___/___/____ (MM/DD/YYYY) *Original Positive ID#: ____________
Source ID: SRC- ____________ Source name (ex. "WELL #1"): ____________

LAB USE ONLY

Sample Received Date/Time: 04 / 05 / 2018 (MM/DD/YYYY) 15 : 35 (Hour: Min) ☐ AM ☒ PM Initials: TF Temp: 9.4 °C
Evidence of cooling? ☒ Yes ☐ No

Analysis Start Date/Time: 04 / 05 / 2018 (MM/DD/YYYY) 15 : 47 (Hour: Min) ☐ AM ☒ PM Initials: TN

ORELAP Method(s): (Check all that apply.)
☒ Colilert® ☐ Colilert-18® ☐ Colisure® ☐ Chromocult® ☐ Coliscan® ☐ Readycult®
☐ SM 9221 B (MTF) + ☐ E or ☐ F ☐ SM 19th Ed. ☐ SM 20th Ed. ☐ SM 21st Ed.
☐ SM 9221 D (P-A M) + ☐ E or ☐ F
☐ SM 9222 B (MF) + ☐ 9221E or ☐ 9221F or ☐ 9222G
☒ SM 9223 ☐ ColiTag® ☐ MI agar ☐ m-ColiBlue® ☐ Other: ____________

Test Results:
Total Coliforms: ☒ Present ☐ Absent
E. Coli: ☒ Present ☐ Absent

Analysis Complete Date/Time: 4 / 6 / 18 (MM/DD/YYYY) 13 : 18 (Hour: Min) ☐ AM ☒ PM
Analyst: BR
Review by: BLR 4 / 6 / 18 (MM/DD/YYYY)

Reported By: BLRead Report Date 4 / 6 / 18 (MM/DD/YYYY)

Sample Invalidation:
☐ Over 30 hours
☐ Leak
☐ Heavy non-coliform growth
☐ Other ____________

DHS USE ONLY

Test results relate only to the parameters tested and to the samples as received by the laboratory. Test results meet all requirements of NELAC unless otherwise noted. This report shall not be reproduced except in full, without written consent of this laboratory. Send results to DHS-DWP P.O. Box 14350, Portland, OR 97293-0350

NELAC standards not met:
☐ not received in lab-supplied bottle
☐ not incubated at proper temperature
☐ other ____________

Comments: called 4/6/18

Health

State of Oregon - Drinking Water Services
Microbiological Analysis (Coliform) Reporting Form for Public Water Supplies (v3.3)

PWS# 41

~~PWS~~ Name: MF ASR 1556301

City, County:

Phone: Fax: pnewman@eaest.com

Return address for report:

Name: EA Engineering

Address: 205 SE Spokane St., Suite 300

City, State, Zip: Portland, OR 97202

ORELAP#: OR100061

Lab Name: Table Rock Analytical Laboratory

Address: PO Box 746 / SW 5th St Pendleton, OR 97801

Phone: 541-276-0385 Fax: 541276-2041

Bottle#:

☐ Results do not meet NELAC Standards

Lab Sample ID#: 180316A1

Sample Collected Date/Time: 3 / 15 / 18 (MM / DD / YYYY) 10 : 55 (Hour : Min) ☒ AM ☐ PM

Chlorinated: ☐ No ☐ Yes

Free Chlorine: ______ mg/L

Collected By: Patty Newman

DISTRIBUTION Sample Type: ☐ Routine ☐ *Repeat ☐ Temporary Routine ☒ Special

*Date of Initial Positive: ___ / ___ / ___ (MM / DD / YYYY)

*Original Positive ID#:

Address: MF-ASR-LWWR-1

Sampled at (ex. "SINK"):

SOURCE Sample Type: ☐ *Triggered ☐ *Confirmation ☐ Assessment ☐ Special

*Date of Initial Positive: ___ / ___ / ___ (MM / DD / YYYY)

*Original Positive ID#:

Source ID: SRC-

Source name (ex. "WELL #1"):

LAB USE ONLY

Sample Received Date/Time: 3 / 16 / 18 (MM / DD / YYYY) 09 : 35 (Hour: Min) ☒ AM ☐ PM

Initials: BLR

Temp: 9.0 °C

Evidence of cooling? ☒ Yes ☐ No

Analysis Start Date/Time: 3 / 16 / 18 (MM / DD / YYYY) 11 : 55 (Hour: Min) ☒ AM ☐ PM

Initials: BLR

ORELAP Method(s): Check all that apply.

☒ Colilert® ☐ Colilert-18® ☐ Colisure® ☐ Chromocult® ☐ Coliscan® ☐ Readycult®

☐ SM 9221 B (MTF) + ☐ E or ☐ F ☐ SM 19th Ed. ☐ SM 20th Ed. ☐ SM 21st Ed.

☐ SM 9221 D (P-A M) + ☐ E or ☐ F

☐ SM 9222 B (MF) + ☐ 9221E or ☐ 9221F or ☐ 9222G

☒ SM 9223 ☐ ColiTag® ☐ MI agar ☐ m-ColiBlue® ☐ Other:

Test Results:

Total Coliforms: ☒ Present ~~☒ Absent~~ (correction initialed)

E. Coli: ☒ Present ☐ Absent

Analysis Complete Date/Time: 03 / 17 / 2018 (MM / DD / YYYY) 07 : 25 (Hour: Min) ☒ AM ☐ PM

Analyst: [signature]

Review by: BLR 3 / 18 / 18 (MM / DD / YYYY)

Reported By: BRead

Report Date 3 / 18 / 18 (MM / DD / YYYY)

Sample Invalidation:

☐ Over 30 hours

☐ Leak

☐ Heavy non-coliform growth

☐ Other

OHA USE ONLY

Test results relate only to the parameters tested and to the samples as received by the laboratory. Test results meet all requirements of NELAC unless otherwise noted. This report shall not be reproduced except in full, without written consent of this laboratory. Send results to OHA-DWS P.O. Box 14350, Portland, OR 97293-0350

For technical support and information, please call Data Management Coordinator (ph. 971-673-0405, M-F, 8am-5pm PT) or visit http://public.health.oregon.gov/HealthyEnvironments/DrinkingWater/Pages/labs.aspx

APPENDIX 2

Table F-1
Baseline Source Water and Native Groundwater Quality
Geochemical Parameters

Parameter (mg/L)	Sample ID						
	Source Water	Native Groundwater					
	Mill Creek - 022499	Well #1	Well #1 - 022499	Well No. 1	Well #2	Well #2 - 022499	Well No. 2
Alkalinity	26	83	94	63	91	96	91
Aluminum	ND	.006	ND	ND	ND	ND	ND
Ammonia	ND	ND	ND	ND	ND	ND	nd
Bicarbonate		83			91		
Calcium	6.1	17	18	13	20	21	17
Carbonate		ND			ND		
Chloride	2.9	1.4	1.5	3	1.9	1.9	ND
Fluoride	ND	0.2	0.3	.2	ND	ND	.3
Iron, Dissolved	0.09	ND	ND	ND	ND	ND	ND
Iron, Total	0.09	ND	ND	.07	ND	ND	ND
Magnesium	2.4	8.4	9	5.8	10	10	8.3
Manganese, Dissolved	ND	ND	ND	ND	ND	ND	ND
Manganese, Total	ND	0.0017	ND	ND	.0017	ND	ND
Nitrate	.12	1	0.91	.3	2.2	2.2	.3
Organic Nitrogen	ND	NT	ND		NT	0.7	
Potassium		2.9			3.2		
Silica	28	47	47	39	45	45	49
Silver	ND	ND	ND	ND	ND	ND	ND
Sodium	3.5	8.7	10	7	7.4	8.4	9.8
Sulfate	0.7	2.7	2.9	2	3.4	3.3	3
TDS	60	140	130	100	160	140	150
TOC	1.2	ND	ND	1.4	ND	ND	ND
TSS	6	ND	2	ND	ND	3	ND
Zinc	ND	ND	ND	ND	ND	ND	ND

mg/L = milligrams per liter

Table F-2
Baseline Source Water and Native Groundwater Quality
Department of Health (DOH) Constituents

Group	Parameter	Sample ID			MCL Primary Standard (mg/L)	Secondary MCL Standard (mg/L)
		Source Water	Native Groundwater, 4/15/99			
		Mill Creek - 022499	Well #1	Well #2		
INORGANIC COMPOUNDS - PHYSICALS						
	Asbestos (MFL)	ND	ND	.6	7 MFL	
	Color (C.U.)	5	ND	ND	15	
	Foaming Agents	NR	ND	ND		0.5
	Hardness (mg/L)	25	83	91		
	pH (S.U.)	NR	7.77	7.39		6.5 _ 8.5
	Sodium (mg/L)	3.4	8.7	7.4		
	TDS (mg/L)	21	140	160	500	
	Turbidity (NTU)	1.8	.11	.27	5 (NTU)	
INORGANIC COMPOUNDS - NUTRIENTS (all units are mg/L)						
	Nitrate-N	.12	1	2.2	10	
	Nitrite-N	ND	ND	ND	1	
INORGANIC COMPOUNDS - METALS (all units are mg/L)						
	Aluminum	.4	.006	ND		0.05 _ 0.2
	Antimony	ND	ND	ND	0.006	
	Arsenic	ND	ND	ND	0.05	
	Barium	.006	.0038	.0008	2	
	Beryllium	ND	ND	ND	0.004	
	Cadmium	ND	ND	ND	0.005	
	Calcium	6.1	17	20		
	Chloride	2.8	1.4	1.9		250
	Chromium	ND	ND	ND	0.1	
	Copper	.03	.0012	.0012	0.2 (SRL)	1
	Cyanide	ND	ND	ND	0.2	
	Fluoride	ND	.2	ND	4	2
	Iron	.25	ND	ND		0.3
	Lead	ND	.0022	.001	0.05	0.015

NR = Not reported by the analytical laboratory

Table F-2
Baseline Source Water and Native Groundwater Quality
Department of Health (DOH) Constituents

Group	Parameter	Sample ID			MCL Primary Standard (mg/L)	Secondary MCL Standard (mg/L)
		Source Water	Native Groundwater, 4/15/99			
		Mill Creek - 022499	Well #1	Well #2		
	Magnesium	2.4	8.4	10		
	Manganese	ND	.0017	.0017		0.05
	Mercury	ND	ND	ND	0.002	
	Nickel	ND	.052	ND	0.1	
	Selenium	ND	ND	ND	0.05	
	Silver	ND	ND	ND		0.1
	Sulfate	.7	2.7	3.4		250
	Thallium	ND	ND	ND	0.002	
	Zinc	ND	ND	ND		5
SYNTHETIC ORGANIC COMPOUNDS						
	2,4,5-TP	ND	ND	ND	0.05	
	2,4-D	ND	ND	ND	0.07	
	Adipates	NR	ND	ND	0.4	
	Alachlor	ND	ND	ND	0.002	
	Atrazine	ND	ND	ND	0.003	
	Benzo(a)Pyrene	ND	ND	ND	0.0002	
	Carbofuran	ND	ND	ND	0.04	
	Chlordane	ND	ND	ND	0.002	
	Dalapon	ND	ND	ND	0.2	
	DBCP	ND	ND	ND	0.0002	
	Dinoseb	ND	ND	ND	0.007	
	Dioxin	ND	ND	ND	0.03	
	Diquat	ND	ND	ND	0.02	
	EDB	ND	ND	ND	5e-005	
	Endothall	ND	ND	ND	0.1	
	Endrin	ND	ND	ND	0.002	
	Glyphosate	ND	ND	ND	0.7	

NR = Not reported by the analytical laboratory

APPENDIX G APPENDIX I APPENDIX H

Table F-3

Well No. 1 Cycle 1 Pre-Injection Groundwater, Source Water and Recovered Water Quality Geochemical Parameters

Parameter Name (mg/L)	Sample ID					
	Pre-Injection Groundwater	Source Water	Recovered Water			
	CW1-PI-41299	CW1-SW1-41399	CW1-R25-41599	CW1-R40-41599	CW1-R60-41599	CW1-R90-41699
Alkalinity	90	23	39	49	60	79
Aluminum	ND	ND	ND	ND	ND	ND
Ammonia						ND
Bicarbonate						
Calcium	17	5.4	8.2	10	12	16
Carbonate						
Chloride	1.7	3.6	4	3	3	3
Fluoride	.2	ND	ND	.2	.2	.3
Iron, Dissolved	ND	ND	ND	ND	ND	ND
Iron, Total	ND	.08	ND	ND	ND	ND
Magnesium	8.4	2.2	3.8	4.7	5.7	7.5
Manganese, Dissolved	ND	ND	ND	ND	ND	ND
Manganese, Total	ND	ND	ND	ND	ND	ND
Nitrate	1	.08	.2	.2	.3	.5
Organic Nitrogen	ND	ND	ND	ND	ND	ND
Potassium						
Silica	51	31	41	43	45	46
Silver	ND	ND	ND	ND	ND	ND
Sodium	9	2.8	4.8	6.4	7.4	9.1
Sulfate	3.5	1.2	2	2	2	3
TDS	160	59	88	110	99	130
TOC	ND	1	.9	.8	.6	.8
TSS	ND	ND	ND	9	2	3
Zinc	ND	ND	ND	ND	ND	.29

mg/L = milligrams per liter

3/1/2018 MF ASR

7:10 • Calibrating YSI:

pH – initial: 4.01, calibrated: 4.00
– initial: 7.00, calibrated: 7.00
– initial: 10.15, calibrated: 10.03

Cond. – initial: 1.422, calibrated: 1.409 mS/cm

D.O. – initial: 9.06, calibrated: 10.0 mg/L
– initial: 106.7%, calibrated: 100.0%

9:00 • At MF Public Works Office
9:09 • Turned on Well #5 (pre-lubing)
9:13 • Checked out Key well
9:16 • back at Well #5 (still pre-lubing)
9:17 • Well #5 running

9:33 • all set-up, collecting WQ parameters.

Time	pH	Cond.	DO %	ORP	Temp
9:34	5.31	0.202	21.6	233.5	14.87
9:35	4.92	0.180	20.0	250.6	14.85
9:36	4.34	0.200	18.8	258.6	14.84
9:37	4.30	0.203	18.2	258.0	14.82
9:38	4.15	0.202	17.8	252.6	14.82
9:39	4.30	0.199	17.6	243.9	14.83

Rite in the Rain

3/1/2018 (cont.)

Time	pH	Cond.	% DO	ORP	Temp
9:40	4.14	0.197	~~236.0~~ → 17.2		14.82
9:41	4.29	0.200	16.9	225.3	14.81
9:42	4.33	0.200	16.7	216.8	14.81

9:45. collect sample:

MF-ASR-WS-030118

10:00 • inspected "Farm Labor Camp Well" right next to diversion

10:15 • Preparing to sample at Walla Walla River (right at the diversion). (before)

• little WW River does not have water flowing to it.

10:45 • all set-up and pumping water from WWR.

3/1/2018 (cont.)

Time	pH	Cond.	% DO	ORP	Temp.
10:51	-3.09	0.068	113.9	440.0	5.21
10:54	-2.89	0.065	114.4	295.8	5.25
10:57	-1.81	0.095	105.5	230.2	5.27
11:00	-0.28	0.237	104.0	206.0	5.33
11:03	1.11	0.225	103.8	96.2	5.40
11:06	2.06	0.209	105.6	45.6	5.46
11:09	1.85	0.270	105.2	45.8	5.50

• collected sample @ 11:20 MF-ASR-WWR-030118

• turbidity:

time	NTU
10:45	0
10:52	0
10:54	0

(no decimal)

• at the diversion @ Cemetery Bridge ~250 ft upstream (south)

3/15/2018 MF ASR

8:00 • Calibrating YSI:

pH: initial = 3.93, calibrated = 4.01
initial = 7.14, calibrated = 7.00

(4.49 mS/cm) Sp. Cond.: initial = 4245 mS/cm, calibrated = 4490
ORP: initial = 221.7, calibrated = 228.1
(8.54) mg/L DO: initial = 32.65, calibrated = 8.53
(763.27 mmHg) % DO: initial = 88.9%, calibrated = 100.3%

10:10 • In MF, at little walla walla river, right behind well #5 location.
10:25 • set up to collect WQ parameters

Time	Temp (°C)	Cond. (uS/cm)	DO(%)	pH	ORP
10:26	3.28	53	109.8	6.46	114.1
10:28	3.28	54	106.3	6.51	110.2
10:32	3.28	55	103.8	6.66	100.1
10:36	3.31	56	102.6	6.77	93.2
10:40	3.34	55	102.4	6.85	88.5
10:44	3.36	54	102.2	6.90	85.0

turbidity:

time	NTU	time	NTU
1036	4	1042	5
1038	2	1044	3

3/15/2018 (cont.)

10:55 • collected sample:

"MF-ASR-LWWR-1"

@ 10:55 am

11:20 • off-site.

4/5/18

11:53 calibrate YSI in office

	Cal	initial	final
sp cond	4.49 mS/cm	2.547	4.490
pH	4.01	4.05	4.01
	7.00	7.03	7.00
	10.00	9.93	9.99
ORP	+228 mV	226.2	228.1
DO	%	101.6	100.2

on site 13:59

Time	Temp	sp Cond	DO	pH	ORP
1402	5.45	0.106	123.7	7.24	100.9
1408	5.32	0.103	108.5	7.22	86.8
1415	5.34	0.108	106.9	7.36	78.4
1420	5.35	0.108	106.5	7.40	75.3
1427	5.36	0.105	106.0	7.45	72.6
1434	5.38	0.103	105.7	7.47	71.8
1441	5.40	0.103	105.4	7.50	70.1

Rite in the Rain

4 / 5 / 18

Time	NTU
1419	0
1437	5
1447	13

1454 off site to deliver Bact. to Table Rock Lab

1800 241 3673 Cody

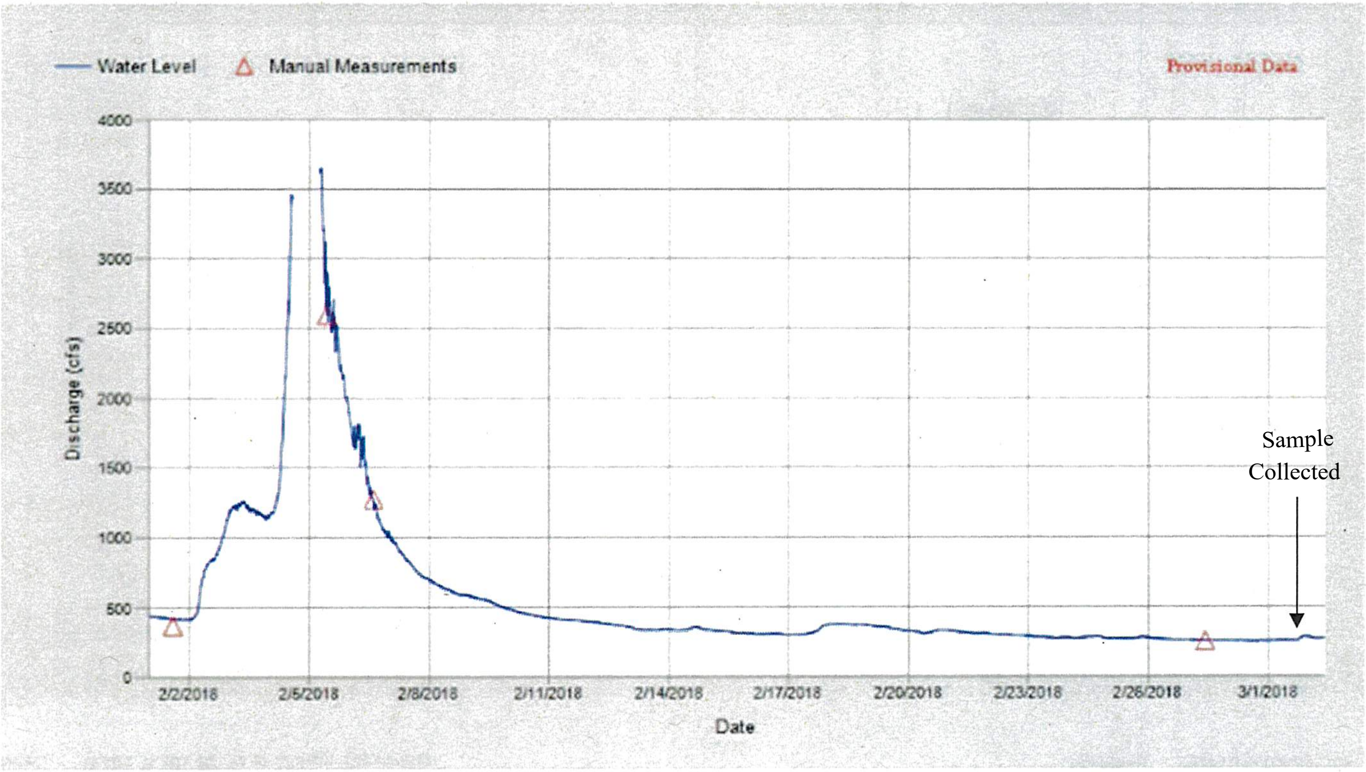
Rite in the Rain

A-1: Monthly Walla Walla River Hydrograph for Samples Collected March 1, 2018

Monthly Chart Report

Site: Walla Walla River at Milton-Freewater

Units: ft^3/s
Identifier: Discharge.Data@S105



Report Date: March 2, 2018 09:30

Source: Walla Walla Basin Watershed Council: http://www.wwbwc.org/monitoring/surfacewater/24-monitoring/surface-water/70-grove.html

A-2: Monthly Walla Walla River Hydrograph for Samples Collected on March 3, 2018

Monthly Chart Report

Site: Walla Walla River at Milton-Freewater

Units: ft^3/s
Identifier: Discharge.Data@S105

Report Date: March 16, 2018 11:30

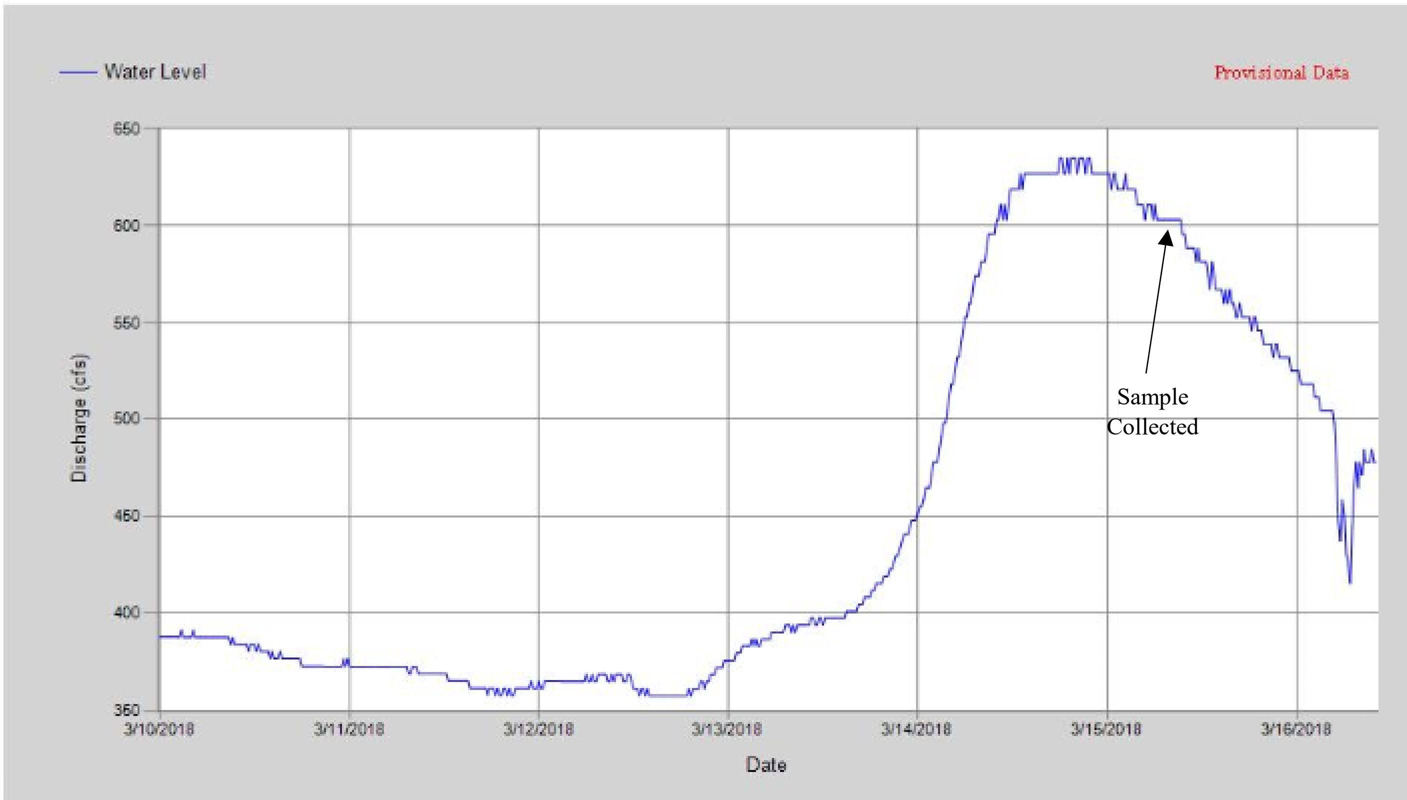
Source: Walla Walla Basin Watershed Council: http://www.wwbwc.org/monitoring/surfacewater/24-monitoring/surface-water/70-grove.html

A-3: Weekly Walla Walla River Hydrograph for Samples Collected on March 3, 2018

Seven Day Chart Report

Site: Walla Walla River at Milton-Freewater

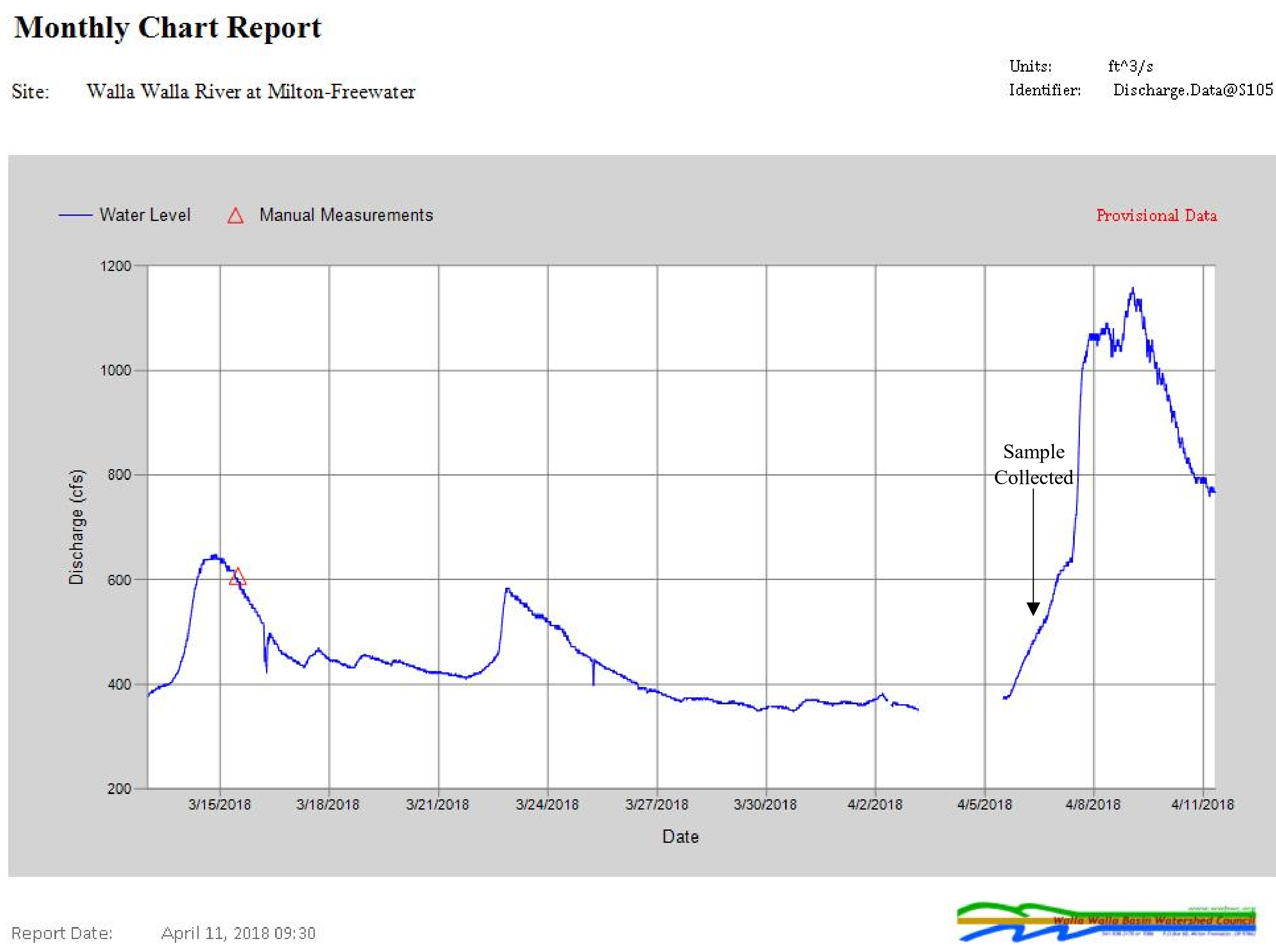
Units: ft^3/s
Identifier: Discharge.Data@S105



Report Date: March 16, 2018 11:30

Source: Walla Walla Basin Watershed Council: http://www.wwbwc.org/monitoring/surfacewater/24-monitoring/surface-water/70-grove.html

A-4: Monthly Walla Walla River Hydrograph for Samples collected on April 5, 2018

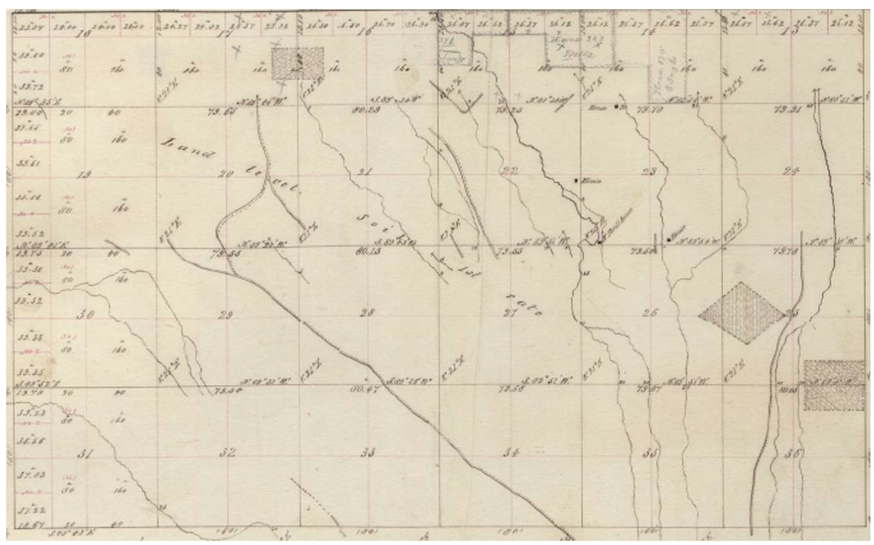


Source: Walla Walla Basin Watershed Council: http://www.wwbwc.org/monitoring/surfacewater/24-monitoring/surface-water/70-grove.html

Walla Walla Basin Watershed Council

Milton-Freewater Aquifer Storage and Recovery Feasibility Study Supplemental Requirements

June, 2019



Milton-Freewater Aquifer Storage and Recovery Feasibility Study Supplemental Requirements

Walla Walla Basin Watershed Council

June 30, 2019

Written by:

Marie Cobb,
Senior Environmental Scientist

This report can be found on the WWBWC website:
www.wwbwc.org
For additional information please contact:
Walla Walla Basin Watershed Council
810 S. Main Street, Milton-Freewater OR 97862
541-938-2170
brian.wolcott@wwbwc.org or marie.cobb@wwwbwc.org

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List of Abbreviations and Acronyms

ac-ft	acre-feet
ASR	aquifer storage and recovery
bgs	below ground surface
cfs	cubic feet per second
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
D50	particle size that 50% of the sampled particles are equal to or smaller than
D84	particle size that 84% of the sampled particles are equal to or smaller than
GLO	General Land Office
GPCD	gallons per capita per day
HEC-RAS	Hydrologic Engineering Center's River Analysis System
IFIM	Instream Flow Incremental Methodology
IHA	Indicators of Hydrologic Alteration
NOAA	National Oceanic and Atmospheric Administration
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PHABSIM	Physical Habitat Simulation
POD	point of diversion
Q2	a peak flow with a 2-year recurrence interval
RM	river mile
TMDL	total maximum daily load
USACE	United States Army Corps of Engineers
USFWS	United State Fish and Wildlife Service
USGS	United States Geological Survey
WDOE	Washington State Department of Ecology
WDFW	Washington State Department of Fish and Wildlife
WUA	weighted usable area
WWBWC	Walla Walla Basin Watershed Council
WY	water year

Summary

In the preceding sections of this feasibility study report, hydrogeological and other specialized consultants assessed three important factors when evaluating the feasibility of the City of Milton-Freewater conducting an aquifer storage and recovery (ASR) project: (1) the suitability of existing infrastructure within the City of Milton-Freewater's drinking water system, especially the construction of the wells; (2) the water quality of surface water and groundwater; and (3) the compatibility of the source water and receiving groundwater. The following sections assess five additional factors influencing the feasibility of water storage projects: the potential impacts of the proposed project on stream flows, comparison to alternative means of supplying water, environmental impacts of the proposed project, the need for and feasibility of augmenting instream flows, and future water demands.

Highlights of the major findings include the following:

- Diverting up to 8.6 cfs from December to May would not impair hydrological conditions in the Walla Walla River near Milton-Freewater nor impair fish habitat.
- Preventing a future diversion of 8.6 cfs from the Walla Walla River near Milton-Freewater during summer low-flow months to supply drinking water to the City of Milton-Freewater would provide a significant benefit to fish habitat. Preventing future decreases in summer flows is both needed and feasible.
- Alternative means of supplying water, such as water conservation, water efficiency, and water reuse, would be unable to meet the City's needs.
- The adverse impact on the riparian area of installing a diversion structure on the Little Walla Walla River near Well No. 5 would be temporary and minimal. No adverse impacts to water quality in the receiving aquifer are anticipated.
- Re-timing the diversion increases the basin's resiliency to future climate changes by relying on drinking water supplies obtained during winter when flows are abundant, instead of relying on diversion during low-flow summer months.
- The maximum potential diversion rates for a fully built-out ASR system would meet projected future demands within the City while alternative means of supplying water would not.

Section I – Background and Purpose

The City of Milton-Freewater's aquifer storage and recovery (ASR) project proposes to use existing basalt wells to store winter water diverted from the Little Walla Walla River in the basalt aquifer for use during the summer, preventing the need for the city to exercise its surface water rights for the Walla Walla River (including withdrawals during summer low flows) if the basalt aquifer is no longer able to meet the city's water needs. Using water stored in the basalt aquifer would prevent a diversion from the Walla Walla River during summer months of up to 8.63 cfs. In the preceding portions of this feasibility study, diversion rates of 2-4 cfs were used because this is the scale of the proposed ASR demonstration project. For this section of the report, however, the maximum theoretical diversion rate (based on water rights) of 8.63 cfs is used to evaluate the potential impacts from a full-scale ASR project. This report documents the results of the following storage-specific analyses required by Oregon Administrative Rules 690-600: (1) ecological flows; (2) alternative ways to supply water; (3) environmental impact; (4) need and ability to augment instream flows; and (5) future local and regional water demand and relationship of the project to other infrastructure projects.

Although the proposed diversion point for the Milton-Freewater ASR project is in the Little Walla Walla River, the following analysis focuses exclusively on potential impacts to the Walla Walla River for two reasons: (1) the channels of the upper Little Walla Walla River are used and controlled as irrigation supply ditches, not as river channels; (2) the Little Walla Walla River is screened to prevent fish access from the Walla Walla River (and potential stranding). Because one of the primary purposes of evaluating ecological flows is to ensure flow alterations do not adversely impact fish populations, an assessment of the upper Little Walla Walla River would be irrelevant. Additionally, all of the water in the Little Walla Walla River at its point of bifurcation comes from the Walla Walla River. Thus, the purpose of this ecological flows analysis is to assess the impact of the proposed Milton-Freewater ASR project on flows in the Walla Walla River from the point of diversion at Milton-Freewater to the state line.

Section II – Analysis of By-pass, Optimum Peak, Flushing and Other Ecological Flows of the Affected Stream and the Impact of the Storage Project on Those Flows

The Walla Walla River in the vicinity of Milton-Freewater is constrained by a seven-mile long levee system built to reducing flooding impacts. The river is located on an alluvial fan, which was formed by deposition of sediments from multiple distributary channels. In a distributary system, a single channel bifurcates into several channels, then the several channels eventually converge into a single channel farther downstream. In the Walla Walla River, flow routing among the distributary channels was altered significantly in past decades.

In highly altered systems like the Walla Walla River, how can ecological flows be determined? This analysis uses two methods: (1) the method as described in the Oregon Department of Fish and Wildlife's (ODFW) channel maintenance/peak flow guidance; and (2) comparing the normative hydrograph to the modern hydrograph to identify key historical hydrograph components or characteristics which may have supported historically abundant fish. Two methods were used because the ODFW guidance notes "Evaluations using this guidance should be reserved for streams that can have geomorphic adjustment. Channels constrained by levees and rock walls….can not properly utilize elevated flows for channel maintenance" (Robison, 2007, p. ii). Unfortunately, the point of diversion of the proposed project is within a leveed reach. The guidance does not offer an appropriate approach to quantify ecological flows in a leveed reach. A search of ecological flow literature found an approach intended for altered system in the Pacific Northwest described in "Functional Flows in Modified Riverscapes: Hydrographs, Habitats, and Opportunities" (Yarnell *et al*., 2015), which formed the basis of the second method used in this analysis.

Ecological Flows Based on ODFW Guidance

By-Pass Flows

What flows are necessary to maintain minimum habitat needs downstream of the point of diversion? OWRD's guidance document describing storage-specific study requirements (OWRD, 2016) recommends using the Instream Flow Incremental Methodology (IFIM) or Physical Habitat Simulation (PHABSIM) model to identify minimum baseflows. These models have been used in the Walla Walla basin at least twice but not to set minimum flows for the levee reach.

(1) The Washington State departments of Ecology and Fish and Wildlife (WDOE and WDFW) used IFIM in 2002 in the Washington portion of the basin to characterize the influence of different flows on habitat availability. The report did not recommend instream flow values, explaining:

> "…an instream flow recommendation requires the evaluation and incorporation of environmental variables other than habitat that affect fish survival, such as dam passage survival, water temperature, harvest and ocean survival. Water quality, the natural hydrology and sediment load should also be considered. Reaching a conclusion about an appropriate instream flow involves integrating the results of the IFIM study with consideration of these environmental variables." (p. 15, WDOE and WDFW, 2002).

WDOE later established regulatory minimum in-stream flows in Washington Administrative Code 173-532-030 for the Walla Walla River at Detour Road, approximately 10 miles downstream of the Milton-Freewater reach. Flow targets for December to May were established but no minimum flow values were established for June to November; instead the rule closed the river to further appropriation during the low flow period.

In 2016, WDOE and WDFW updated the weighted useable area habitat curves based on multiple studies, none of which were conducted in the Walla Walla River (WDOE and WDFW, 2016). The minimum in-stream flow targets for the Walla Walla River were not changed.

(2) The U.S. Army Corps of Engineers used PHABSIM to compare current conditions to future alternatives in managing the Walla Walla River but did not use the model to recommend base flows. Instead, the feasibility study's stated first objective was "…to establish a minimum

instream flow of 25 cfs to provide habitat connectivity by 2020" for the June to November period (USACE, 2010a, p. H-56).

Minimum instream flow values have been adopted by OWRD in OAR 690-507-0030 based on recommendations from the Oregon Department of Fish and Wildlife, as described in *Environmental Investigations: Umatilla Basin* (Oregon State Game Commission, 1973). More recently, the Walla Walla Watershed Flow Study Steering Committee recommended minimum summertime flows needed for fish habitat in the *Walla Walla Basin Integrated Flow Enhancement Study* (Walla Walla Watershed Flow Study Steering Committee, 2017). In 2019, the Confederated Tribes of the Umatilla Indian Reservation provided draft recommendations for wintertime minimum flows to the Steering Committee (CTUIR, undated).

The proposed maximum diversion rate for the Milton-Freewater ASR project is 8.6 cfs, to be diverted from December through May. With a 8.6 cfs diversion, minimum flow targets adopted by OWRD and draft targets recommended by CTUIR would still be met based on the average monthly flows in the Walla Walla River downstream of the Little Walla Walla River diversion and at Pepper's Bridge, just past (north of) the state line (Table 1).

Table 1. Impact of the proposed diversion on minimum flows.

Month	OWRD regulatory minimum in-stream flows (cfs)	CTUIR recommended minimum in-stream flows (cfs)	Average flow (cfs) downstream of Little Walla Walla River (altered, modern dataset)	Average flow (cfs) minus 8.6 cfs	Average flow (cfs) at Pepper's Bridge	Average flow (cfs) at Pepper's Bridge minus 8.6 cfs
Dec	70	95	210	201	168	160
Jan	70	95	266	257	259	250
Feb	95	120	296	287	300	292
Mar	95	130	333	324	343	334
Apr	95	150	349	341	353	344
May	95	150	300	291	288	279

Optimum Peak Flows

The ODFW flow guidance identifies two key functions of peak flows – flows which trigger an ecological process (such as fish migration) and flows which enable channel maintenance processes. Needed channel maintenance flows range from those that move fine sediment to those that overtop banks (to replenish riparian vegetation), scour banks (to recruit wood), and scour the channel (to prevent encroaching riparian vegetation and retain conveyance capacity).

Ecological Triggering Flows

The ODFW guidance states "The ecological timing related discharges that are associated with biological behavior shifts are most often species and location specific." (p. ii, Robison, 2007). No data were found characterizing the magnitude or frequency of flows triggering migration and spawning by salmon or steelhead in the Walla Walla River when reviewing various fish assessment reports. None of the local fish biologists were aware of any such data.

In two fisheries annual monitoring and evaluation reports, there were discussions of run timing in comparison to flow conditions but not in terms of cause and effect:

> "Adult spring Chinook return to NBD between April and June and peak migration coincides with a strong decline in the hydrograph" (2018 CTUIR M&E, p. 9).
>
> "…peak spring Chinook returns occur in late spring during receding stream flows (Figure 9) and increasing stream temperature. Figure 9 shows that the tail end of the Chinook run coincides with a steep decline in flow. It appears that the late spring freshet may be sufficient for a few late running Chinook to reach Nursery Bridge in June. However, we presume the lack of sufficient cool flow within the lower mainstem to preclude migration for some late running spring Chinook." (CTUIR and WEC, 2008, p. 37).

Based on the lack of data, no ecological triggering flows were identified in this ecological flow analysis.

Channel Maintenance Flows

To determine the magnitude of channel maintenance flows, the process in Robinson *et al.* was followed: identify the channel type, dominant substrate, bankfull flows, and critical flows. Bankfull flows were determined using recurrence intervals of peak flows. Critical flows were determined using cross-sectional and substrate data to estimate the critical velocity or shear stress that will likely initiate movement of bed materials.

Channel Type and Dominant Substrate

Using the *Oregon Watershed Assessment Manual* classification system (Watershed Professionals Network, 1999), the channel type is "alluvial fan" (see Appendix A for description). Two recent field-based surveys relied on the Rosgen classification system (ODEQ, 2005, and GeoEngineers, 2012). The Rosgen classifications of the channel types in the levee were primarily C3 and C4 but also B4, while downstream of the levee to the state line was D4 system (Table 2 and Table 3). B4, C4, and D4 are gravel-bed streams while C3 is a cobble-bed stream. All four classifications are for low-gradient (< 0.02) channels.

Table 2. Rosgen classifications for the Walla Walla River near Milton-Freewater.

ODEQ, 2005 (surveyed in 2000)			**GeoEngineers, 2012 (surveyed in 2010-2011)**		
RM	**Site Description**	**Rosgen Class**	**RM (WWBWC)**	**Site Description**	**Rosgen Class**
41.8	Private property, Matthew's Land	D4	No comparable location		
44.1	Willow Lane (0.5 mile downstream Nursery Bridge)	C4	43.6 - 44.5	Tum-A-Lum Bridge to Gravel Pits	C4
44.9	1st Street, M-F levee section	C3	44.5 - 45.9	Gravel Pits to Nursery Bridge	C3
46.1	Near Frasier Farmstead museum, M-F levee section	C4	45.9 - 47	Nursery Bridge to Cemetery Bridge	C3
No comparable location			47 – 47.9	Cemetery Bridge to 15th Ave Bridge	C3
48.1	Private property (Off Day Road)	B4c	47.9-49.5	15th Ave Bridge to Zell Ditch	C2, C3

Table 3.Description of Rosgen channel types.

Rosgen channel type	Description
B	Moderately entrenched (entrenchment ratio 1.4-2.2), moderate gradient (0.02-0.039), riffle-dominated, infrequently spaced pools. Very stable plan and profile. Stable banks. Moderate relief, colluvial deposition +/or structural. Moderate width/depth ratio (>12). Narrow, gently sloping valleys. Rapids predominate with scour pools. Sinuosity >1.2.
B4c	Slope < 0.02, channel material gravel
C	Low gradient (< 0.02), meandering (sinuosity > 1.2), point bar, riffle/pool, alluvial channels. Broad, well-defined floodplains. Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched (entrenchment ratio > 2.2). Well-defined meandering channels. Width/depth ratio >40.
C3	Slope 0.001-0.02, channel material cobble
C4	Slope 0.001-0.02, channel material gravel
D	Braided channel with longitudinal and transverse bars. Very wide channel (width/depth ratio >40) with eroding banks. Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment with abundance of sediment supply. Convergence/divergence of bed features, aggradational processes, high bedload and bank erosion. Slope < 0.04.
D4	Slope 0.001-0.02, channel material gravel

The Oregon Department of Environmental Quality's (ODEQ) temperature Total Maximum Daily Load (TMDL) provided the following data on substrate size (Table 4):

Table 4. Substrate type.

Location	D50 (mm)	Classification
Upstream of the levee, downstream of the Forks RM 48.1	48-64	gravel
Within the levee, near Frasier Farmstead Museum, RM 46.1	48-64	gravel
Within the levee, 1st Street, Milton-Freewater, RM 44.9	64-96	cobble
Within the levee, 0.5 miles downstream of Nursery Bridge, RM 44.1	48-64	gravel
Downstream of the levee, Matthew's Lane, RM 41.8	16-24	gravel

Based on these prior analyses, the dominant substrates are large gravel and cobble. The ODFW guidance differs for gravel and cobble-based streams. To be conservative – to ensure adequate flow is retained instream to move cobble, not just gravel – this analysis relied on the guidance for cobble-bed streams.

Bankfull Based on Recurrence Intervals

As described in the ODFW guidance for cobble bed streams, the two-to-three year recurrence peak flow intervals (Q2 to Q3) and/or the bankfull flow may be used as initial estimates of the magnitude of flows needed to support channel maintenance functions.

Several studies of the Walla Walla River have determined recurrence intervals of peak flows at different locations between the confluence of the South and North Forks and the state line (Table 5). Most of the published values include Q2 but not Q3 intervals. Within the levee, two estimates of Q2 are 2,083 cfs and 1,200 cfs, while another evaluation within the levee but for Q1.5 is 2,160 cfs. The wide range of estimates for the same reach reflects the importance of the underlying data used in the analyses and

Table 5. Published recurrence intervals for the Walla Walla River near Milton-Freewater.

Analysis	Return interval	Associated flow (cfs)	Location	Method
CTUIR, 2019	2-yr= bf 7-yr	1,005 -- 1 day duration 1,360 -- 3 day duration	D.S. of forks, U.S. of M-F	1931-2009 POR. 7-yr recurrence = riparian refreshment (overtops banks not constricted by levees). Used mean daily annual peak flows, not instantaneous flows to create flow duration curves. Under-represents actual peak flows.
Pine Creek Reservoir, CH2M, 2017	1.5-yr 2-yr=bf	1,719 2,083	RM 45.9 Cemetery Bridge	Proportional area method + GeoEng peak flow analysis (which used skewed not weighted). Trigger flow = 2,083 cfs.
Nursery Bridge, GeoEngineers, 2014	1.5-yr	2,160	Nursery Bridge	> 400 cfs begin to spill onto floodplain within the levee. Peak velocity at bankfull = 6.45 ft/s and at 1.5-yr event 9.98 ft/s.
M-F Levee Alt, GeoEngineers, 2011	1.5-yr=bf 2-yr 5-yr 10-yr	2,160 2,618 3,939 4,970	State line	Historic records for 3 gages (S Fk[1903-1991, continuous 1932-1991], N Fk [1930-1969], N Fk [1969-1991]. POR 60 years, 1932-1991. Used regression to est Q (incl peak Qs) at stateline. Stateline peak Q analyzed using Log-Pearson Type III distribution (per Bulletin 17B) but used statistical skew instead of weighted skew due to long POR and need to be conservative (stat skew results in larger flood Qs). Represents worst-case.
USACE, Feasibility, 2010a		BF=1 to 2 yr	--	Annual peak Q frequency curve on Plate 9 is dated 1992.
USACE Sediment, 2010b	2-yr=bf	1,633 duration of <1 day	At confluence of forks	N Fk + S Fk peak Q 1932-1991. Composite peak Q freq curve for N Fk + S Fk was calc using Bulletin 17B. Adjusted for ungauged portion using proportional area method. Q2 consistent w/ observed peak Q frequency at Pepper Bridge (1500-1600) and USGS regional regression for SE WA (area 9) calc Q2 of 1,785 cfs.
USACE Floodplain Restoration, 2000	1.5-yr 2-yr	940 1,200	WWR at M-F	Plate 3. Annual peak Q freq curve, dated May 2000. Drainage area 162 mi2, POR 1904-1970; POR was extended by flood analysis. Procedures: *Stats Methods in Hydrology*, Beard, 1962. Curve was re-drawn from curve dev by USACE 1973.
USACE Fish Passage, 1996	1.5-yr 2-yr	810 1,100	WWR abv M-F	POR not stated. Curve dated Jan 1992. Drainage area 140 mi^2 abv MF. Freq stats determined by analysis of stats & basin characteristics of nearby gaged sites.
USACE Levee, 1948	1.5-yr 2-yr 10-yr	1,300 1,600 4,200	WWR nr M-F	POR 1882-1943 max. annual floods (1882, 1894 mj floods; 1883, 1893, 1895-1902 estimated by historical method; 1906, 1919, 1921, 1927, 1929, 1931 publ records WWR nr Milton; 1909, 1912, 1914, 1915, 1930, 1932-43 publ records of upstream stations; 1903-1905, 1907-08, 1910-11, 1913, 1916-1918, 1922-1926 pub records in WWR and Umatilla River basins.
Castro & Jackson, 2001	1.03 yr = bf		WWR at Touchet gage	Measured bankfull indicators. Related bankfull stage to gage height and discharge. Used annual maximum peak flow frequency curve to determine recurrence interval of bankfull.

Notes: bf=bankfull. POR = period-of-record. Q=discharge. D.S. = downstream. U.S. = upstream. nr = near. N Fk = North Fork. S Fk = South Fork. WWR = Walla Walla River.

the choices made regarding various steps in the analysis. For the Milton-Freewater ASR ecological flows analysis, the Q2 of 1,633 cfs with a duration of less than one day (USACE Sediment Analysis) was selected for the following reasons: (1) The method relied on standard Bulletin 12B methods and a weighted skew; (2) it is relatively recent; (3) although the location is at the confluence of the forks, during peak events flows at the confluence are expected to be very similar to flows within the levee because such a small proportion of peak flows are allowed into the Little Walla Walla River; and (4) the report specified the duration of the Q2 flows (most published values did not include duration).

In recent years, within the levee near Nursery Bridge a low-flow channel was constructed as part of a fish passage project. The low-flow channel was intended to contain flows up to 400 cfs; higher flows are intentionally spilled out onto the “floodplain” within the levee. A flow of 1,633 cfs therefore represents minor flooding that would occur in the mini-floodplain within the levee at least in some locations.

Based on the analysis from the USACE sediment study, every other year a peak flow of at least 1,633 cfs (if the peak is that high) should not be diverted for a one-day period but allowed to re-work the sediment deposited in the levee reach.

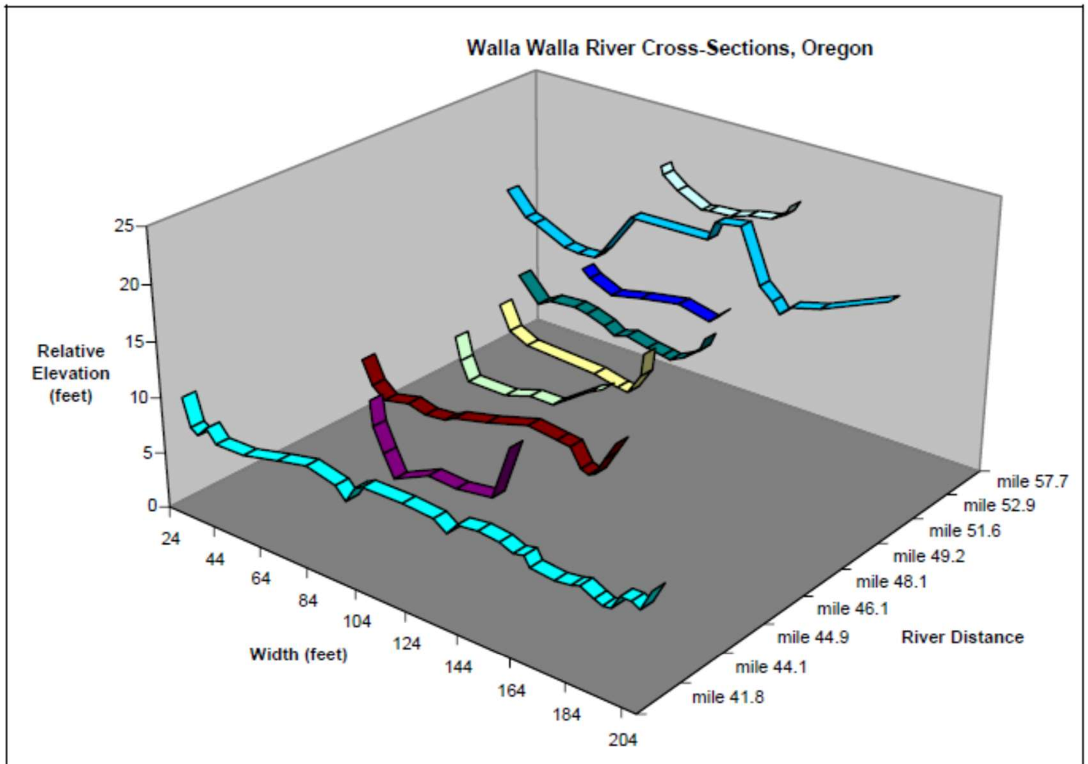
Critical Flows

Previous assessments have also determined critical flows in the Walla Walla River – flows at which bed sediments are mobilized. Conditions in the levee are significantly different than downstream of the levee. Just one illustration of the importance of the levee to the hydrologic functions of the river is shown in Figure 1. When the river exits the levee system (the lower left light blue ribbon in the upper diagram), channel width increases abruptly and significantly, as the river adjusts to the increased floodplain width.

Alternatives Analysis & Conceptual Design Milton-Freewater Levee and Habitat (GeoEngineers, 2017)
“Levee sections of the river tend to have deeper flow depths, and higher flow velocities, shear stresses and stream power as compared to the non-levee sections. The average top width of water is also reduced within the levee system. This creates the potential for the movement of more and larger sediment, decreased channel complexity, and reduces the amount of wetted usable area during a wide range of discharges within the levee section of river.” (p. 27)

Based on hydraulic properties estimated using the project HEC-RAS model, the authors concluded:

- “Shear stress decreases in the downstream direction, as slope decreases, favoring stability of finer material downstream;
- Shear stress is approximately equivalent to or slightly lower than critical shear stress for the median grain size based on average flow depths at the 1-year flow and is higher than critical shear stress for the median streambed grain size in the thalweg at the 1-year flow and for both average and thalweg depths at the 10-year flow. This is indicative of dominantly equilibrium sediment transport regimes under existing conditions within the reach.
- Shear stress is locally highly variable within the Project Reach, which in turn provides variability in substrate size distribution needed for high quality habitat within the Project Reach.” (p. 32).



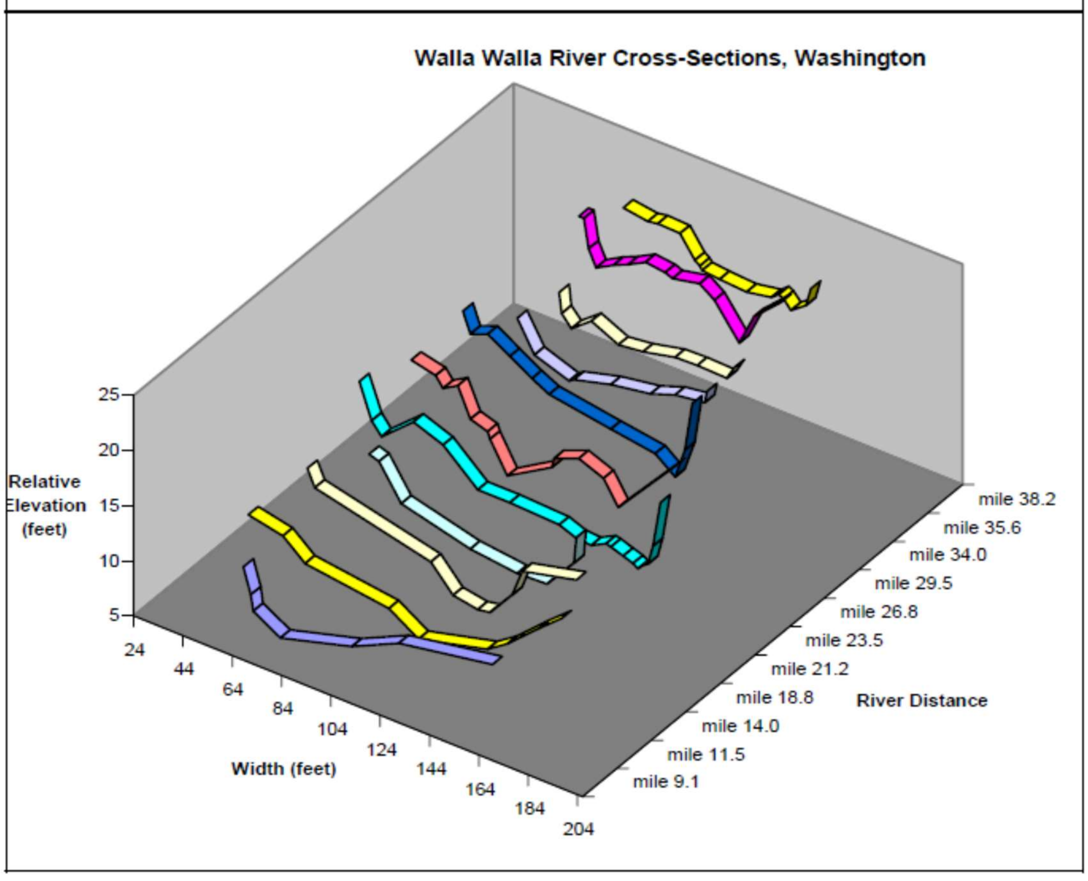


Figure 1. Channel cross-sections, ribbon ends are at bankfull (ODEQ TMDL, p. 31).

The appendix to the GeoEngineers report lists 1,066 cfs as the 1-year discharge (pdf p. 177) and 4,970 cfs as the 10-year discharge. Based on the above language, substrate of a typical size in the levee reach would move in the thalweg but not in the rest of the channel at 1,066 cfs. During 10-year peak flow events, the typically-sized substrate in portions of the channel with at least average depths of water would move at 4,970 cfs.

As the river leaves the levee, hydraulic parameters change. Using a modeled flow of a 1.5-year recurrence event of 2,160 cfs, the average channel depth, velocity, shear, and stream power all decrease (Table 6). Channel width increases abruptly and significantly for a short distance. The average shear stress is greater than critical shear stresses for the median-sized substrate (Table 7).

Table 6. Average hydraulic parameters in levee and non-levee reaches (GeoEngineers, 2012).

Reach	Channel depth (ft)	Velocity (ft/sec)	Shear (lb/ft^2)	Stream power (lb/ft*sec)
Levee	3.0	6.7	1.8	13.0
Non-levee	2.4	5.7	1.1	7.5

Table 7. Critical shear stresses (GeoEngineers, 2012).

RM	Location description	D50 (mm)	Critical shear stress for D50 (lb/ft^2)	Shear stress (lb/ft^2) at 1.5-yr recurrence interval Q
44.1	Levee, Willow Lane, 0.5 mi ds Nursery Bridge	58.9	0.62	0.1 to 4.8, average 1.8
44.9	Levee, 1st St MF	85.2	0.89	
46.1	Levee, nr Frasier Farmstead Museum	58.9	0.62	
48.1	Upstream of levee, near Zell Diversion	55.3	0.58	

Note: Bed sediment moves when shear stress is greater than the critical shear stress.

Walla Walla River, Milton-Freewater, Oregon, Levee System Sediment Impact Assessment, Stage 1 (USACE, 2010b)

Based on hydraulic and sediment size data and using a Shields curve: D50 particles likely move above Nursery Bridge during Q2 events (p. 95) but not D84 particles – typical of alluvial channels that have developed an armor layer. Estimated stable widths depths and slopes based on published equations: for 2-yr return interval of 1,500 cfs, stable width 77-100 ft, depth 3.0-3.8 ft, and slope 0.5-1%. At very high flows, entire bed moves, threaten the levee; only a series of grade control structures as originally envisioned by the designers would counteract tendency to scour and degrade during high flows.

Concept Study Pine Creek Reservoir, Draft Report (CH2M, 2017)

The HEC-RAS model was used to identify critical discharge values using rating curves for cross-sections between Cemetery Bridge at RM 45.9 and Nursery Bridge at RM 44.7. The results were highly variable. In fourteen of the 25 cross sections, the critical shear stress of 0.9 psf was exceeded at flows less than 800 cfs. The critical discharge values for the remaining eleven cross-sections varied from 950 to 2,350 cfs, with an average of 1,755 cfs (CH2M, 2017). Because of the great uncertainty in the variables used to calculate shear stress, CH2M also conducted a Monte Carlo statistical analysis of critical discharge, using the estimated mean and standard deviation of the Shields parameter, d50 grain size, Manning's "n" coefficient, slope, and channel top width. The simulation "…makes 1000 calculations by randomly selecting values of Shield's number, d50 grain size, and Manning's "n" from user-specified statistical distributions for each calculation." The result was a mean critical discharge of 1,983 cfs with a standard deviation of 274 cfs.

<u>USACE 1948 Levee Design</u>
The maximum annual flood probability curve indicates a Q2 of roughly 720 cfs. The hydraulic design assumed that 750 cfs would be the critical flow.

<u>Observation</u>
Based on observations of channel form after spring freshets recede, gravel and cobble substrate in the riverbed in the levee section tend to mobilize at discharges greater than 500 cfs (Wolcott, pers. comm., 2019).

Because the critical flow values in the GeoEngineers and CH2M studies are typically lower in magnitude than peak flow events occurring every two years as characterized in the same studies (Table 8), it is likely both fine and coarse sediments are being mobilized more often than every two years. This is supported by the paucity of fine sediment deposited in the levee reach -- none of Rosgen channel classifications were for a channel bed dominated by fine sediments and none of the pebble counts were dominated by fine sediments.

Table 8. Comparison of critical flows and critical shear stresses.

Analysis	Q2 (cfs)	Critical flow (cfs)	Critical shear stress for D50 (psf)
GeoEng M-F Levee Alt	2,618 at stateline (RM 40)	1-yr flow (1,066 cfs) in thalweg	0.58-0.89
Pine Ck Reservoir (CH2M)	2,083 between RM 44.7 – 45.9	250 to 2,350 (average 1,755; modeled mean 1,983 cfs)	Highly variable. Most common: 0.9
USACE 1948 Levee Design	720	750 assumed	--

Impact of the Project on Base and Peak Flows

To summarize the available information, the flows at which the gravel and cobble bed begins to move under current conditions are estimated to range from 250 to 2,350 cfs. A decrease in flow of 8.6 cfs from December through May for the Milton-Freewater ASR diversion will not substantially reduce the frequency, magnitude or duration of flow events which are capable of moving fine sediment or the coarse bed substrate.

Ecological Flows Based on Functional Flows Approach

As described below, the hydrology of the Walla Walla River is highly altered due to the levee system and changes in flow routing. The ODFW guidance describes that the process outlined in the peak flow guidance is not appropriate for leveed systems. Therefore, a second approach to determine ecological flows was used which is intended for highly altered systems. The approach is described in "Functional Flows in Modified Riverscapes: Hydrographs, Habitats and Opportunities" (Yarnell *et al*., 2015), hereinafter referred to as the Functional Flows approach. The approach recommends retaining specific process-based components of the natural hydrograph (functional flows) but not attempting to mimic the full natural flow regime. The key functional components of the hydrograph are wet-season initiation flows, peak magnitude flows, recession flows, dry-season low flows, and interannual variability (Figure 2). While OWRD's ecological flow setting approach focuses on two significant outcomes of the hydrograph – sediment transport and ecological triggers – the Functional Flows approach assumes that retaining key functional components of the hydrograph will support and enable many interrelated physical and ecological processes, including sediment transport, algal growth, nutrient cycling, large wood movement, riparian succession, and short- and long-term population dynamics.

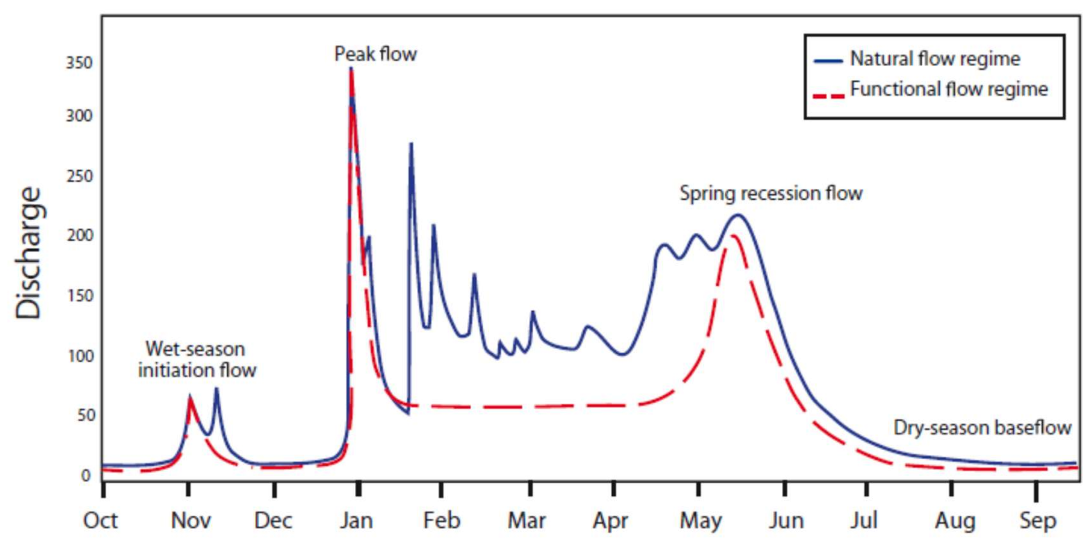


Figure 2. Natural and functional flow regimes in a Mediterranean–montane climate, where spring occurs April to June. Peak flows are typically rain-driven events in winter, whereas a pronounced snowmelt pulse occurs in spring. The functional flow regime retains key components of the natural hydrograph that support physical and ecological processes across the riverscape.

Figure 2. Reproduction of Figure 2 from Yarnell *et al*.

To quantify the key components of the hydrograph in the Walla Walla River, The Nature Conservancy's *Indicator of Hydrologic Alternation* software was used. Then the five principles of managing highly altered rivers described in the Functional Flows article were applied to results from the IHA software (see callout box). This evaluation process required a significant amount of work to assess potential impacts from a relatively small diversion. However, in addition to wanting to use an approach suitable for a leveed reach, it was hoped this alternative approach could be used in future evaluations of proposed larger diversions within the leveed reach.

"Five Principles for Management of Highly Modified Rivers

Guiding principles for management of rivers in highly modified riverscapes.

1. **Hydrogeomorphic connections within the riverscape should be maintained or restored in order to achieve optimal ecosystem functionality.** This requires peak flows equal to at least the channel-filling discharge that can access overbank areas and are of appropriate duration to move the annually delivered sediment supply. The more space given to a channel and its floodplain, the greater the ecological benefit from flood flows.

2. **Transitions in flow between seasons should be retained.** High turbidity wet-season initiation flows and spring recession flows have high ecological benefit across a riverscape.

3. **Seasonality of baseflows should be retained.** Higher baseflows in wet seasons support channel margin habitats and promote groundwater recharge, and lower baseflows in dry seasons create habitat partitioning and limit nonnative species. Variations in baseflows can help limit impacts from prolonged constant flows.

4. **Flow regimes should reflect interannual climate variability.** Larger peak flows, longer duration recessions, and higher baseflows should occur in wet years, whereas smaller, shorter, lower flows should occur in dry years. Within year variability may be necessarily limited in extreme years, such as prolonged drought or flood.

5. **Water management for human uses should consider the seasonality of natural flows.** Greater water abstraction, high flow releases to the river from hydropower, or water supply deliveries should occur during wetter months rather than drier months. A few floods should be retained at near full magnitude and duration, whereas others are removed for consumptive uses, rather than reducing all flood magnitudes."

Quoted from Yarnell et al, 2015, p. 971.

Historical Alterations to Flow Patterns

In the mid-1800's, at least six major distributary channels of the Little Walla Walla River and Walla Walla River spread across the roughly three-to-four mile wide alluvial fan near the present-day location of Milton-Freewater. As a result, for 15 miles from the initial bifurcation upstream of Milton-Freewater at river mile (RM) 47 to where the West Little Walla Walla River converges with the Walla Walla River at RM 32.2, in the mid-1800's the Walla Walla River may have contained only a portion of the discharge from the single channel emerging from the Blue Mountains. The proportion of flows conveyed by each channel would be expected to vary over time (within and among years) due to the nature of stream channels on an alluvial fan. A modern map of the basin conveys the nature of the distributary system on the alluvial fan (Figure 3).

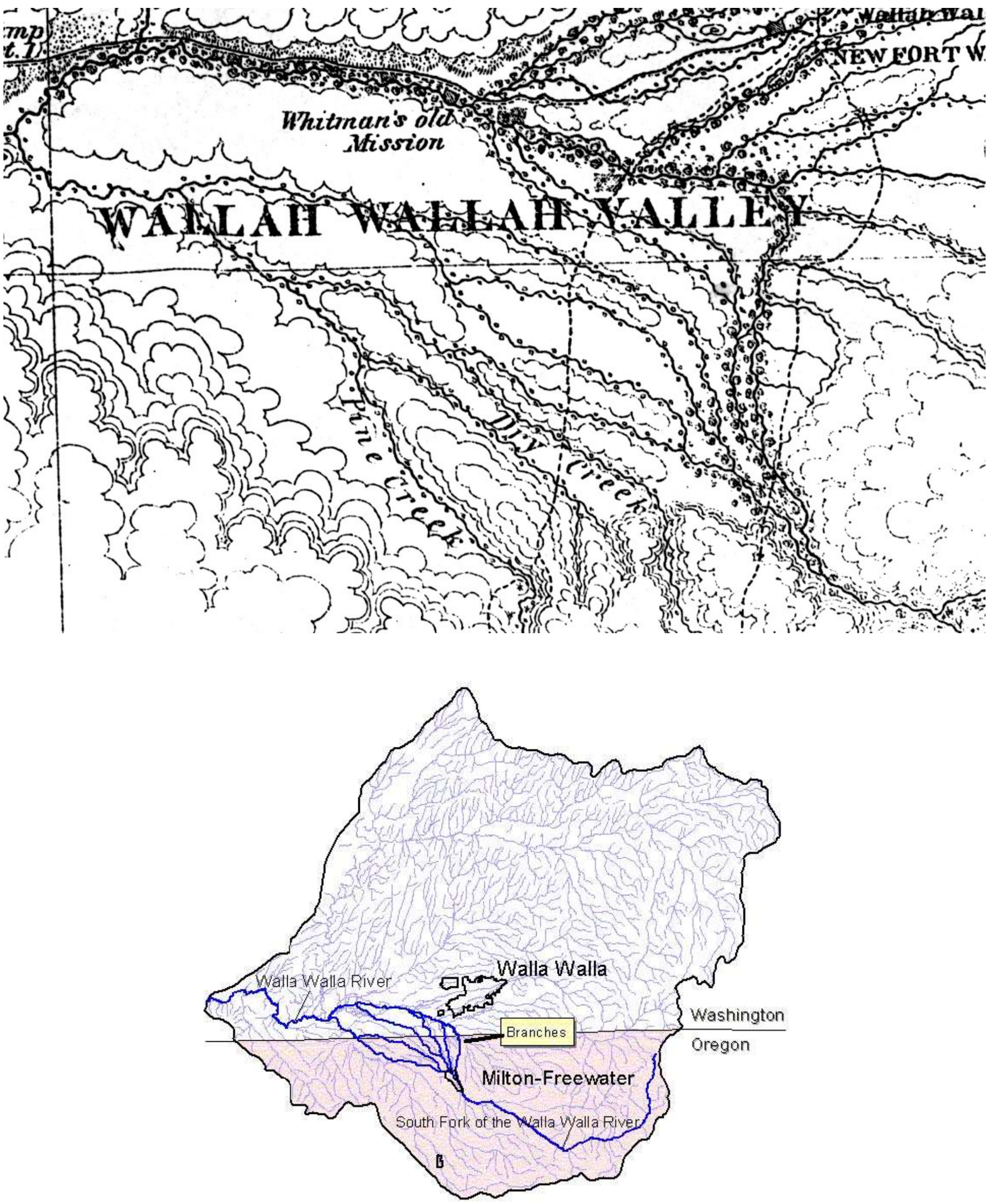


Figure 3. Distributary channels near Milton-Freewater in 1858, above (Mulllan, 1863) and in 2005, below (ODEQ, 2005).

Because of frequent flooding on the alluvial fan, early settlers built individual levees to attempt to protect their property. However, frequent flooding continued and in 1934-39, a head gate was installed to control the inflow of water to the Little Walla Walla River and prevent flooding (Little Walla Walla River Co-op Irrigation Union, 1934-40). The energy of peak flow events in the single channel coming out of the mountains was no longer able to be diffused across multiple channels.

The Walla Walla River responded to this change by increasing the width of its channel. As described later in this report, the width of the Walla Walla River in 1865 was 6.6 to 39.6 ft[1] from Nursery Bridge to just south of the stateline (General Land Office, 1865). In contrast, GeoEngineers estimated the pre-levee channel width of the Walla Walla River in 1944 was 600 ft from Nursery Bridge to the gravel pit area roughly 4,550 ft downstream of Nursery Bridge (GeoEngineers, 2012). As documented in a 1944 aerial photograph of the Walla Walla River near Milton-Freewater (Figure 4) the width of a scoured area from Nursery Bridge to upstream of Tumalum Bridge was up to roughly 3,000 ft, based on the scale included in the photograph. The U.S. Army Corps of Engineers (USACE) levee construction did not begin until 1947.

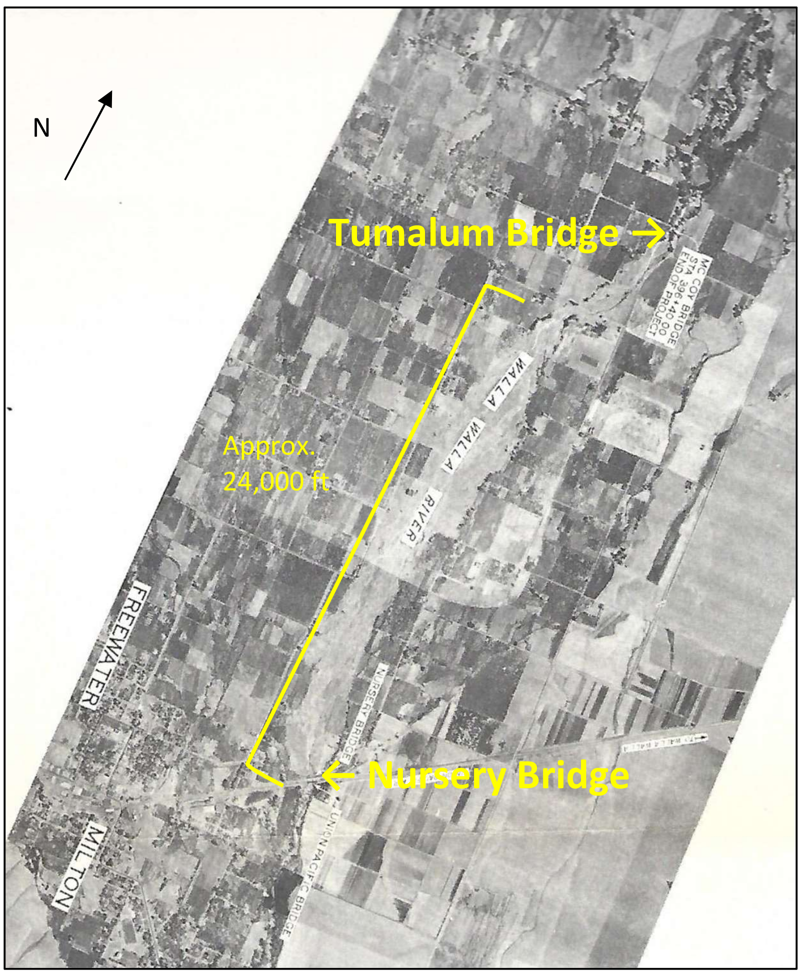


Figure 4. Walla Walla River near Milon-Freewater, December 1944.

Source: *Definitive Project Report on Milton-Freewater, Walla Walla River, Oregon*, U.S. Army Corps of Engineers, 1945. North arrow added.

[1] The General Land Office survey notes do not describe the type of width that was measured by the surveyors – channel width, wetted width, bankfull width, etc.

The widths of the Little Walla Walla River decreased from 6.6 to 29.7 ft in 1865 (General Land Office, 1865) to 4 to 11.8 ft in 2006 and 2012 (Mahoney *et al*. 2006; WWBWC, 2012). In Figure 5, photographs of the East and West Little Walla Walla River at Sunnyside Road in 2019 show greatly decreased modern stream widths at the same location as measured by the General Land Office in 1865 when the rivers were 19.8 ft and 13.2 ft wide, respectively.

Figure 5. East and West Little Walla Walla River at Sunnyside Road, June 2019.

Then, in the 1950's, a USACE levee system was constructed to prevent flooding from the eastern-most channel, concentrating the available stream power within the levee corridor. The consequence of this "fire-hose" approach to water management is seen in modern conditions in the levee reach – channel degradation has decreased bed elevations of up to 18 feet compared to pre-levee conditions (GeoEngineers, 2012), lack of long-term accumulation of fine sediments in the Nursery Bridge to Tumalum reach (ODEQ, 2005), insufficient number of pools (Walla Walla Watershed Planning Unit and WWBWC, 2004), and a wider channel than in the mid-1800's (General Land Office, 1865). Modern bankfull widths in the levee reach range from 76 to 200 ft (GeoEngineers, 2012, pp. 37-43) -- less than the estimated pre-levee dimensions of 1944 but greater than the 1865 widths of 6.6 to 39.6 ft (General Land Office, 1865).

The alluvial fan was a significant element of the historical hydrological system, in part because it served the same functions as a floodplain, including providing extensive recharge of the shallow aquifer under the alluvial fan, especially during peak flows. The extensive spring system resulting from annual recharge of the shallow aquifer prompted early observers to describe the Walla Walla valley as having "thousands" of springs never known to fail (Mullan, 1863; Wilkes, 1845). "The valley can boast of many large ice-cold springs" (Oregon State Board of Horticulture, 1898). The springs provided clear, cool groundwater to downgradient streams, which would have in turned cooled the mainstem of the Walla

Walla River. Even as far downstream as the Whitman Mission, the river was described as "limpid and cool throughout the year" (Farnham, 1843). Historically, the estimated yield from the 57 surveyed springs was 50,000 ac-ft (Oregon State Water Resources Board, 1963), or 69 cfs on an annual basis. For perspective on the potential historical importance of these springs, on August 26, 1897 the flow of the Walla Walla River one-half mile downstream of the mouth of the Little Walla Walla River, at Whitman, was 78 cfs and the gage height was 0.86 feet (USGS, 1899, p. 492).

The floodplain function of the alluvial fan was essentially eliminated when the USACE levee was built. Even without its floodplain function, the alluvial fan remains a significant element of the modern-day hydrological system due to the coarseness of the alluvial sediment in the alluvial fan, the depth and width of the alluvial deposits, increased irrigation-induced recharge, and the direct connection of the alluvial aquifer under the fan with the Walla Walla River.

Developing a Normative Hydrograph

Because the Functional Flows approach relies on retaining components of the natural flow regime, the first step in the analyzing ecological flows was to develop a normative (natural) hydrograph for the Walla Walla River at Milton-Freewater to quantify the key components which supported physical and ecological processes and functions before they were impaired. Appendix B provides the details of the normative hydrograph development. A summary follows.

To calculate natural flows coming out of the Walla Walla canyon, a 47-year period-of-record for water year (WY) 1970 to 2016 was created which combined the OWRD gaging data from the North Fork and South Fork, and a synthesized dataset for Couse Creek. This combined dataset, called the "Composite" dataset, captures the temporal variability over almost five decades of nearly natural flows coming out of the mountains onto the valley floor.

On the valley floor, the river historically bifurcated into at least six major distributary channels. The first step in estimating discharge in each of the six major distributary channels was to obtain data from the General Land Office surveys. In the Walla Walla basin, surveyors from the General Land Office measured stream widths where the streams crossed the section lines in 1864-1865 – before major alterations of the hydrograph (see Appendix A for detailed map; Figure 6 is a simplified schematic). The West Little Walla Walla River, East Little Walla Walla River, and Walla Walla River each had two channels at various locations.

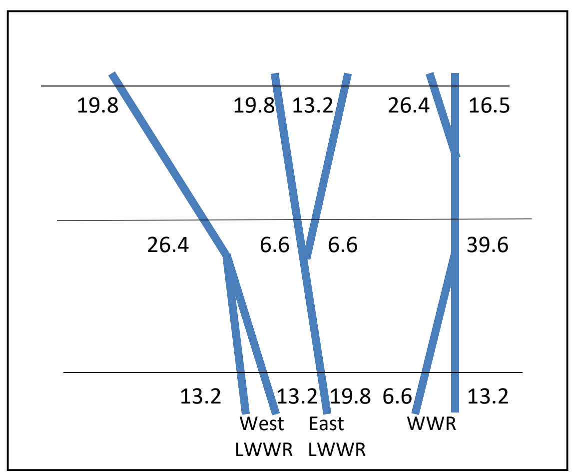


Figure 6. Schematic of stream widths (ft) in 1865

The ratio of the width of each of the six channels to the total width of all six channels was calculated at each section line, then the results from the three section lines were averaged to yield three ratios, one each for the West Little Walla Walla River, East Little Walla Walla River, and the Walla Walla River (Table 9). Based on the measured widths, the Walla Walla River channels accounted for 42% of the total channel widths while the Little Walla Walla River channels accounted for 58% of the total widths.

Table 9. GLO Measured Widths.

Variable	WLWW #1	WLWW #2	ELWW #1	ELWW #2	Tumalum #1	Tumalum #2	Total width (ft)
At northern edge of S 35/36							
Stream width (ft)	13.2	13.2	19.8	--	6.6	13.2	66.0
Proportion of width by channel	0.2	0.2	0.3	--	0.1	0.2	--
Proportion of width by river	*0.4*	--	*0.3*	--	*0.3*	--	--
At S 25-27							
Stream width (ft)	26.4	--	6.6	6.6	39.6	--	79.2
Proportion of width by channel	0.3	--	0.1	0.1	0.5	--	--
Proportion of width by river	*0.3*	--	*0.2*	--	*0.5*	--	--
At S 22-24							
Stream width (ft)	19.8	--	19.8	13.2	26.4	16.5	95.7
Proportion of width by channel	0.2	--	0.2	0.1	0.3	0.2	--
Proportion of width by river	*0.2*	--	*0.3*	--	*0.4*	--	--
River	Little Walla Walla River				Tumalum (Walla Walla River)		
Average percent of the proportions	58				42		

Discharge (flow) is the product of velocity times water depth times wetted width. The width is known, so what can we reasonably conclude about velocity and depth? As described in more detail in Appendix B, physical factors influencing water depth and/or velocity include gradient, channel bed roughness, river bed and bank cohesiveness, and the type/size of sediment being transported by the stream. All of these factors would have been similar across the alluvial fan due to the single source of sediment (the Walla Walla River in the canyon), the low gradient of the fan, and the chaotic non-preferential deposition of sediments which created the fan. Based on these factors, it is reasonable to conclude the amount of flow in each channel was roughly proportional to the width of each channel.

Therefore, relying on the proportions of stream widths, an estimated 42% of the flow leaving the mountains in 1865 would have entered the Walla Walla River channels and 58% would have entered the Little Walla Walla River channels. In contrast, under modern water management, roughly 75% of the annual flow leaving the mountains occupies the Walla Walla River channel while 25% occupies the Little Walla Walla River (predominantly during the summer).

The historical ratio of 42% was applied to the daily mean discharge measurements in the 47-year composite dataset to create a hydrograph reflecting the probable magnitude, timing, and variability of natural flows in the Walla Walla River downstream of the Little Walla Walla River bifurcation before flow patterns were altered. The normative hydrograph has exactly the same pattern of timing and variability of flows as the composite dataset; the only difference is a 58% reduction in the magnitude of each day’s average flow value.

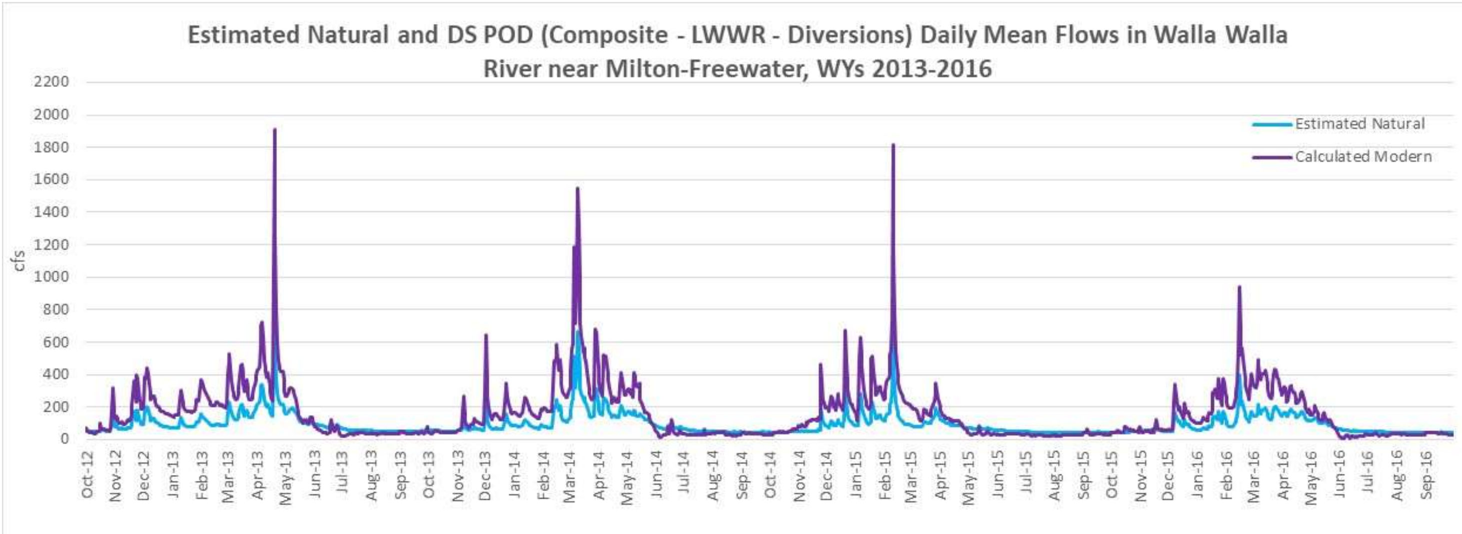
While these ratios provide an insight into conditions in 1865, it must be emphasized the ratios are not intended to imply these historical conditions were rigid and unchanging even before human intervention. The nature of channels on alluvial fans is that they move frequently and are inherently transitory. Additionally, it is not possible to determine if the measured widths were representative of typical conditions along the approximate 3-mile lengths of the channels on the alluvial fan. So it is important to realize this approach results in an approximation of natural conditions – not a quantification of them.

The natural hydrograph was then compared against the modern hydrograph. The 47-year dataset used to represent modern altered conditions in the Walla Walla River downstream of the Little Walla Walla River was created by subtracting the following flows from the daily average flows in the composite dataset: (1) daily average flows in the Little Walla Walla River, based on 15-minute data from the OWRD gaging station near the location where the Little Walla Walla River splits off from the Walla Walla River; (2) average diversion rates for the Eastside diversion of 1 cfs in March, 2 cfs in April, 4 cfs in May, June, and October, and 5 cfs in July and August (CH2M, 2017); and (3) average diversion rates upstream of Milton-Freewater in the mainstem Walla Walla River, North Fork, and South Fork, of 10 cfs in May and September and 20 cfs in June, July and August (CH2M, 2017). For those days when the subtractions resulted in negative values, the negative values were replaced with a zero. No attempt was made to adjust for seepage losses, since insufficient data are available to estimate seepage losses throughout a 47-year period of record. Instead, when evaluating fish habitat conditions in later sections of this report, stream flow data from the Nursery Bridge and Peppers Bridge gaging stations, which do reflect seepage losses, were used to represent modern conditions.

The impact of the altered flow routing resulting from the presence of the headgate is illustrated in Figure 7, which shows estimated natural flows vs. modern flows in the Walla Walla River and the Little Walla Walla River. As mentioned earlier, because the Little Walla Walla River has fish screens to prevent fish from accessing its channels and flows in the river are largely controlled and managed for irrigation water conveyance, the remainder of this analysis focuses exclusively on the Walla Walla River.

Alluvial Fan Characteristics

"Alluvial fans are typically found in situations where an upland drainage basin flows out onto a wide plain…The sudden change from confined to unconfined conditions lead to flow divergence, while mean flow velocity is decreased by the reduction in slope. The resultant deposition leads to the formation of a conical feature with a convex cross-profile….Fans are commonly found in dry mountain regions, where an abundant sediment supply is associated with extreme discharges and frequent mass movements… Frequent shifts are often seen in the position of the braided channels that cross the fan surface….In long profile, the slope is steepest at the fan head, progressively decreasing along the length of the fan. There is also a down-slope reduction in sediment size, although deposits are coarse and poorly sorted. Incision and fan head trenching is associated with decreases in sediment supply, or increases in slope." (p. 114, *Fundamentals of Fluvial Geomorphology*, 2008].



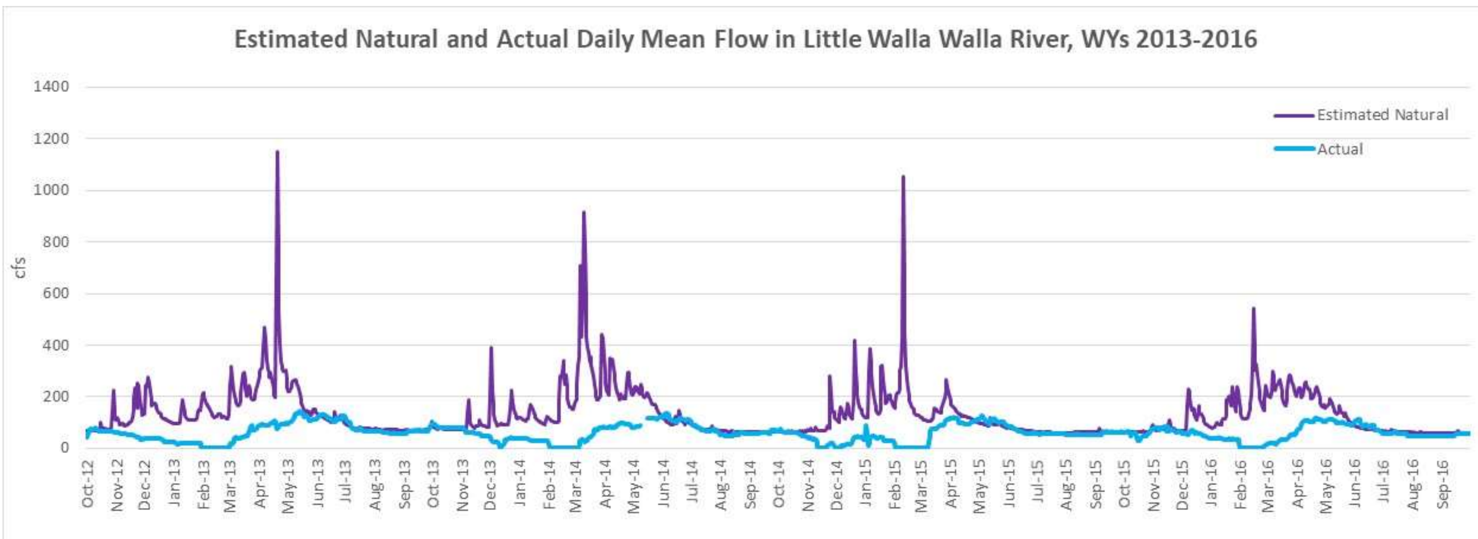


Figure 7. Estimated natural and modern daily mean flows, Walla Walla River and Little Walla Walla River, WY2013-2016.

To quantify the differences in the key components of the natural and altered hydrographs, both datasets were analyzed with *Indicators of Hydrologic Alteration*, version 7.1 (The Nature Conservancy, 2009).

Indicators of Hydrologic Alteration

As described on The Nature Conservancy's webpage,

> "Indicators of Hydrologic Alteration (IHA) is a software program that provides useful information for those trying to understand the hydrologic impacts of human activities or trying to develop environmental flow recommendations for water managers. Nearly 2,000 water resource managers, hydrologists, ecologists, researchers and policy makers from around the world have used this program to assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios.

This program was developed by scientists at The Nature Conservancy to facilitate hydrologic analysis in an ecologically-meaningful manner. The software program assesses 67 ecologically-relevant statistics derived from daily hydrologic data. For instance, the IHA software can calculate the timing and maximum flow of each year's largest flood or lowest flows, then calculates the mean and variance of these values over some period of time. Comparative analysis can then help statistically describe how these patterns have changed for a particular river or lake, due to abrupt impacts such as dam construction or more gradual trends associated with land- and water-use changes" (The Nature Conservancy, 2019).IHA was used to compare the natural (pre-) and modern, altered (post-) hydrographs to estimate the magnitude and significance of alterations, which enables an assessment of the ability of the Milton-Freewater ASR project to restore key elements of the natural hydrograph. This comparison is based on the premise that the historically abundant fish population was integrally tied to the natural hydrograph, which would have generated geomorphic and hydraulic processes and functions supporting key life history features and habitat conditions.

Identifying Key Components of the Hydrograph

The output from the software quantifies 33 IHA parameters (such as monthly average flow, minimum and maximum flows over different durations, number and frequency of pulses, etc.) and 34 environmental flow components (such as monthly low flows, small flood peaks, rise and fall rates associated with high flows, small floods, and large floods) of the modern (altered) and natural hydrographs. These outputs quantify the magnitude, timing, and duration of key components of the hydrograph that differ from natural conditions. Other authors have attempted to identify key components consistent within multiple rivers; one paper concluded the determination of key components is inherently river-specific.

For this analysis, to identify the hydrograph components of most importance to the Walla Walla River, three factors were considered: which of the modern-day parameters were outside the range of estimated natural parameters, the magnitude of the difference in each parameter between natural and altered hydrographs, and which parameters are most closely tied to processes or functions directly supporting fish life histories.

With one exception, the software's default settings were used to define the categories of flow:

Low flow	Less than the average flow, the dominant condition in most rivers
Extreme low flow	Less than the 10 percentile flows, typically associated with drought periods
High flow	Greater than 75 percentile flows (of the flow duration curve – not the peak Q analysis?). Begins when flow increases by more than 25% per day and ends when flow decreases by less than 10% per day.
High flow pulse	Water rises that do not overtop the channel banks
Large floods	Typically rearranges biological and physical structure of a river and its floodplain. Peak flow greater than 10-year return interval.
Small floods	All river rises that overtop the main channel but does not include large floods.

The exception: the default definition of small floods is greater than a 2-year return interval. For the purposes of this analysis, a 1.25-year return interval was used instead because several lines of evidence suggests the river rises over the top of the channel every year flooding the mini-floodplain within the levee and rose over the top of the main channel almost every year under natural conditions (see Appendix C for details).

IHA Results

Table 10 lists outputs for the indicators of hydrologic alteration. The deviation factor is calculated by subtracting the pre-value from the post-value, then dividing the difference by the pre-value --- the same formula as a percent change, but expressed as a decimal. Table 11 does not list all the outputs for the environmental flow components because a two-period analysis was conducted. As described in the IHA output file, for two-period analyses, it is better to rely on the IHA parameters in groups 1 and 2 to quantify impacts on flow magnitude (e.g., monthly flow) instead of the EFC values. Peak flow analyses are based on daily average values, not instantaneous values, so they are not comparable to conventional peak discharge curves.

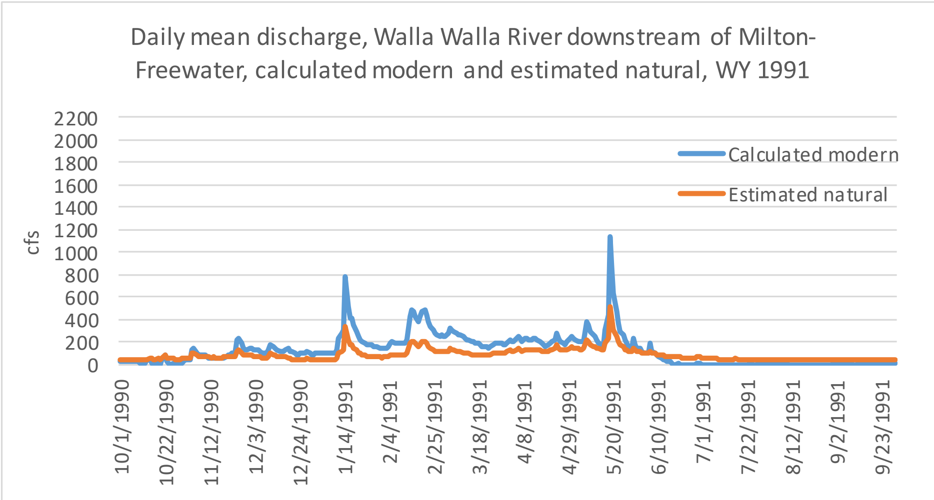
To illustrate the magnitude of the differences in a few select annual hydrographs, the hydrograph for WYs 1991, 1981, and 1975 representing dry, average, and wet water years are shown (Figure 8). These years were selected from an existing ranking of the annual discharge for each WY for the 47 years (CH2M, 2017), choosing the 10th highest discharge (1975), near the middle of the list (1981), and the 10th lowest discharge (1991).

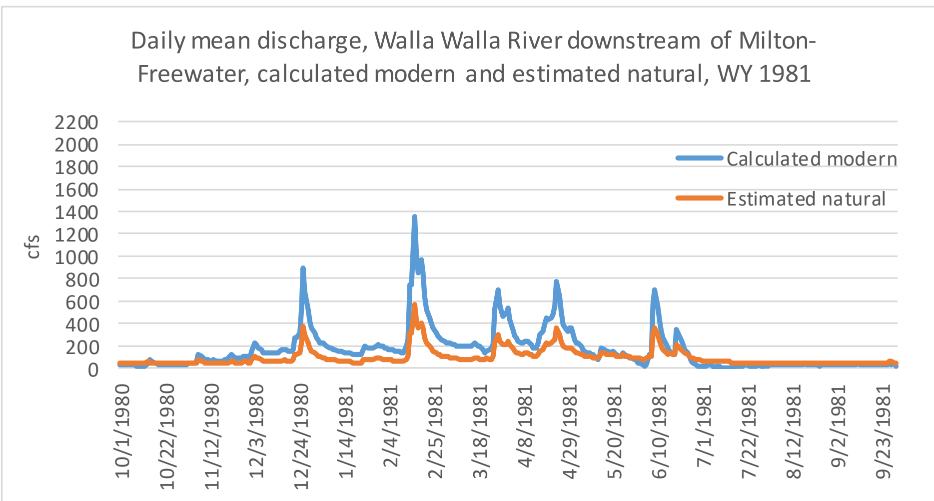
Out of 28 IHA parameters, 18 were significantly different and 10 had differences in magnitude of greater than 100 percent (Table 10). The following parameters had statistically significant differences and large magnitude of changes: monthly median[2] flows from December to March, maximum flows (1-day, 3-day, 7-day, 30-day, and 90-day), and high pulse duration. Because of the biological importance of minimum flows to fish, minimum flows are also included in the subsequent discussion.

[2] Medians are similar to averages. Medians are used to represent typical conditions in data with non-uniform distributions while averages are used when characterizing typical conditions in data with uniform distributions.

Table 10. Output for IHA parameters (median values).

Parameter	Natural estimate	Altered, modern	Units	Deviation factor	Significance (<0.05)
October	48	36	cfs	0.2	**0.00**
November	60	92	cfs	0.5	**0.00**
December	72	149	cfs	**1.1**	**0.00**
January	84	186	cfs	**1.2**	**0.00**
February	110	243	cfs	**1.2**	**0.00**
March	143	312	cfs	**1.2**	**0.00**
April	162	308	cfs	0.9	**0.00**
May	160	274	cfs	0.7	**0.00**
June	85	70	cfs	0.2	0.41
July	54	23	cfs	0.6	**0.00**
August	49	26	cfs	0.5	**0.00**
September	48	25	cfs	0.5	**0.00**
1-day minimum	44	3	cfs	0.9	0.09
3-day minimum	44	5	cfs	0.9	0.09
7-day minimum	45	9	cfs	0.8	0.07
30-day minimum	46	19	cfs	0.6	**0.02**
90-day minimum	50	24	cfs	0.5	**0.00**
1-day maximum	511	1140	cfs	**1.2**	**0.00**
3-day maximum	446	992	cfs	**1.2**	**0.00**
7-day maximum	346	723	cfs	**1.1**	**0.00**
30-day maximum	232	471	cfs	**1.0**	**0.00**
90-day maximum	184	379	cfs	**1.1**	**0.00**
Number of zero days	0	0	days		
Base flow index (7-day min/annual mean)	0	0	--	0.9	0.32
Julian date of minimum (and calendar date)	275 (Oct 1)	195 (Jul 13)	date	0.4	**0.00**
Julian date of maximum (and calendar date)	47 (Feb 16)	47 (Feb 16)	date	0	0.95
Low pulse count	5	3	count/yr	0.4	**0.00**
Low pulse duration	13	18	days	0.4	0.05
High pulse count	7	3	count/yr	0.6	**0.00**
High pulse duration	5	21	days	3.2	**0.00**
Low Pulse Threshold	51	--	cfs	--	--
High Pulse Threshold	129	--	cfs	--	--
Rise rate	4	6	cfs/day	0.6	**0.00**
Fall rate	-2	-7	cfs/day	**2.0**	**0.00**
Number of reversals	95	116	count	0.2	**0.00**





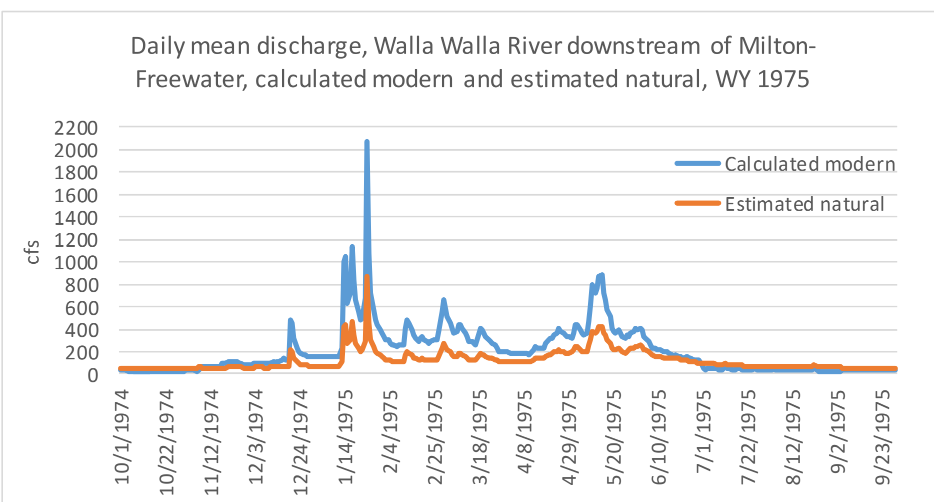


Figure 8. Daily mean discharge, calculated actual and estimated natural, WYs 1991, 1981, and 1975, Walla Walla River downstream of Milton-Freewater.

The pre- and post-altered median flows during March and August illustrate the magnitude of alterations on a monthly scale (Figure 9). Over the 47-year period of record, median daily flows during March increased from 143 cfs (natural) to 312 cfs (modern altered) (Table 10). Median daily flows during August decreased from 49 cfs (natural) to 26 cfs (modern altered). Out of 12 months, modern median flows were within the range of natural variability only during June (Figure 10 and Figure 11). Maximum daily average values have also increased for all durations, 1-day, 3-day, 7-day, 30-day, and 90-day. Over the entire period of record, the one-day maximum daily flow increased from 511 cfs to 1,140 cfs, while the 90-day maximum flows increased from 184 cfs to 379 cfs (Figure 12 and Table 10). In contrast, minimum flows have decreased. One-day minimum flows decreased from 44 cfs (natural) to 3 cfs (modern) and 90-day minimum flows decreased from 50 to 24 cfs (Figure 13 and Table 10). The mean annual flow increased from 102.5 cfs under natural conditions to 173.6 cfs under modern altered conditions (Table 10). On average, discharge in the modern Walla Walla River immediately downstream of Milton-Freewater is a total of 51,357 ac-ft per year higher than the natural discharge.

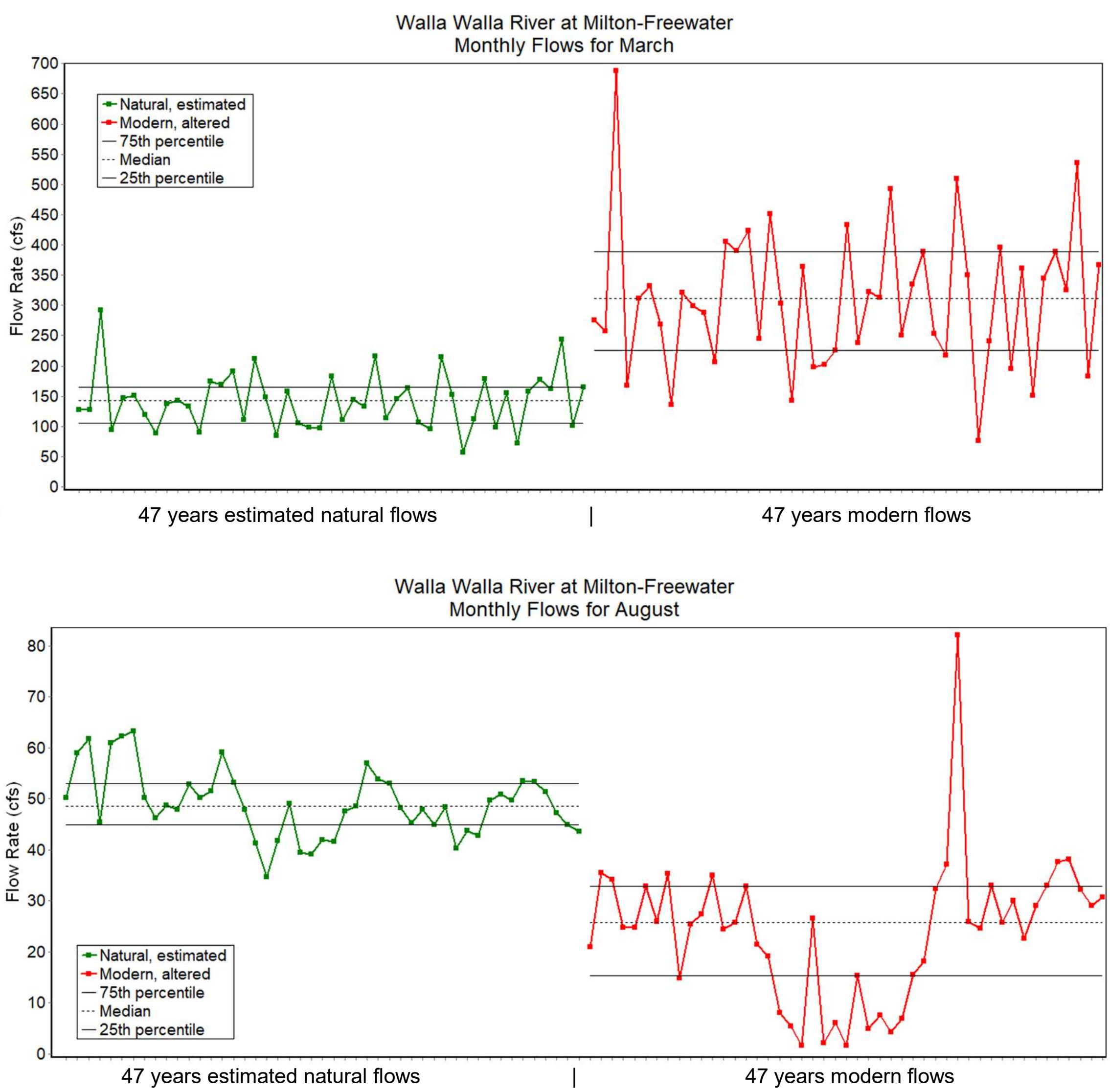


Figure 9. Daily average flows during March and August from the estimated natural and modern altered hydrographs.

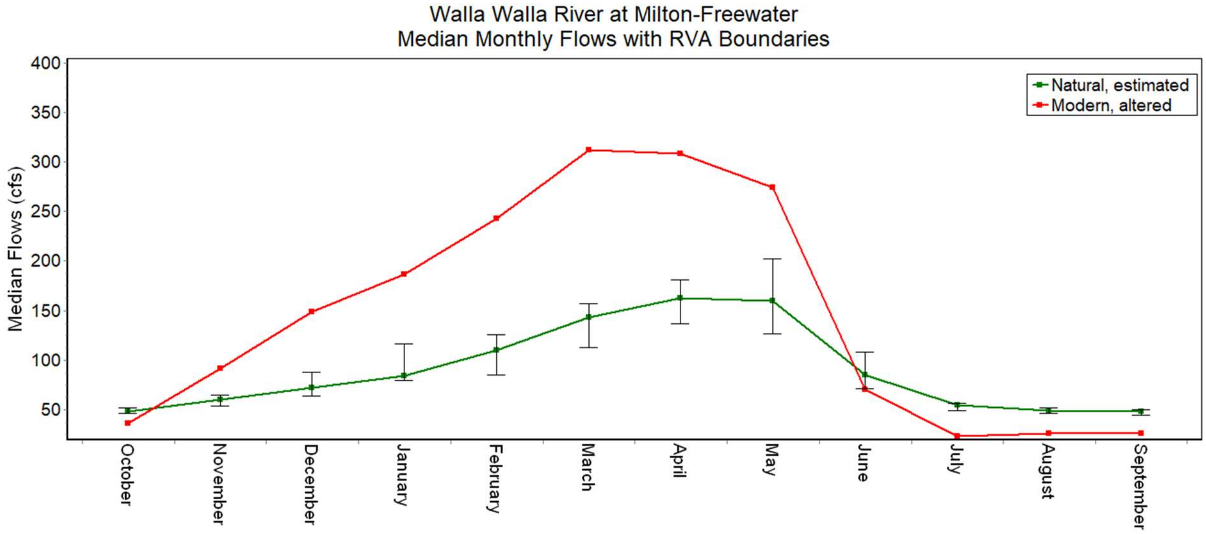


Figure 10. Monthly flow alterations with range of variability (RVA) boundaries.

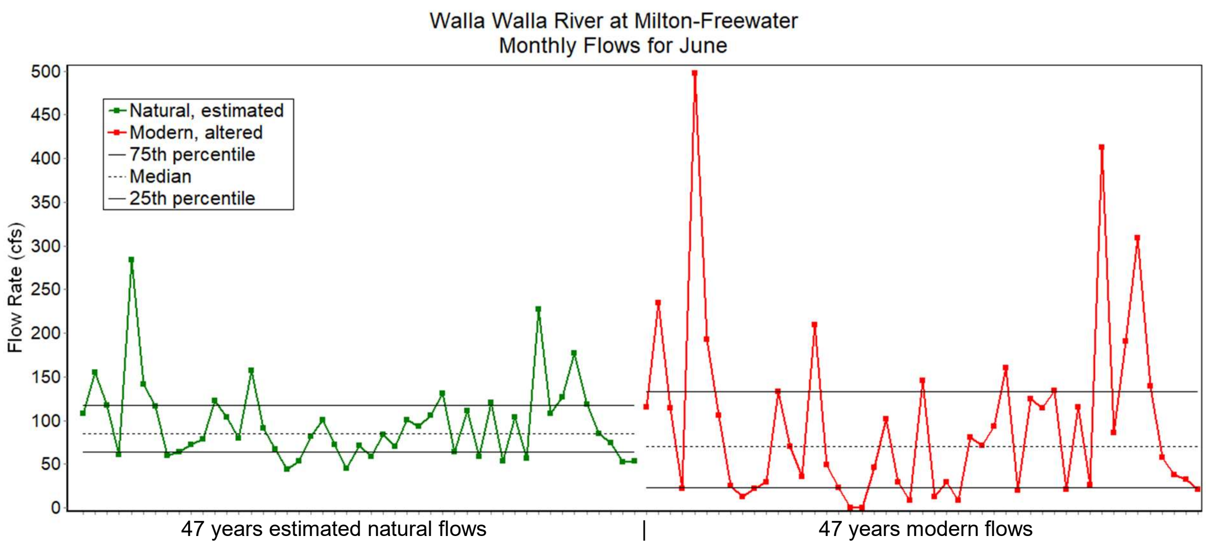
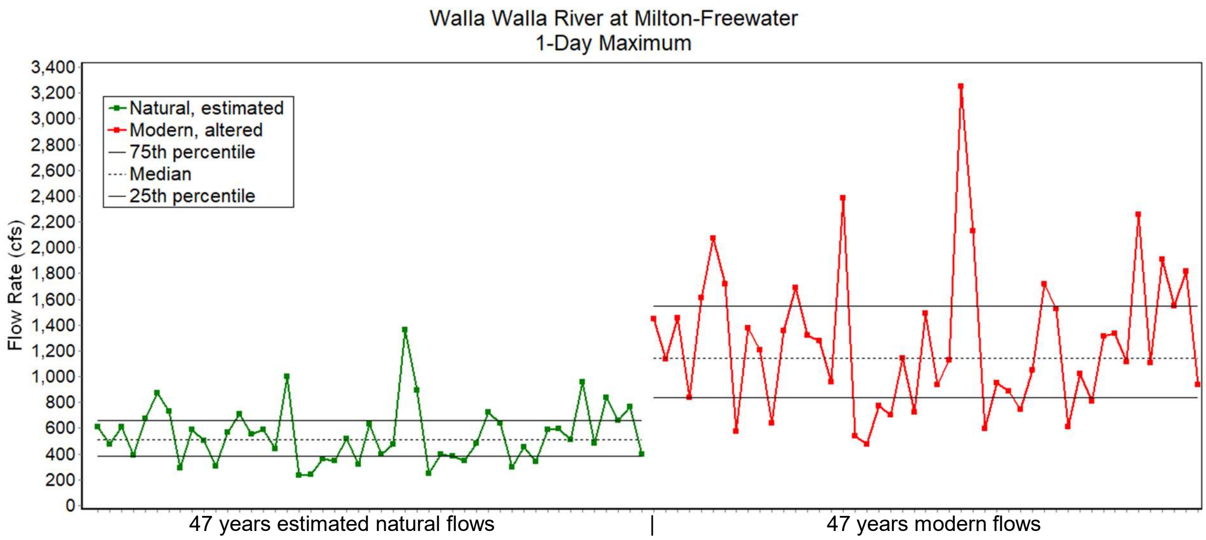


Figure 11. Daily average flows during June from the estimated natural and modern altered hydrographs.



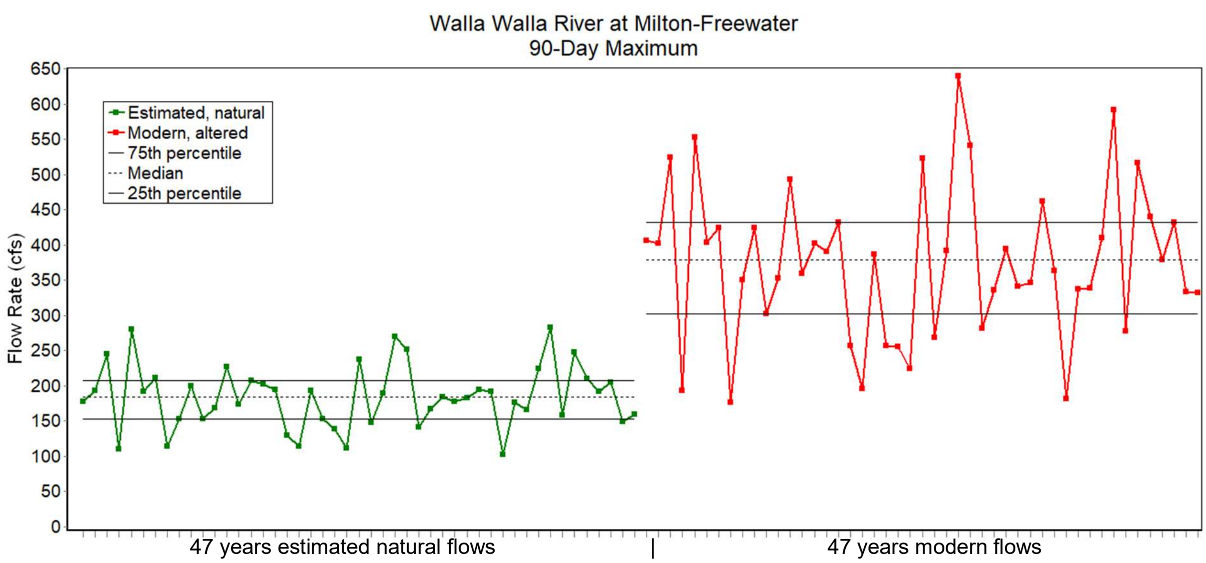
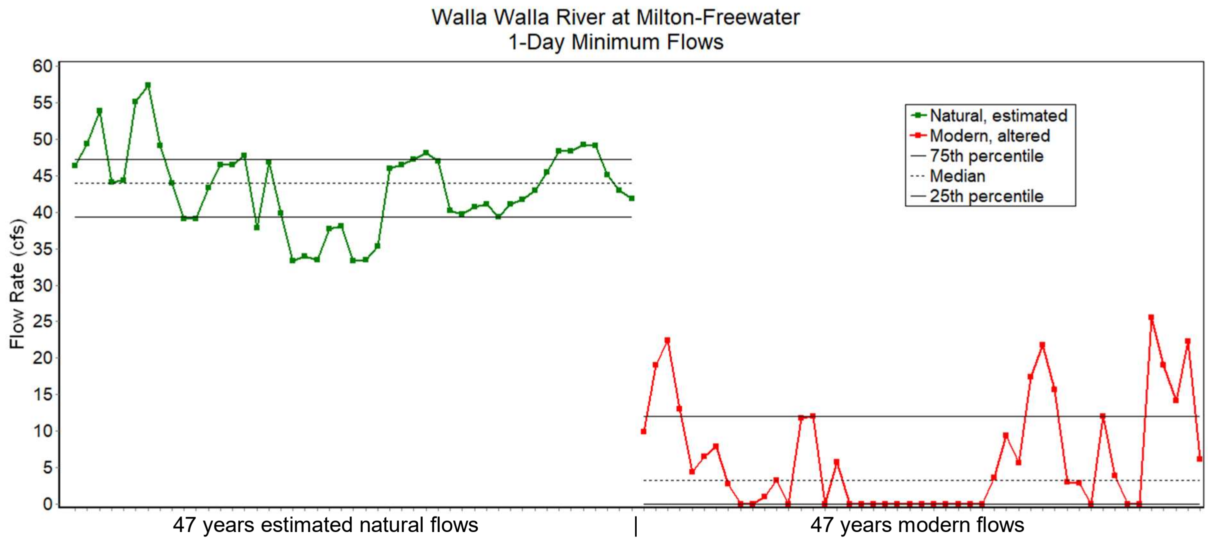


Figure 12. One-day and 90-day maximum flows from the estimated natural and modern altered hydrographs.



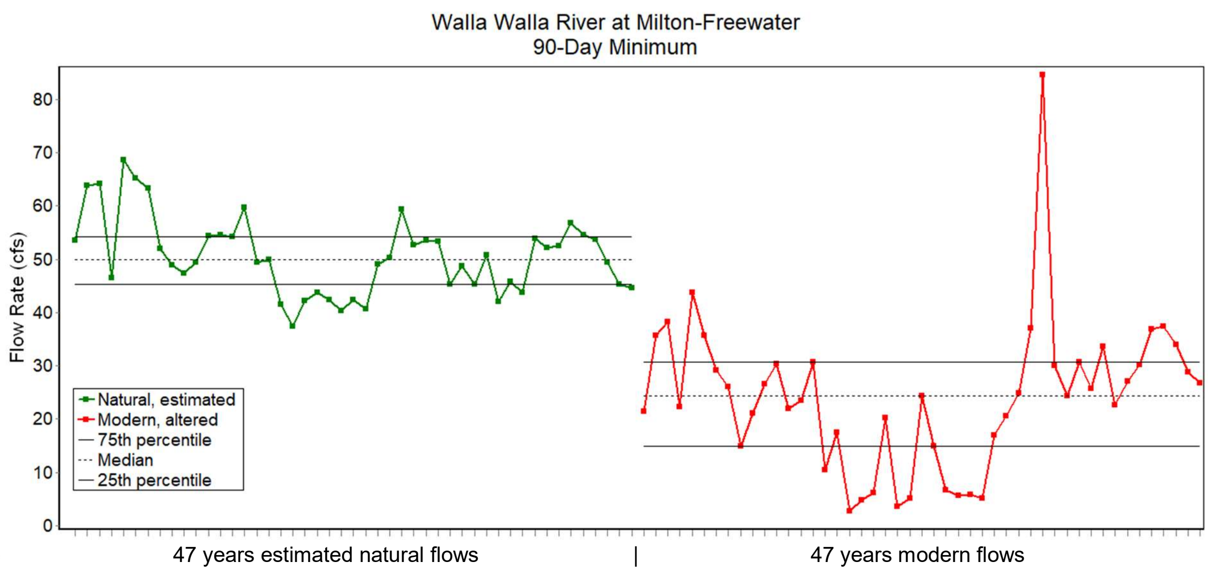


Figure 13. One-day and 90-day minimum flows from the estimated natural and modern altered hydrographs.

Table 11 lists outputs for the environmental flow components related to flow timing, frequency, and duration. Out of 18 environmental flow components listed in Table 11 , seven were statistically significantly different and three had large magnitude alterations. The three components with significant and large-magnitude differences were the timing of extreme low flows, high flow duration, and large flood duration. The timing of extreme low flows changed from a median date of January 5 to January 15. Because the difference was greater than 2x, the deviation factor appears large. However, the actual difference is small. High flow duration increased from a median of one day per year to four days per year. The large flood duration increased from a median of 24 days per year to 160 days per year.

Table 11. Output for environmental flow components (median values).

Parameter	Natural estimate	Altered, modern	Unit	Deviation factor	Significance (<0.05)
Extreme low flow duration	43	24	days/yr	0.4	**0.01**
Extreme low flow timing	5 Jan 5	15 Jan 15	date	**2.0**	**0.00**
Extreme low flow freq.	254	234	count/yr	0.1	0.21
High flow duration	1	4	days/yr	**3.0**	**0.00**
High flow timing	172 Jun 20	159 Jun 7	date	0.1	0.14
High flow frequency	6	1	count/yr	0.8	**0.00**
High flow rise rate	34	34	cfs/day	0.0	0.98
High flow fall rate	-16	-18	cfs/day	0.2	0.43
Small Flood duration	31	38	days/yr	0.3	0.48
Small Flood timing	68 Mar 8	36 Feb 5	date	0.2	**0.01**
Small Flood freq.	1	1	count/yr	0.0	**0.02**
Small Flood riserate	74	78	cfs/day	0.0	0.80
Small Flood fallrate	-30	-22	cfs/day	0.3	0.06
Large flood duration	24	160	days/yr	**5.8**	**0.00**
Large flood timing	10 Jan 10	41 Feb 20	date	0.2	0.05
Large flood freq.	0	1	count/yr		
Large flood riserate	239	35	cfs/day	0.9	0.06
Large flood fallrate	-48	-14	cfs/day	0.7	0.09

The large flood (10-year return interval) duration increased substantially because the software applies the definition of large flood for the pre-alteration (natural) period to the post-alteration period. Under natural conditions, large flood peaks occurred in 4 out of the 47 years, ranging from 897 to 1,262 cfs. Under modern altered conditions, large flood peaks occurred in 35 out of the 47 years, ranging from 885 to 3,251 cfs. A comparison of all the environmental flow components in the estimated natural and modern hydrographs for their entire periods of record show a general pattern of increased large flow events and extreme low flows in the modern hydrograph compared to the estimated historical hydrograph (Figure 14).

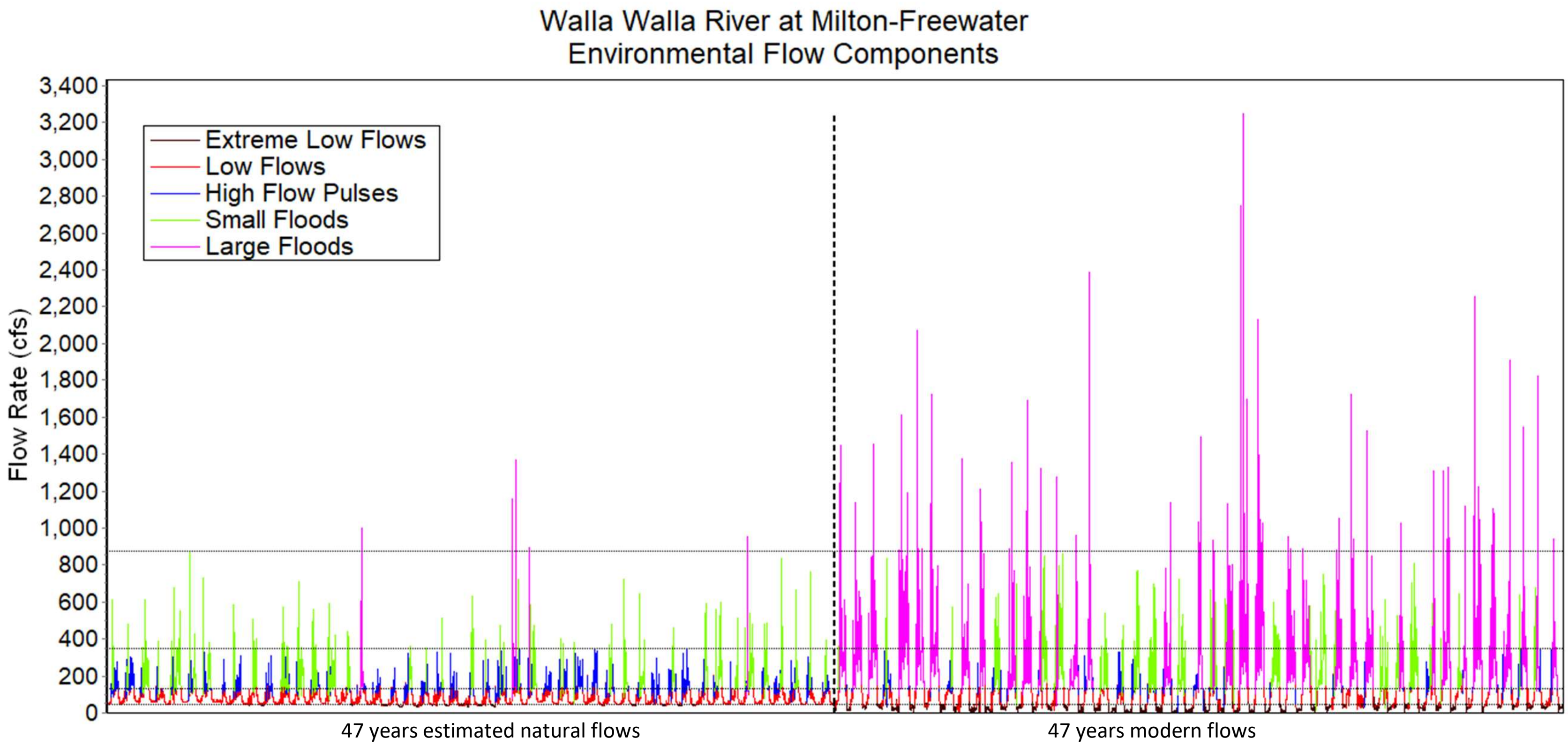


Figure 14. Environmental flow components for 47 years, estimated natural and modern altered flows.

Because the natural channel was able to make geomorphic adjustments in response to changing conditions, flows in the natural channel would inherently encompass those needed for channel-forming and channel-maintenance processes. The specific flows at which those processes occurred cannot be identified with the available data. Without data on historical channel depths, basic hydraulic conditions in the historical channels cannot be calculated. Additionally, because the 47-year dataset is based on daily average values instead of instantaneous values, recurrence intervals for peak flows cannot be calculated. However, as described in the earlier section on the conventional ecological flows analysis, several analyses of peak flow recurrence intervals have already been conducted, based on flows leaving the mountains and assuming the flows only entered the Walla Walla River. Based on the Q2 calculated by the USACE's sediment study of 1,633 cfs, then reducing that by 58% to represent flows that naturally would have entered the Walla Walla River channels, results in a peak flow with a two-year return interval of 686 cfs, which is less than the IHA large flood threshold of 978 cfs and greater than the small flood threshold of 485 cfs. The IHA analysis assumed large floods occurred every 10 years and small floods occurred every 1.25 years.

To summarize, the most important characteristics of the natural hydrograph of the Walla Walla River at Milton-Freewater were lower wintertime flows, much lower peak flows of shorter duration, and higher minimum (base) flows. Additionally, the channel was narrower (Table 12) and likely deeper[3] than modern conditions. To restore the three key characteristics of the natural hydrograph would require reducing wintertime flows to the average monthly natural flows, reducing peak flows by roughly 58%, and increasing minimum summer/base flows to 48-54 cfs. The natural flows at which channel-maintenance processes occurred may have been in the range of 485 to 690 cfs.

Table 12. Historical and modern channel widths.

Channel widths (ft)				
Walla Walla River		**Little Walla Walla River**		
GLO (1865)	**GeoEngineers (2012)**	**GLO (1865)**	**West LWWR (WWBWC, 2012)**	**East LWWR (Mahoney *et al.*, 2006)**
6.6 to 39.6	76 to 160	6.6 to 26.4	4 (average)	11.8 (average)

Functional Flows

The Functional Flows article described five principles of managing highly altered system. The ASR project proposal follows four of the five principles. The only principle not incorporated into the ASR project is restoring the connection of the river to its floodplain.

[3] The supposition that the channel was deeper under natural conditions is based on the fact that the combined width of all six channels in 1864 was 66 to 96 ft, mostly less than the modern widths of 76 to 200 ft in only one channel (the Walla Walla River).

Table 13. Application of functional flow principles to the ASR project.

Functional flow principle	Application to Milton-Freewater ASR project
Hydrogeomorphic connections within the riverscape should be maintained or restored in order to achieve optimal ecosystem functionality.	The ASR project does not restore the river's connection to its floodplain.
Transitions in flow between seasons should be retained (e.g., high turbidity wet-season initiation flows and spring recession flows).	The ASR project would not divert during the period when wet-season initiation flows typically occur (October-November). By diverting during the spring recession flows, the project would slightly improve the spring recession flows by working towards a more natural flow pattern. Decreasing spring recession flows to natural conditions would enhance fish habitat by decreasing artificially high velocities.
Seasonality of baseflows should be retained.	The diversion for the ASR project is small enough it would not impact winter base flows; no diversion during summer base flows would occur.
Flow regimes should reflect interannual climate variability	The variability in water supply provided by the Blue Mountains between wet, dry and average years would remain. Both the natural and modern hydrographs include wet, dry, and average years. The ASR project would not change that.
Water management for human uses should consider the seasonality of natural flows	The nature of the ASR project considers the seasonality of natural flows by diverting only when flows are abundant.

As discussed in the preceding section, no data were found characterizing the magnitude or frequency of flows triggering migration and spawning by salmon or steelhead in the Walla Walla River. None of local fish biologists who were contacted about this ecological flows analysis were aware of any studies specific to the Walla Walla basin which quantified a cause-and-effect relationship between the shape of the hydrograph and fish migratory timing. The Functional Flows approach is based on the premise that identifying and restoring key component of the hydrograph will support key ecosystem functions and processes, including the timing of fish migrations especially during the spring flow recession.

Impacts of the Project on Restoring Natural Flows and Meeting Flow Targets

Diverting 8.6 cfs from December to May would only provide 6% of the average needed 155 cfs reduction in winter monthly flows and a negligible percent of the needed reduction from 1,633 cfs to 485-690 cfs in channel-maintaining flows. The Milton-Freewater ASR project could prevent decreased flows during low-flow months by approximately 8.6 cfs, which represents up to 18% of natural or 37% of modern flows during low-flow months.

Downstream of the levee reach the natural flows are unknown because the natural seepage rates and natural groundwater return rates are unknown. An important data gap is the amount of seepage that has been lost due to the near elimination of flooding across the floodplain – the alluvial fan (see Appendix B for floodplain details).

Comparing estimated natural and actual modern flows in the upper portion of the leveed reach and actual flows just past the stateline, with and without an 8.6 cfs diversion, all targets except two would be met during the diversion period (Table 14). The exception: diverting 8.6 cfs from estimated natural flows at Milton-Freewater would result in slightly less than the CTUIR-recommended targets of 95 cfs for December and 120 cfs for February.

Because of the low proposed diversion rate, there was no need to develop project operational parameters for the ASR diversion. The diversion would only occur during winter months when actual flows exceed flow targets by far more than 8.6 cfs.

Table 14. Impact of the proposed diversion on target flows (cfs).

Month	OWRD target	BiState Flow Study target	CTUIR target	Average flow, altered modern	Average flow minus 8.6 cfs	Average flow, Pepper's Bridge	Average flow, Pepper's Bridge minus 8.6 cfs	Estimated natural flow	Estimated natural flow minus 8.6 cfs
Dec	70	--	95	210	201	168	160	98	89
Jan	70	--	95	265	256	259	250	118	109
Feb	95	--	120	296	287	300	292	128	119
Mar	95	--	130	334	325	343	334	152	143
Apr	95	150	--	351	342	353	344	182	173
May	95	150	--	314	305	288	279	176	167

Note: red font indicates flows less than the associated target value.

Potential Limitations of the Natural Hydrograph Approach

While using a natural hydrograph to quantify fish habitat and geomorphic processes is a technically rigorous approach that has been used throughout the Pacific Northwest, several potential limitations in the application of this concept to the Walla Walla River must be considered:

1. Feasibility of diverting peak flows
2. Impacts on fish habitat from mimicking natural flows in the modern, wider channel
3. Geomorphic impacts

Feasibility of Diverting Peak Flows

When WWBWC staff began this analysis and became aware of the magnitude of changes in the Walla Walla River hydrograph since 1865, it first appeared restoring key elements of the natural hydrograph could be a viable alternative to the estimated $450 million cost of setting the entire length of the levee back (Anderson Perry & Associates, 2013). However, considering the magnitude of the reduction needed in peak flows, restoring key components of natural flows may not be possible. In comparing the pre- and post-alteration environmental flow components (Figure 14), the largest peak flow under natural conditions over the 47-year period assessed was roughly 1,400 cfs. To mimic this component of the natural hydrograph would require diverting nearly all flows exceeding 1,400 cfs, to prevent channel destruction or impairment. In the modern hydrograph, flows greater than 1,400 cfs occur 0.16% of the time, or 27 days over the 47 years. It is unknown if it is technically or economically feasible to divert flows of this magnitude.

The diminished channels of the Little Walla Walla River could not accommodate natural peak flows without significant costly flooding. Many homes and businesses have been built and crops are produced very close to the Little Walla Walla River channels. The maximum diversion for the planned Pine Creek reservoir is only 270 cfs (CH2M, 2017) – a small fraction of the needed reduction in peak flows. Some communities are able to rely on designed floodways – channels accessed only during floods – to reduce flooding but the intensity of development on the alluvial fan and the potential issue of fish becoming stranded in the artificial channel suggests this may not be a viable alternative.

Potential Impacts to Fish Habitat

In terms of fish habitat, the most obvious difference between natural and modern hydrographs on a watershed scale is the loss of fish habitat within the Little Walla Walla River channels. The Milton-Freewater ASR project would have no impact on restoring this lost habitat. In the modern system, fish screens have been installed at the top of Little Walla Walla River and mid-way down its channels to prevent salmonids from entering the Little Walla Walla system, thus reducing the number of channels potentially usable for migration to and from the North and South Forks from at least three channels to only one channel. Even if the screens were removed, habitat quality under modern management is generally poor. CTUIR conducted fish habitat surveys of the Little Walla Walla River in 2004-05 and concluded “12 habitat metrics ranked poor, two fair, and four ranked good for the system as a whole” (Mahoney *et al*., 2006, p. 41).

Within the Walla Walla River, potential impacts of increasing summer base flows and reducing average wintertime flows on fish habitat, water depths, water velocity, and weighted usable area (amount of useable habitat) were evaluated in detail. The review relied on a white paper from CTUIR provided to the BiState Flow Study Steering Committee in 2018 recommending winter flow targets based on the highest flows needed by three species at critical life stages (CTUIR, undated):

- Chinook May-July (adult migration)
- Steelhead all other months
    - October-December juvenile rearing,
    - January-March adult upstream migration,
    - April spawning, and
    - August-September juvenile rearing.
- Bull trout – not the highest need in any month

To evaluate the impact of natural flows in the modern channel could have on the amount of usable habitat, the updated weighted usable area (WUA) curves were obtained from the Washington State Department of Ecology and Department of Fish and Wildlife (2016). Because CTUIR described in their winterflows white paper that 80% WUA is a common target for fish habitat, flows associated with the WUA closest to 80% (82-84%) were obtained from the curves. These became “targets” against which natural and modern flows were compared (Table 15). While natural flows would be higher than modern flows in the summer, natural flows would still not meet the 80% WUA target in summer. In contrast, the

80% WUA target would still be met in the upper portion of the reach of interest during winter if average winter flows were reduced to natural flows.

Table 15. Comparing natural and modern flows to weighted usable areas.

Species, life stage	Flow associated with 80% WUA	Mean monthly flow (cfs), estimated natural dataset	Mean monthly flow (cfs), altered modern dataset	Mean monthly flow (cfs), Nursery Bridge, S-106 gaging station	Mean monthly flow (cfs), Pepper's Bridge, S-108 gaging station
Chinook adult passage May-July	66 cfs = 84% WUA	May 176 Jun 103 Jul 56	May 300 Jun 109 Jul 25	-- -- Jul 30	May 288 Jun 125 Jul 18
Steelhead adult passage Jan-Mar	72 cfs = 82% WUA	Jan 118 Feb 128 Mar 152	Jan 266 Feb 296 Mar 333	-- -- --	Jan 259 Feb 300 Mar 343
Steelhead juv rearing Aug-Dec	66 cfs = 83% WUA	Aug 49 Sept 48 Oct 50 Nov 72 Dec 98	Aug 24 Sept 27 Oct 38 Nov 115 Dec 210	Aug 32 Sept 34 Oct 37 -- --	Aug 19 Sept 23 Oct 33 Nov 74 Dec 168
Steelhead spawning Apr	72 cfs = 82% WUA	Apr 182	Apr 349	--	Apr 353

Notes: Red font indicates mean monthly flow is less than modeled flow providing 80% WUA.
The symbol "--" indicates insufficient data. The gage at Nursery Bridge was typically operated only during low flows when the gaging station was initially established.

Velocities were evaluated by comparing recommended velocities in the Washington State Department of Ecology and Washington State Department of Fish and Wildlife's *Instream Flow Study Guidelines* (2016) and National Oceanic and Atmospheric Administration Fisheries' *Anadromous Salmonid Passage Facility Design* (2011) to velocities modeled in two different modeling studies (GeoEngineers, 2012, and USACE, 2010a) and to actual velocities during discharge measurements conducted by WWBWC. The records of discharge measurements were randomly selected and only meant to supplement the modeling data; they were not intended to be a comprehensive assessment. Table 16 summarizes the recommended velocities. Flow duration curves from IHA were used to evaluate the duration of varying flows and associated velocities.

Table 16. Recommended maximum velocities.

Species, life stage	Maximum velocity, tolerated and preferred	Information source
Chinook adult passage	< 5 fps; preferred 2.25-2.35	WDFW 2016
Steelhead adult passage	< 5 fps, preferred 1.55-1.95 fps	WDFW 2016
	< 4 fps	NOAA 2011
Steelhead spawning	< 5 fps, preferred 1.55-1.95 fps	NOAA 2011
	< 4 fps	WDFW 2016
Steelhead juv rearing	< 4.5 fps for 80-100 mm size; < 2.5 fps for 45-65 mm	NOAA 2011
	< 5 fps; preferred 0.75 fps	WDFW 2016

In the USACE modeling, preferred velocities of 1.6 to 1.95 fps for adults and 0.75 cfs for juveniles are exceeded even at 25 cfs (Table 17). Maximum tolerated flows of 5 fps are only exceeded in the highest velocity-areas and only at flows greater than 75 cfs. The percent of time during which 75-150 cfs flows occur has increased from 19-47% under natural condition to 42-58% under modern conditions. In the GeoEngineer's modeling supporting an evaluation of levee setback alternatives, velocities associated with two-year recurrence interval peak flows (2,160 cfs) ranged from 5.5 to 7.9 fps.

Table 17. USACE modeled velocities and percent exceedances from flow duration curves.

USACE modeled velocities from Nursery Bridge to Mill Creek			IHA % time flow exceeded year-round, altered modern hydrograph	IHA % time flow exceeded year-round, natural hydrograph
Flow (cfs)	**Average Velocity (fps)**	**Maximum Velocity (fps)**		
25	1.27-2.21	1.87-3.74	81	100
50	1.81-2.77	2.57-4.68	63	78
75	1.95-3.16	2.48-5.19	58	47
100	1.37-1.72	2.78-5.51	53	35
125	2.25[4]-2.28	3.02-5.81	48	26
150	2.38-3.87	3.22-6.05	42	19

Out of six discharge measurements conducting during routine monitoring by the WWBWC, ranging from 378 to 705 cfs, velocities exceeded 5 fps in 22 to 70 percent of the measurements (Table 18).

Table 18. Velocity data from selected discharge measurements.

Location	Date	Number of velocity measure-ments	Percent of measure-ments > 5 fps	Instanta neous flow (cfs)	% of time flow exceeded in same month as "Date" column, IHA altered modern dataset	% time flow exceeded, in same month as "Date" column, IHA natural dataset
Tumalum	Mar-2019		70	705 cfs	4.7	0.07
Tumalum	Mar-2003	28	50	511 cfs	13	0.4
Grove	Feb-2003	30	53	437 cfs	14	1.7
Tumalum	Feb-2004		46	398 cfs	17	2.3
Tumalum	Feb-2003	25	32	388 cfs	17	2.4
Grove	Apr2003	31	22	378 cfs	33	2.9

[4] Table 21 in the USACE's Feasibility Study, Appendix A – Hydrology, lists an average velocity of ".72" for the Peppers Bridge to Mill Creek reach at 125 cfs. Since the average velocities in the same reach at 75, 100, and 150 cfs were 3.16, 3.46, and 3.87, respectively, the entry of .72 appears to be a typographical error. Therefore the range in Table x for 125 cfs includes only the values for two of the three reaches.

Modeled and measured velocities may overestimate the impact of high velocities to fish because fish can preferentially occupy areas with reduced velocities, such as near the riverbed, behind boulders, or in riprap along the levee.

In the USACE modeling, the average and minimum depths associated with six flows were modeled (Table 19). Decreasing average monthly winter flows to natural levels provide sufficient average water depths from November to May but not sufficient minimum water depths (Table 20). In the summer, neither natural nor altered flows provide sufficient minimum depths to meet most of the depth criteria.

Table 19. USACE modeled depths from Nursery Bridge to Mill Creek.

Flow (cfs)	Average depth (ft)	Minimum depth (ft)
25	0.59-0.89	0.15-0.37
50	0.97-1.26	0.29-0.63
75	1.21-1.52	0.39-0.80
100	1.37	0.48-0.94
125	1.5-1.88	0.56-1.08
150	1.61-2.01	0.62-1.15

Bull trout were not identified by CTUIR as having the most critical flow needs in any given month. For the 2007 and 2009 bull trout passage surveys, USFWS relied on previous research indicating a minimum thalweg depth of less than 0.6 ft across at least $1/5^{th}$ of the wetted width at a riffle constitutes a passage barrier. The model predicted 42.3 cfs (at Pepper's Bridge) is needed to provide the minimum depth (USFWS and Utah State University, 2014).

In summary, reducing wintertime flows to mimic natural flows would reduce the duration and magnitude of excessive water velocities yet still meet the 80% WUA target. Increasing summertime flows to natural levels would increase depths slightly but not enough to meet depths recommended for fish habitat.

Table 20. Depth criteria and depths associated with various flows.

Species, life stage	Minimum depth needed	Information source	Comparison to estimated natural flows			Comparison to modern flows at Nursery Bridge		Comparison to modern flows at Pepper's Bridge	
			Mean monthly flow (cfs)	USACE model average depth (ft)	USACE model minimum depth (ft)	Mean monthly flow (cfs) Jun-Sept	USACE model average depth (ft)	Mean monthly flow (cfs)	USACE model average depth (ft)
Chinook adult passage May-July	1 ft	NOAA Fishway	May 176 Jun 103 Jul 56	>1.6-2.0 1.4 1-1.3	>0.6-1.1 0.5-0.9 0.3-0.6	 Jun 69 Jul 30	 1.2-1.5 0.6-0.9	May 288 Jun 125 Jul 18	>1.6-2.0 1.5-1.9 < 0.6-0.9
	0.94 ft	WDOE/WDFW, 2016							
	9.5" (0.8 ft)	2001 draft subbasin plan							
Steelhead adult passage Jan-Mar	0.74 ft	WDOE/WDFW, 2016	Jan 118 Feb 128 Mar 152	>1.4 1.5-1.9 1.5-1.9	0.5-0.9 0.6-1.1 0.6-1.1	--		Jan 259 Feb 300 Mar 343	>1.6-2.0 >1.6-2.0 >1.6-2.0
	min 7" (0.6 ft), 100 cfs	2001 draft subbasin plan							
Steelhead spawning Aug-Dec	1 ft	NOAA Fishway	Aug 49 Sept 48 Oct 50 Nov 72 Dec 98	1-1.3 1-1.3 1-1.3 1.2-1.5 1.4	0.3-0.6 0.3-0.6 0.3-0.6 0.4-0.8 0.5-0.9	Aug 32 Sept 34	0.6-0.9 0.6-0.9	Aug 19 Sept 23	< 0.6-0.9 < 0.6-0.9
	0.74 ft	WDOE/WDFW, 2016							
Steelhead juvenile rearing Apr	0.5 ft	NOAA Fishway	Apr 182	>1.6-2.0	>0.6-1.2	--		Apr 353	>1.6-2.0
	0.47 ft	WDOE/WDFW, 2016							

Note: Red font indicates modeled water depths for a range of flows (see Table 19) encompassing the mean monthly flow were less than minimum depths needed for passage.

Possible Geomorphic Consequences

Reducing peak flows to mimic the magnitude and duration of natural peaks could have adverse consequences on the riverine ecosystem due to much less water volume being contained in a wide channel. It could take decades for the river to form a continuous narrower and deeper channel. To prevent chaotic channel formation and poor quality instream conditions that might persist for decades, it would be necessary to design and shape a channel to accommodate the reduced flows. Based on a very rough estimate of $1,500,000 per mile, a channel-shaping effort through the seven miles of the levee could cost $10,500,000. This channel enhancement may occur within a portion of the levee as part of a proposed levee setback project along the lower miles of the leveed reach.

Reducing monthly average wintertime flows and increasing monthly average summer base flows would not be expected to impact channel-forming or channel-maintenance processes since these average flows are less than the channel-maintaining flows.

Local Input

WWBWC staff met individually with hydrologists, geomorphologists, and fish biologists familiar with the Walla Walla basin to discuss an overview of the methods, datasets, and preliminary results of the normative hydrograph approach. Project impacts to ESA-listed species and riparian habitat were also discussed. These meetings were informal give-and-take discussions, not a formal request for comments. Yet several of the individuals offered valuable insights or comments on interpreting the flow data, additional sources of information, or ways to clarify the information presented, which were incorporated into this report.

Discussion

Storage projects may negatively impact ecological flows "when changes to the natural flow and sediment regimes of the stream network affect the ability to maintain ecological functions in the stream." (*Feasibility Study Grants, Storage-Specific Study Requirements: Application Guidance*, pp. 5-6). This concept assumes the stream network retains some semblance to natural flow and sediment regimes. In the case of the Walla Walla River system this is not a valid assumption. The balance between stream power and sediment transport has been so significantly altered due to reduced flows in the distributary channels, increased flows in the Walla Walla River, and the presence of the levee system that a stable channel cannot be maintained in the levee reach.

Two theoretical options to reduce energy in high flow events in the Walla Walla River, thus allowing formation of a stable channel, are to set back the levees enough to allow meanders to form which reduce energy by reducing the channel gradient, and/or reduce the magnitude of peak flows. The cost of setting back the entire levee by 500 feet has been estimated to be more than $450 million (Anderson Perry & Associates, Inc., 2013). While the levee alternatives analysis (GeoEngineers, 2012) included proposals to set back small portions of the levee, the geomorphic benefit of these conceptual proposals have not yet been estimated. Substantially increasing flows in the Little Walla Walla River is not possible for the same reason it is not possible to restore many floodplains – too many people live and work on the floodplain, in this case, the alluvial fan. The Little Walla Walla River distributary channels are no longer large enough to contain even close to historical flows without flooding. However, if excessive peak flows could be diverted away from the Walla Walla River during the winter and stored, this could theoretically reduce energy levels sufficiently to restore the power-sediment balance in the leveed portion of the Walla Walla River. Thus, the appropriate questions to answer in this ecological flows analysis are not “How much water can be diverted from the Little Walla Walla River and its parent stream the Walla Walla River without adverse impacts” but rather “How much water needs to be diverted from the Walla Walla River in the winter in order to return hydrological and ecological functions to the river” and “Is it possible to divert the needed amount?”

The proposed Milton-Freewater ASR project does not divert enough water in winter to significantly reduce the level of impairment. The ASR project conducted in conjunction with existing and proposed future uses of winter water may be able to divert enough water to provide two of the three key components of the hydrograph – decreased monthly winter flows and increased summer minimum flows. If the managed aquifer recharge program continues to recharge at least 6,400 ac-ft per winter and if the proposed reservoir diverts 22,000 ac-ft per winter, assuming a diversion season of 200 days, would be equivalent to an average 142 cfs reduction, close to averaged needed reduction of 155 cfs. An additional unknown amount of winter water may be proposed for diversion to private ASR projects if groundwater levels in the basalt aquifer continue to rapidly decline resulting in designation as a critical groundwater area with subsequent reductions in withdrawals. The proposed reservoir would increase summer flows to the levee reach greater than the average monthly natural flows. None of the proposed projects, however, provides the third key component of the natural hydrograph -- reducing peak flows sufficiently to prevent continued degradation of the channel which has resulted from diverting wintertime flows from the Little Walla Walla River into the Walla Walla River and the presence of the levee on the Walla Walla River.

Conclusion

The results of various conventional analyses which treat the Walla Walla River as a single-channel system, conclude that short-term flows of 1,055 to 2,350 cfs are needed for channel-maintenance processes in the levee reach. The results of the normative flows approach, which attempts to answer the question ‘what were hydrological conditions like when fish were abundant’, conclude that 485 to 690 cfs were needed for channel-maintenance processes under natural conditions. It may not be feasible to reduce peak flows sufficiently to mimic natural flows, a serious limitation of this application of the normative hydrograph approach. However, the insight into historical flow conditions provided by the GLO measurements improves our understanding of hydrological conditions which historically supported abundant fish populations.

Section III - Comparative Analyses of Alternative Means of Supplying Water

Three alternative means of supplying water to meet the City’s demands and increase summertime flows in the Walla Walla River were evaluated: (1) reduce demand by increasing conservation, (2) reduce demand by increasing efficiency, and (3) reuse treated wastewater from the City’s recently updated wastewater treatment plant. None of the three alternative means of supplying water could meet existing or future demand for water if the basalt aquifer declines to the point of being unusable.

Increased conservation

Because the City currently obtains all of its drinking water from the basalt aquifer, conservation practices would only benefit the aquifer, not summertime flows in the Walla Walla River. However, increased conservation could potentially slow the decline in groundwater levels, prolonging the number of years for which the City is able to rely on the basalt aquifer instead of the Walla Walla River for its water source.

The City has already completed several of the mandatory conservation practices in the *Water Management and Conservation Plan Guidebook* (OWRD, 2015), including full metering of the water system and conducting annual water audits, a public education program, and high use monitoring. The City has also adopted several non-mandatory measures to increase conservation, including adopting a progressive water rate structure for residential and commercial accounts, providing financial incentives to encourage water efficiency (e.g., credits or reimbursements for qualifying clothes washers and dishwashers), conducting leak detection in mainlines, implementing low water use landscaping on City projects, and implementing a low flow showerhead and faucet aerator program. In the future, the City is evaluating possibly promoting low flush toilets and timed underground irrigation systems for landscaping. (Anderson-Perry, 2010).

The three largest types of users of the City's water services are residential, public (large), and industrial, accounting for 62.8%, 17.9%, and 11.8% of total water use, respectively. The average use is 18,646 gallons per household per month from April through September versus an average 7,489 gallons per household per month in winter. Summer use is approximately 2 ½ times greater than winter use, so practices which conserve irrigation water could be important. Nearly 50% of residential water users have an underground irrigation system in place. Total annual use has decreased [from when to when] from slightly more than 900 MG per year to less than 600 MG per year, largely due to fewer fruit packing and processing operations (Anderson-Perry, 2011).

The average gallons per capita per day from 2006-2010 in Milton-Freewater was 270 gpcd (Anderson-Perry, 2011), which is a higher rate than in 11 small cities in the eastern portions of Oregon and Washington (from 170 to 266 gpcd) but less than the highest rates of 323 to 530 gpcd in five small cities (Anderson-Perry, 2010). This suggests there is potential for increased conservation if homeowners were willing to change their irrigation practices. However, some of the low daily rates in other cities are because the cities have separate water sources for irrigation.

Assuming a very rough estimated 304 acres of lawns, gardens, and trees are irrigated within the City limits (total acres 1,216 x 25%) and assuming an average consumptive use of 29 inches for lawns and 26 inches for trees for an average of 27.5 inches (2.3 ft) results in an estimated 304 x 2.3 = 697 ac-ft to meet the plants' consumptive needs. Dividing the 697 ac-ft by a 180-day growing season results in an average of 3.9 ac-ft per day. Dividing the 3.9 ac-ft per day by the 2,737 accounts results in 0.001425 ac-ft (234 gallons) per account per day or 7020 gallons per month to meet the consumptive uses. However, even highly efficient sprinkler irrigation systems are able to operate at only 85% efficiency, meaning that an extra 15% needs to be provided than is needed by the plant. 7020 x 1.15 = 8073 gallons per month needed to water plants in a very efficient system. Subtracting the winter use rate (which presumably reflects year-round indoor water use) and the consumptive need for the plants (18646-8073-7489 = 4137) results in a gross estimate of an average 3,084 gallons per month (or 103 gallons per day) inefficiency per account. So the challenge is providing sufficient incentives and change in culture to support increased irrigation water practices.

Increased Efficiency

The potential for water savings through increased delivery efficiency is low because in the five most recent years (2011-2015) the City only loses 8-14 percent of its supply as measured between the supply wells and the meters (City of Milton-Freewater, 2016). The losses range from 47,307,230 to 83,245,900 gallons, or 150 to 225 ac-ft (0.21 to 0.31 cfs year-round) potential savings. Between 2010 and 2015, the City replaced 3,520 feet of old water lines and plans to continue replacing old water lines in accordance with their master water plan.

While the costs of increased efficiency are far less than the cost of an ASR project, increased efficiency alone cannot meet the future water demands if the aquifer no longer is able to supply drinking water.

Reuse

There is limited additional potential for water savings through reuse because all domestic and industrial wastewater is already reused. In the *City of Milton-Freewater, Oregon Water Management and Conservation Plan* (Anderson-Perry & Associates, Inc., 2010), “All domestic wastewater produced in the City is routed to the City's wastewater treatment plant. Treated wastewater is then applied to a hay field owned and operated by the City. Industrial wastewater used for fruit and vegetable washdown is not routed through the treatment plant. This industrial wastewater is directly applied to the City's hay.” So on a municipal level, reuse is at a maximum rate.

On an individual water user level, it would be possible to install grey water reuse systems but the permit and annual reporting requirements of ODEQ likely act as a disincentive to do so. The typical cost to hire someone to install a Type 1 system (no treatment or minimal solids/fats removal of < 300 gpd) to provide underground irrigation water is unknown. The known costs include $93 for application fee and $40 annual compliance fee (which can be waived if the permit holder submits an annual report). Assuming $100 of materials cost for a do-it-yourselfer, results in an estimated cost of $193 capital + $40 O&M x 10% of 2,443 residences = 244 x $193 = $47,092. Assuming 90-110 gallons graywater per day per household, 100 gpd x 30 days x 6 months = 18,000 gal per irrigation season x 244 residences = 4,392,000 gal or almost 7 ac-ft. The estimate of 244 people willing to install a grey water system is 10x more than the total number of statewide permits issued by 2012.

Even if an extraordinary number of people installed gray water reuse systems, it would not meet the City’s needs if the basalt aquifer can no longer provide drinking water.

Section IV - Analyses of Environmental Harm or Impacts from the Proposed Storage Project

The potential positive and negative outcomes of the following types of environmental impacts were considered: impacts to species listed under the Endangered Species Act, riparian habitat important to wildlife, groundwater levels, water quality, ecosystem resiliency to climate changes, and ecological limiting factors.

The project location is within the City of Milton-Freewater. Nearby land use is primarily residential and industrial manufacturing. Well No. 5, the well to be used in pilot-scale ASR testing, is within a small pump house on a 0.06 ac lot covered with coarse gravel. Immediately adjacent to the city-owned lot are a public road and privately-owned parcels used for warehouses and residences. The Little Walla Walla River is approximately 54 feet to the west of the well.

Potential construction-related impacts from the proposed project could occur during modification of the wellhead and installation of a portable treatment unit at well No. 5. Potential impacts to water resources and riparian areas within the Little Walla Walla River and Walla Walla Rivers could also occur.

ESA-Listed Fish and Other Species

The U.S. Fish and Wildlife Service lists bull trout as threatened (USFWS, 2019) and NOAA Fisheries lists Middle Columbia River steelhead as threatened (NOAA Fisheries, 2019). The Walla Walla River is designated as critical habitat. The Little Walla Walla River is not designated as critical habitat for either species. Spring chinook were extirpated but CTUIR began re-introducing spring chinook from out-of-basin stock beginning in 2000.

The maximum diversion rate for the Milton-Freewater ASR project would be 8.63 cfs, which would be diverted from December through May. OWRD has established minimum flow targets for those months based on ODFW recommendations in 1973 for the Walla Walla River below the confluence of the North Fork and South Fork of the Walla Walla River. In a draft white paper, CTUIR identified the key species and life stages needing the highest flows in a given month as juvenile steelhead rearing in November and December, adult steelhead migration in January-March, steelhead spawning in April, and adult Chinook migration in May. In the white paper, CTUIR also recommended minimum flow targets to provide adequate habitat; however, the data supporting the recommendations were not provided. Therefore, to estimate the impact of the diversion on habitat, this assessment relied on updated IFIM WUA curves from WDOE and WDFW (2016), which provided a sufficient data to allow its application to this feasibility study.

The impact of the Milton-Freewater ASR project on fish habitat is estimated by subtracting the maximum proposed diversion of 8.6 cfs from the mean flows at Pepper's Bridge (the lowest flows within the area of interest) and summarizing the corresponding WUA at that lessened flow (Table 21). The differences in WUA were negligible.

Table 21. IFIM habitat results, subtracting 8.6 cfs.

Month	Mean flows (cfs), WWR at Pepper's Bridge	Steelhead juvenile		Steelhead spawning		Chinook juvenile		Chinook spawning & rearing	
		% habitat at mean Q	% habitat at mean Q minus 8.6 cfs	% habitat at mean Q	% habitat at mean Q minus 8.6 cfs	% habitat at mean Q	% habitat at mean Q minus 8.6 cfs	% habitat at mean Q	% habitat at mean Q minus 8.6 cfs
Dec	168	91	91	100	100	85	83	96	99
Jan	259	94	94	95	95	92	92	78	78
Feb	300	100	100	95	95	100	100	67	67
Mar	343	--	--	--	--	--	--	--	--
Apr	353	--	--	--	--	--	--	--	--
May	288	100	94	95	95	100	92	67	78

Note: Rounded up or down to nearest flow increment in IFIM table. The highest flow in the IFIM table was 325 cfs.

Two other species are listed by the USFWS as threatened or endangered in Umatilla County -- the yellow-billed cuckoo and gray wolf. No counties within Oregon are considered as critical habitat for the yellow-billed cuckoo; one key characteristic of critical habitat is the presence of riparian plant communities in wide (>325 ft) floodplains. The USFWS has proposed de-listing the gray wolf within Oregon, California, Michigan, Washington, and Wisconsin (USFWS, 2019).

Based on the habitat needs of the yellow-billed cuckoo and the gray wolf, neither species would be expected to occupy the riparian area along either the Walla Walla or Little Walla Walla Rivers, because these riparian areas are much narrower than the habitat needed by the yellow-billed cuckoo and the urban nature of the City would discourage a gray wolf from establishing its home range within the City.

Native Fish Species of Importance to CTUIR

In the U.S. Fish and Wildlife Services' the bull trout recovery plan (2002), "Information provided by the Confederated Tribes of the Umatilla Indian Reservation indicates tribal fishers took chum, steelhead, coho, and eels at usual and accustomed sites in the lower Walla Walla River near the mouth. Summer steelhead are the only native anadromous salmonid found in the Walla Walla River Basin at present…" (pp. 12-13). Spring chinook have been reintroduced to the Walla Walla River and adults have been returning under their own volition since 2004.

In ODFW's *Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment* (OWFW, 2010), "Historically, Mid-C steelhead were found throughout central Oregon and south-central Washington. Mid-C steelhead were important to Native Americans of the interior west, including the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Confederated Tribes of the Warm Springs Reservation. Native Americans throughout the Pacific Northwest maintain strong cultural values for steelhead and salmon species. These fish have long had important tribal subsistence, ceremonial and commercial value." (p. 2-4)

CTUIR suggested Pacific and western brook lamprey, historically abundant in the Walla Walla basin, be considered as focal species during the BPA subbasin planning process but the final report did not include them as a focal species (Subbasin Plan, p. 72). “Freshwater mussels are also culturally important to Native Americans.” (p. 72).

Riparian Habitat

Most of the geographic scope of the study is within the USACE levee system. Where riparian habitat is present, the width of riparian habitat is constrained by the levee. The USACE’s feasibility study summarizes a vegetation assessment conducted by ODEQ and WWBWC in the summer of 2000, which found limited vegetation through substantial portions of the levee; downstream of levee to past the stateline (to Dry Ck), common species were mixed alder, large and small willow, cottonwood dominance with Box Elder, Ailanthus, Russian Olive, Black and honey locust, red osier dogwood, and other small deciduous trees were common (USACE, 2010a, p. H-42). In the 2012 levee alternatives assessment, riparian vegetation was described in different reaches as absent, limited, just getting established, or becoming denser (GeoEngineers, 2012).

Riparian wetlands were selected during the subbasin planning process as one of several priority terrestrial habitats (WWWPU and WWBWC, 2004).

Installing a diversion structure on the Little Walla Walla River adjacent to Well No. 5 would require minor temporary disturbance of the riparian habitat.

Groundwater Levels

Groundwater level declines of up to four feet per year in the basalt aquifer prompted the Oregon Water Resources Department to declare the Oregon portion of the aquifer to be a serious water problem management area (OWRD, 2016). The shallow aquifer has also experienced localized significant declines (WWBWC, 2018). The proposed ASR project would directly benefit the basalt aquifer by increasing groundwater levels. The impact (positive or negative) on the shallow aquifer is unknown. While early models of the basalt and gravel aquifers assumed water is transmitted from the basalt to the gravel aquifer (Barker and MacNish, 1975 and 1976), it is unknown the degree to which such transmission would occur under the reduced groundwater elevations in the basalt aquifer.

Existing data are not sufficient to support an estimate of increased groundwater elevations which would result from the project. The potential net benefit to the aquifer water budget from a total build-out can instead be estimated based on the maximum diversion rate of 8.6 cfs and duration of 167 days (Dec 1 to May 15). 8.6 cfs/day is equal to 17.1 ac-ft/day, multiplied by 167 days equates to 2,856 ac-ft of injected water. Short-term mound development is estimated to be 16 to 17 feet at 100 ft from each of three wells needed for a full-scale ASR project.

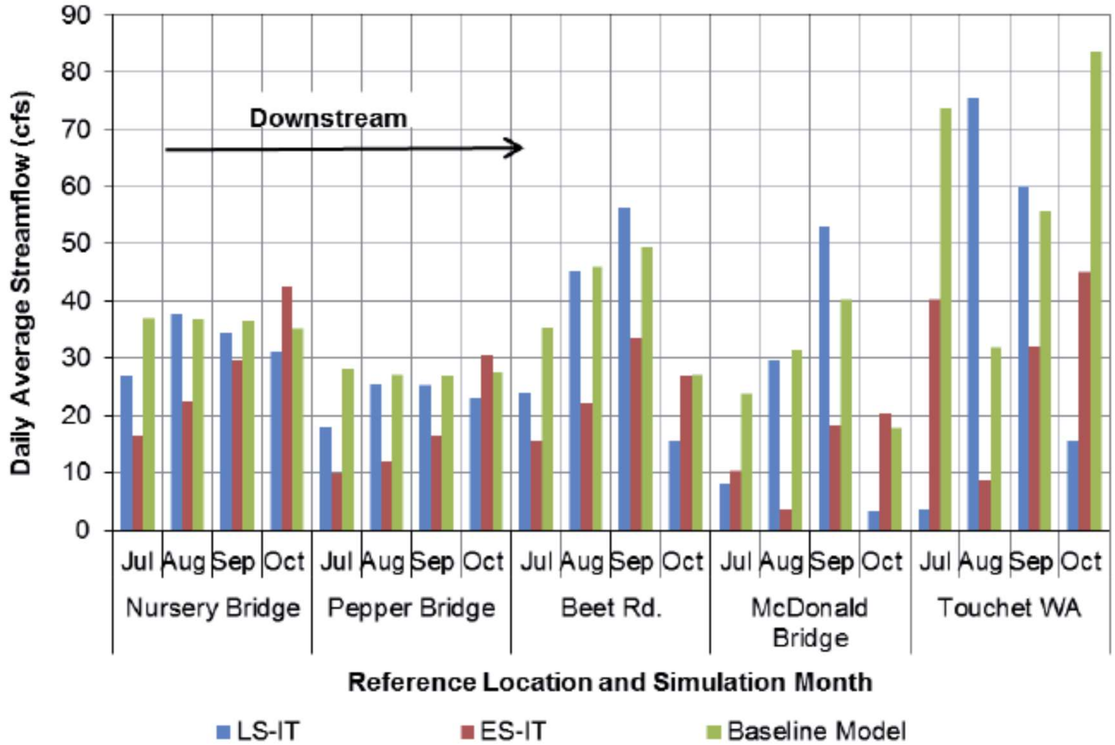
Actual improvements to groundwater elevations would be required to be monitored and reported by the limited license under which the pilot stage of the ASR project would operate.

Water Quality

As described in Murraysmith's technical memorandum, the water quality of samples from the Walla Walla River and Little Walla Walla River was generally high. All primary Safe Drinking Water Act regulated contaminants were not detected and secondary contaminants were well below the maximum contaminant level. In the Little Walla Walla River samples, turbidity values were less than 10 NTU. All samples, however, were positive for the presence of total coliform and *E. coli*. The water quality of the surface water samples was better than the water quality of the groundwater sample from Well No. 5, except for turbidity. The ASR project would be required to treat source water to meet drinking water standards prior to injection into the basalt aquifer, including the turbidity standard. So no adverse impact on groundwater quality is expected due to introduced contaminants. Because introduced water has the potential to degrade water quality through chemical and physical interactions water with the groundwater, the compatibility of water from the Walla Walla River was assessed for its compatibility with the receiving groundwater. The two water sources were compatible on a preliminary basis. No adverse impact to water quality is anticipated from the proposed project.

Ecosystem Resiliency to Climate Change Impacts

In *Walla Walla Basin Integrated Flow Model: Alternative Climate Scenario Water Resources Report* (GeoSystems Analysis, 2017), the impact on stream flows as a result of two future climate scenarios were modeled using a calibrated surface water-groundwater finite element numerical model for the Walla Walla basin. Due to warmer air temperatures, precipitation would more often fall as rain than as snow. The duration of low flow periods during summer would increase. As indicated in Figure 15, the following changes were modeled: at Nursery Bridge, a decreased daily average flow from roughly 37 cfs to 16 - 26 cfs; and at Pepper's Bridge a decrease from roughly 28 cfs to 10 - 18 cfs. The duration and length of dry channel increased from 11 days per year dry for 1.2 miles under modern conditions to 88 to 132 days for 4.9 to 8.3 miles under modeled future conditions. As irrigators relied more heavily on groundwater, reduced shallow groundwater elevations exacerbated low summer flows. The warmer summer temperatures also increased the agricultural water demand from 139,701 ac-ft/year baseline to 147,836 to 154,815 ac-ft/yr in the future.



Source: *Walla Walla Basin Integrated Water Flow Model: Alternative Climate Scenario Water Resources Report*, GeoSystems Analysis, Inc., 2017

Figure 15. Predicted Walla Walla River flow rates, July through October.

Based on trends of stream flows from 1900-2009 on Columbia River Basin tribal reservations and a variety of other information sources, basins with high percentages of less than 4000 ft elevation were especially vulnerable to future climate changes. The Walla Walla basin had 91% of its drainage lower than 4000 ft in elevation. In the Walla Walla basin, peak flows are occurring 12.6 days sooner and spring-summer flows have decreased by 17% (Dittmer, 2013).

Base flow in the Walla Walla River is almost entirely from groundwater in the mountains; summer precipitation is negligible. No modeling results or other studies were found to estimate if the decreased snowpack but increased rainfall would have any impact on groundwater elevations in the mountain basalt aquifer. Variability of yields from July 1 – October 30 over the past 86 years has been high, with no strong trend observed (Figure 16).

The Milton-Freewater ASR project would increase the community's resiliency to the expected outcome of decreased summer flows in the Walla Walla River by relying on abundant winter time flows instead of low summer flows for its water supply.

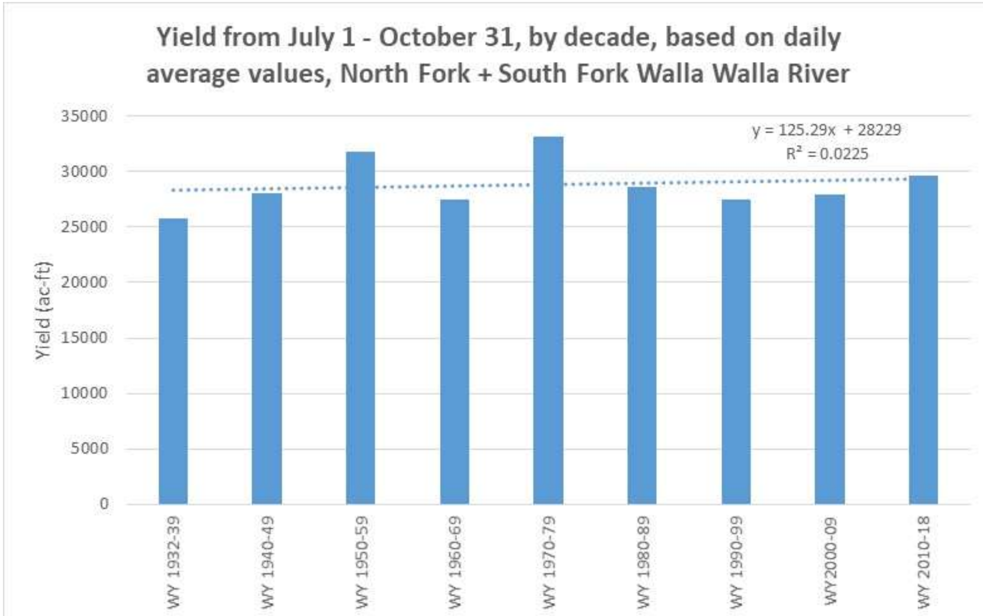


Figure 16. Decadal yields of the North Fork and South Fork Walla Walla River.

Limiting Ecological Factors in the Watershed

The *Walla Walla Subbasin Plan* summarized ecological factors limiting salmon and steelhead abundance in the Walla Walla River as stream flows, stream temperatures, large woody debris, confinement, riparian function, pool habitat, and bedscour (p. 69). No limiting factors for the Little Walla Walla River were described in the plan, although the EDT analysis was conducted on the Little Walla Walla River. Limiting factors for terrestrial species were not listed but many factors affecting terrestrial habitats were described. For riparian/riverine wetlands, such factors included loss of habitat, alteration of the natural hydrology, habitat alteration, habitat degradation, habitat fragmentation, human disturbance, and recreational disturbance (pp. 189-190).

Of the above limiting factors, the proposed project would only impact stream flows. The project would potentially reduce wintertime flows by a maximum of 8.6 cfs. As detailed in the preceding section on ESA-listed fish, a decrease of 8.6 cfs in the winter and spring when average monthly flows are 210 to 300 cfs will not decrease the amount of habitat usable by fish in the Milton-Freewater reach of the Walla Walla River. If the City is forced to use its surface water rights to supply its needs in the future, the ASR project could also potentially avoid an 8.6 cfs decrease in flows during the summer. Average flows from July through October are 24 to 38 cfs. Preventing a 29-36% decrease in flow is a substantial benefit to stream flows.

Section V - Need for and Feasibility of Using Stored Water to Augment In-stream Flows to Conserve, Maintain and Enhance Aquatic Life, Fish Life and Any Other Ecological Value

As described in the ecological flow analysis, the annual volume of water produced by the watershed upstream of Milton-Freewater was calculated for a 47-year period of record, from 1970 to 2016, by adding the daily average discharge from the three major tributaries which contribute flows to the Walla Walla River south of Milton-Freewater – the North Fork Walla Walla River, South Fork Walla Walla River and Couse Creek. Discharge data from the North Fork Gaging Station (14010800), South Fork Gaging Station (14010000), and a derived dataset for Couse Creek (in part based on historical data from gaging station 14011800). The yearly average annual volume of water for this period of record is 176,598 ac-ft.

This project would not increase instream flows but rather prevent the decrease of instream flows. As described above, preventing a decrease of 8.6 cfs in summer flows would prevent a 24-38% decrease in July-October flows in the Walla Walla River, if the City is forced to use its existing surface water rights to supply water for its water users. As described in the ecological flows portion of this report, reducing wintertime flows by 8.6 cfs would slightly decrease the magnitude of the impairment of the normative hydrograph but not sufficiently to improve geomorphic functions or channel conditions.

Based on the observed declines in groundwater elevations of up to 200 feet in wells used by the City of Milton-Freewater (Figure 17), the basalt aquifer at Milton-Freewater could easily store the potential maximum 2,856 ac-ft per year which could be diverted for ASR. Short-term mound development resulting from the maximum ASR is estimated to be 16 to 17 feet.

As described in the first part of this feasibility study, the major elements of the project are technically feasible (suitability of the well for ASR, availability of infrastructure, water chemistry of surface and groundwater). As described below, water rights are secured. The economic feasibility is dependent on the availability of funding sources other than rate payers, which is unknown at this time.

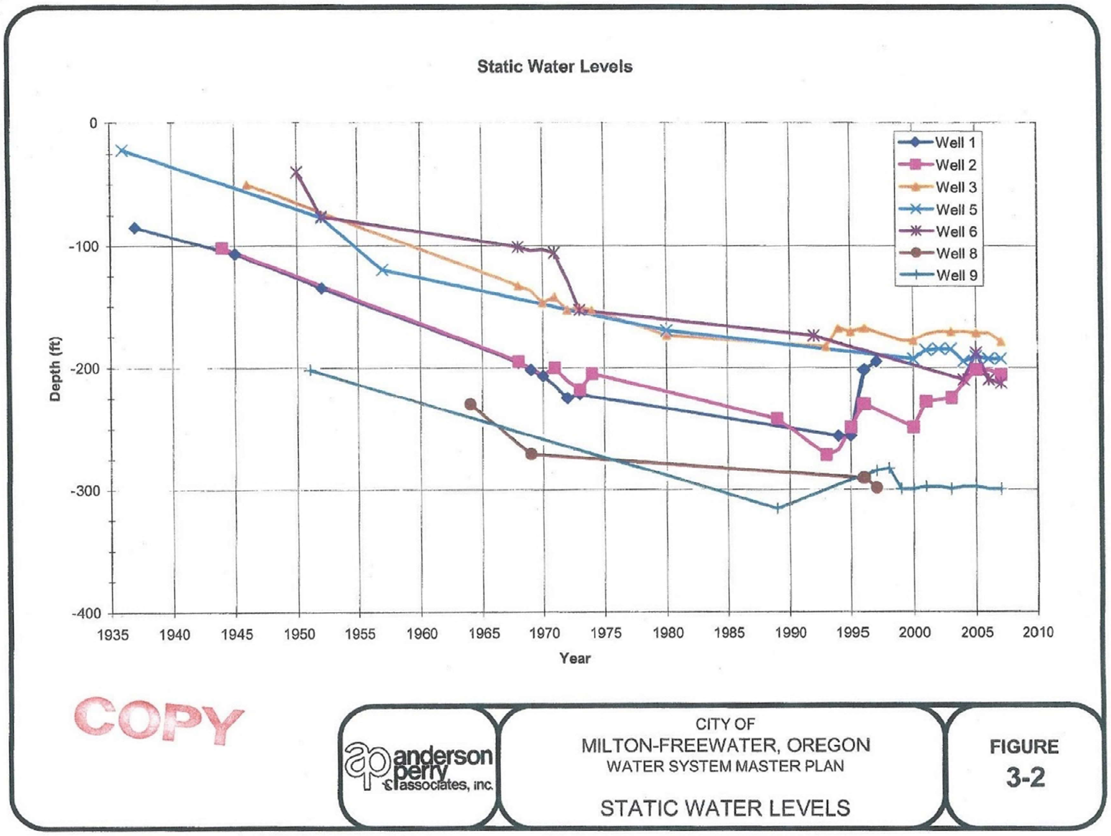


Figure 17. Static water levels, City of Milton-Freewater.

Water Rights and Availability

Water Rights

The following information is taken primarily from *Project Report for the City of Milton-Freewater Well No. 5 Aquifer Storage and Recovery Demonstration Project,* 2018, Anderson-Perry*.* All quoted text is from the 2018 report. Additional details were provided specifically for this report by an independent consultant.

The goals of this project are to store water below ground during periods of higher stream flow and low demand, and to increase stream flows during periods of low flow and high demand by protecting "natural flow" water rights instream. "To meet this goal, the City will develop an aquifer storage and recovery (ASR) project to store water below ground using an existing surface water right. The stored water would be recovered and used for irrigation at the City's golf course, and several of the City's existing surface water rights currently used for irrigation would be protected instream. The water rights mechanisms necessary to implement this approach are described below."

"OWRD is the lead agency that permits and oversees ASR projects in the State of Oregon; however, OWRD consults with the Oregon Department of Environmental Quality (DEQ) and the Oregon Health Authority (OHA) Drinking Water Program on various aspects of ASR projects. To develop an ASR project, a water right authorizing the use of water for the project is required. ASR is an inherent (authorized) use of water under any existing water right in Oregon, meaning that any existing water right could be used as a source for an ASR project. However, the water right's use of water must be consistent use for which the recovered stored water will be used. All proposed ASR project proponents must also seek authorization from OWRD for an "ASR limited license" for ASR pilot testing."

Water Rights Transfer Process

This section describes the water rights transfer process required for an ASR Demonstration project.

Water Right for ASR Source Water

"Storing water under the ASR process would require a water right authorizing the ultimate use of the water and a limited license to authorize ASR testing. Based on discussion with City staff for this project, the stored water will be used for irrigation purposes. The City is proposing to use its water right Certificate 12920, which authorizes the use of up to 7.24 cubic feet per second (cfs) for domestic and municipal purposes. Since municipal use includes the use of water for irrigation purposes, Certificate 12920 could provide the needed water right authorization for an ASR project that would provide stored water for irrigation purposes."

"The City's proposed ASR project includes diverting water from the Little Walla Walla River (which diverts water from the Walla Walla River), treating the water, and then injecting the treated water into [the City's] Well 5. The City's Certificate 12920 authorizes the use of water from the Walla Walla River, but it is not clear that the currently authorized point of diversion is consistent with the proposed project." The authorized point of diversion for Certificate 12920 is not clearly identified in the Walla Walla River decree. OWRD's on-line water right information system (WRIS) "does not include a map for this water right and the location is not included in the certificate. Certificate 12920 was issued as the result of the Walla Walla River Decree, and the decree provides the following description of the location of the City's point of diversion: "about one and one-fourth miles above the bank building on Main Street in the said City." Based on information provided by the City, this authorized location is upstream from the point where the Little Walla Walla River diverts water from the Walla Walla River. Under these circumstances, the City should be able to file a water right transfer application for Certificate 12920 that would add a point of diversion for this water right at the Little Walla Walla River near Well 5." OWRD will review the transfer application to determine whether the requested change would cause injury to other existing water rights or enlargement of Certificate 12920. As the new point of diversion would be downstream from the authorized point of diversion, and assuming any injury and/or enlargement concerns are addressed, OWRD should be able to approve the transfer application. The transferred water right would allow diversion of water from the Walla Walla River into the Little Walla Walla River.

Limited License for ASR Testing

The City will be required to obtain a limited license from OWRD to authorize ASR testing. "To approve an ASR limited license, OWRD must determine that the ASR testing will not impair or be detrimental to the public interest, that testing will produce adequate information regarding resulting groundwater water quality and water quantity, and the proposed use will not expand the use under the original water right.

The primary objectives of ASR pilot testing are to 1) confirm the findings from the ASR feasibility study through data collection and observation and 2) allow incremental development of the ASR system over time up to the limits allowed by the ASR limited license." An ASR limited license is issued for a 5-year period and can be renewed for additional 5-year periods if prolonged testing is found to be necessary to fully develop the project (e.g., if multiple wells are proposed). "Once testing has been completed, the applicant can apply to OWRD for an ASR permit."

Protect Existing Irrigation Rights Instream
"A third transaction would be required to protect the City's existing irrigation rights instream." According to the City, it currently uses water right Certificates 89164, 89166, and 89168 to irrigate the City golf course and/or sports fields. "These water rights authorize the use of up to 0.16 cfs, 0.64 cfs, and 0.59 cfs, respectively, from the Walla Walla River for irrigation purposes. These existing natural flow water rights could be protected instream (in the Walla Walla River) using an instream transfer." Instream transfers can be permanent or time-limited (temporary.) "The water rights could also be protected instream through an instream lease, for up to 5 years. At the end of a time-limited transfer or an instream lease, the water right reverts back to its original place of use. A permanent transfer likely could not be reverted back." Under a temporary transfer of instream lease the priority date of the water rights remains unchanged while the water is protected instream."

OWRD will review an application for an instream transfer to determine whether it will cause "injury" to existing water rights or an enlargement of the water right to be transferred. Under an instream transfer, the water could be protected throughout the irrigation season. Although we would not expect OWRD to consider this "injury," downstream junior irrigators could receive less water after an instream transfer than when the rights were used for irrigation.

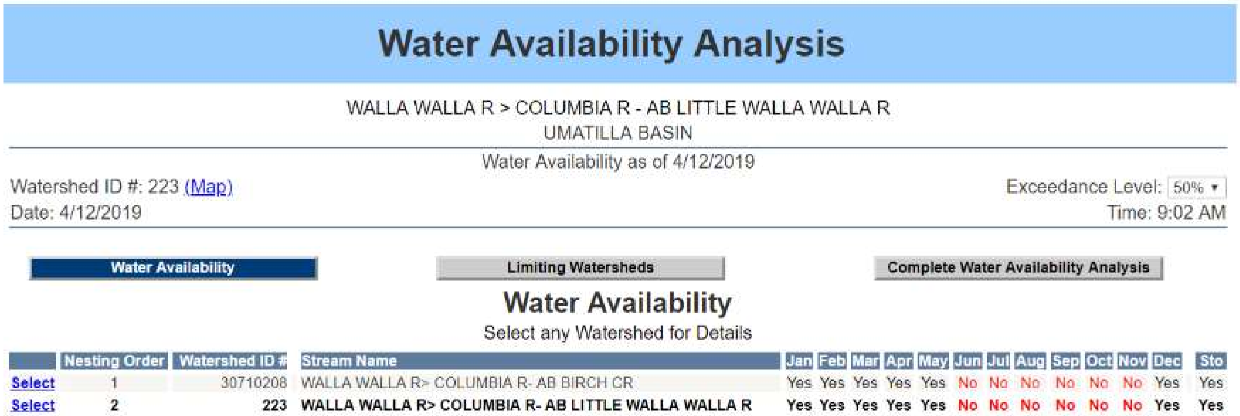
Water Availability

WWBWC used OWRD's Water Availability on-line tool to identify the availability of water for this project. The tool indicates there is unallocated water available from December through May (Figure 18 and Figure 19). The amount of available flow from December through May (38.3 to 201 cfs) is greater than the maximum proposed diversion of 8.6 cfs for the ASR project. The proposed diversion for storage would occur from December 1 until May 15, assuming OWRD instream flow goals for the Walla Walla River are met (Table 22).

Assuming a maximum diversion of 8.6 cfs for 6 months, the total possible diversion is 2,856 ac-ft (8.6 cfs x 1.98 ac-ft/day x 167 days), less than the annual amount of water available.

Table 22. OWRD minimum flows for the Walla Walla River.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Flow (cfs)	70	95	95	95	95	70	50	50	50	30	30	70



Water Availability Analysis

WALLA WALLA R > COLUMBIA R - AB LITTLE WALLA WALLA R
UMATILLA BASIN

Water Availability as of 4/12/2019

Watershed ID #: 223 (Map)
Date: 4/12/2019

Exceedance Level: 50%
Time: 9:02 AM

Water Availability | Limiting Watersheds | Complete Water Availability Analysis

Water Availability

Select any Watershed for Details

	Nesting Order	Watershed ID #	Stream Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sto
Select	1	30710208	WALLA WALLA R> COLUMBIA R- AB BIRCH CR	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes
Select	2	223	WALLA WALLA R> COLUMBIA R- AB LITTLE WALLA WALLA R	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes

Figure 18. Water availability analysis, screen-shot of OWRD's on-line tool.

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Water Availability Analysis

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Water Availability Analysis

Detailed Reports

WALLA WALLA R > COLUMBIA R - AB LITTLE WALLA WALLA R
UMATILLA BASIN

Water Availability as of 9/26/2018

Watershed ID #: 223 (Map)
Date: 9/26/2018

Exceedance Level: 50%
Time: 7:20 AM

Water Availability Calculation | Consumptive Uses and Storages | Instream Flow Requirements | Reservations
Water Rights | Watershed Characteristics

Water Availability Calculation

Monthly Streamflow in Cubic Feet per Second
Annual Volume at 50% Exceedance in Acre-Feet

Month	Natural Stream Flow	Consumptive Uses and Storages	Expected Stream Flow	Reserved Stream Flow	Instream Flow Requirement	Net Water Available
JAN	221.00	98.70	122.00	0.00	70.00	52.30
FEB	296.00	98.70	197.00	0.00	95.00	102.00
MAR	328.00	98.80	229.00	0.00	95.00	134.00
APR	397.00	101.00	296.00	0.00	95.00	201.00
MAY	392.00	104.00	288.00	0.00	95.00	193.00
JUN	207.00	106.00	101.00	0.00	70.00	31.00
JUL	124.00	112.00	12.20	0.00	50.00	-37.80
AUG	107.00	109.00	-2.14	0.00	50.00	-52.10
SEP	111.00	104.00	6.90	0.00	50.00	-43.10
OCT	115.00	99.90	15.10	0.00	30.00	-14.90
NOV	155.00	98.70	56.30	0.00	30.00	26.30
DEC	207.00	98.70	108.00	0.00	70.00	38.30
ANN	160,000.00	74,300.00	86,100.00	0.00	48,200.00	46,800.00

Figure 19. Water availability calculation, screen-shot of OWRD's on-line tool.

Existing Instream Water Rights

Using OWRD's on-line water rights mapping tool, a search was conducted for instream water rights within, above, or below the diversion reach. The proposed point of diversion is within the Little Walla Walla River, where the Little Walla Walla River bifurcates from the Walla Walla River. When selecting that location in the on-line tool, no instream water rights upstream of the location were returned from the search query. When searching for all instream water rights downstream of the selected location, the only point of use listed was certificate 94126. Certificate 94126 is for anadromous and resident fish habitat with a priority date of 1/1/1892, owned by OWRD on behalf of the public. The amount listed on the certificate is 0.06 cfs from April 1 to October 31. The certificate was signed December 20, 2018. It confirms an allocation of conserved water recorded in Special Order Volume 112 page 125, approving conserved water application CW-16.

A second search was conducted for instream water rights in the Walla Walla River, since the point of diversion in the Little Walla Walla River would immediately impact flows in the Walla Walla River. Upriver of the Little Walla Walla River bifurcation, six minimum flow references were found in the mapping tool:

(1) MF 538, owned by OWRD for aquatic life (instream), with a priority date of 3/31/1998. The POD use lists the following maximum rates: Jan 25 cfs, Feb-May 36 cfs, Jun 25 cfs, Jul-Sept 15 cfs, Oct-Nov 5 cfs, and Dec. 25 cfs. The location is North Fork of the Walla Walla River from below the confluence of Little Meadow Creek to the mouth.
(2) MF 539, owned by OWRD for aquatic life (instream), with a priority date of 3/31/1998. The POD uses lists the following maximum rates: Jan 60 cfs, Feb-May 80 cfs, Jun 60 cfs, Jul-Sept 40 cfs, Oct-Nov 25 cfs, and Dec. 60 cfs. The location is South Fork of the Walla Walla River from below the confluence of Elbow Creek to the mouth.
(3) MF 541, owned by OWRD for aquatic life (instream), with a priority date of 3/31/1998. The POD uses lists the following maximum rates: Jan-May 25 cfs, Jun 10 cfs, Jul-Aug 5 cfs, Sept 2 cfs, Oct 5 cfs, Nov 10 cfs, and Dec. 25 cfs. The location is Couse Creek at the mouth.
(4) certificate number 72648, owned by OWRD for anadromous and resident fish habitat, with a priority date of 8/21/1990. The POD uses lists the following maximum rates: Jan 100 cfs, Feb-May 136 cfs, Jun 100 cfs, Jul-Sept 70 cfs, Oct-Nov 54 cfs, and Dec 100 cfs. The location is South Fork of the Walla Walla River from Reser Creek to the confluence with the North Fork of the Walla Walla River.
(5) certificate number 72649, owned by OWRD for anadromous and resident fish habitat, with a priority date of 8/21/1990. The POD uses lists the following maximum rates: Jan 36 cfs, Feb-May 50 cfs, Jun 26.6 cfs, Jul 10.4 cfs, Aug 8.15 cfs, Sept 8.2 cfs, Oct 9.6 cfs, Nov 17.8 cfs, and Dec 36 cfs. The location is North Fork of the Walla Walla River from the headwaters to the confluence with the South Fork of the Walla Walla River.
(6) certificate number 72987, owned by OWRD for anadromous and resident fish habitat, with a priority date of 8/21/1990. The POD uses lists the following maximum rates: Jan 13.6 cfs, Feb-Apr 25 cfs, May 24.2 cfs, Jun 4.26 cfs, Jul 1.84 cfs, Aug 1.04 cfs, Sept 0.92 cfs, Oct 1.15 cfs, Nov 2.19 cfs, and Dec 11.7 cfs. The location is Couse Creek from the headwaters to the mouth.

Because the instream water rights and identified minimum flows are upstream of the proposed diversion, the maximum diversion of 8.6 cfs would not impact any of these rights.

When searching the Walla Walla River downstream of the Little Walla Walla River bifurcation, the search returned too many records to list. The "include tribs" feature was disabled and the search was repeated. Seven water rights were returned, all of which were for multiple instream uses owned by OWRD on behalf of the public. The amounts listed and locations of the seven water rights were:

(1) Certificate 81536, priority date 12/31/1900, for two PODs: (a) instream transfer T9618, for 0.027 cfs from 890 ft north and 425 ft west from C ¼ of section 1 to the state line; and (b) 0.005 cfs from April 1 to October 31, from the location of the diversion to the stateline for fishery enhancement instream (primary).
(2) Certificate 89163, priority date 12/31/1885, for CW57, 0.03 cfs from April 1 to October 31, from 15 ft south and 385 east from W ¼ corner of section 18 to the state line.
(3) Certificate 89165, for CW57, 0.02 cfs with a priority date of 1/1/1886 and 0.05 cfs with a priority date of 1/1/1888, both of which are from April 1 to October 31, from 1030 ft north and 900 ft east from C ¼ corner of section 12 to the state line.
(4) Certificate 89167, for CW57, from April 1 to October 31, 0.11 cfs with a priority date of 1/1/1876 and 0.21 cfs with a priority date of 1/1/1894, from 1030 ft north and 900 ft east from C ¼ corner of section 12 to the state line.
(5) Certificate 90630, for CW46, for varying flow rates of 0.004 to 0.278 cfs from April 1 to October 31, from 1080 ft south and 450 west from N ¼ corner of section 1 to 1080 ft south and 450 west from N ¼ corner of section 1.
(6) Certificate 91215, for CW73, for varying flow rates of 0.001 to 0.475 cfs, from April 1 to October 31, with priority dates from 1876 to 1904, from river mile 50 to the state line.
(7) Certificate 91464, for CW74, from RM 50 to the stateline 1.76 cfs, from April 1 to October 31.

All of the instream water rights for the Walla Walla River downstream of the Little Walla Walla River bifurcation were for the period of April 1 to October 31.

In conclusion, it appears water is available for the proposed project during those months when the instream minimum flow targets are met. Water for this ASR project will only be diverted at times of surplus (likely December through May 15) so as not to impact other water rights or instream target flows for fish.

Section VI - Analysis of Local and Regional Water Demand and the Proposed Storage Project's Relationship to Existing and Planned Water Supply Projects

The *City of Milton-Freewater, Oregon Water Management and Conservation Plan* describes the following: In 2009, the population of Milton-Freewater was 6,465. The 20-year population projections (for the year 2029) based on annual growth rates of 1.0, 1.5, and 2.0 percent were 8,072, 8,954, and

9,928, respectively. Based on a 2.0 percent population growth, and current average and peak demands, the projected demands in 2029 are 2,031 gpm average daily demand and 5,078 gpm peak daily demand. (Anderson-Perry & Associates, Inc., 2010). An addendum to the City's Conservation Plan explains that the City's certificated groundwater rights of 8,572 gpm will be able to supply the projected 20-year peak daily demand of 6,771 gpm (Anderson-Perry, 2011). The purpose of the ASR project is to provide a sustainable source of water for the City if the basalt aquifer becomes unreliable or unusable.

This project proposes to use water from the Walla Walla River (via the Little Walla Walla River) from December to May. Competing demands on winter water include agricultural diversions, the managed aquifer recharge program, and a proposed surface water reservoir.

The future agricultural demand for surface water in Umatilla County is projected to increase by 416,600 acre-feet (10%) by 2050 (p. 19, *Oregon Statewide Long-Term Water Demand Forecast*, OWRD, 2015). Because no new surface water rights exist in the Milton-Freewater area, the only water available to supply new demand is winter water from streams or groundwater. If groundwater declines force a declaration of the aquifer as a critical groundwater area, growers currently relying on basalt wells may invest in private ASR projects. In the Washington portion of the basin, downstream of the levee reach, in Water Resource Inventory Area 32, irrigation demand is forecasted to increase slightly in April, May, and October but decrease in June through September as a result of crop mix changes; it appears from the graph on page 69 the magnitude of the decreased demand is greater than the increased demand (WSU, 2016). Municipal demands are projected to increase by 9% by 2035; more frequent curtailments of surface water diversions are also forecasted to occur (WSU, 2016).

In recent years, WWBWC's current managed aquifer recharge program typically diverts 5,000 to 8,000 ac-ft per year. The goal stated in the existing recharge program strategic plan is to recharge 20,000 ac-ft per year (WWBWC, 2013).

In the *Walla Walla Basin Integrated Flow Enhancement Study*, two types of major methods to increase flows in the Walla Walla River were forwarded for further evaluation – a reservoir on Pine Creek to store water primarily from the Walla Walla River and a pump-exchange with the Columbia River (Walla Walla Watershed Flow Study Steering Committee, 2017). Reservoir sizes that were considered ranged from 26,600 to 58,500 ac-ft per year and the pump-exchange options ranged from 13,600 to 30,900 ac-ft per year. A separate report evaluated the availability of water for the proposed reservoir and concluded, based on a draft report regarding a proposed percent of flow approach, that the fisheries benefits of the reservoir would justify diverting more than 15 percent of the flow of the Walla Walla River (CH2M, 2017). Depending on the size of the reservoir which is forwarded to a feasibility study, the proposed diversion needed for the reservoir could use all of the annual 46,800 ac-ft of water currently indicated as being available in OWRD's on-line tool.

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Appendix A: Oregon Watershed Assessment Manual Alluvial Fan Description

The following is an image copied from a portion of Oregon's *Watershed Assessment Manual*.

ALLUVIAL FAN CHANNEL AF

Alluvial fans are generally tributary streams that are located on foot-slope landforms in a transitional area between valley floodplains and steep mountain slopes. Alluvial fan deposits are formed by the rapid change in transport capacity as the high-energy mountain-slope stream segments spill onto the valley bottom. Channel pattern is highly variable, often dependent on substrate size and age of the landform. Channels may change course frequently, resulting in a multibranched stream network. Channels can also be deeply incised within highly erodible alluvial material. Smaller alluvial fan features may be difficult to distinguish from FP3 channels.

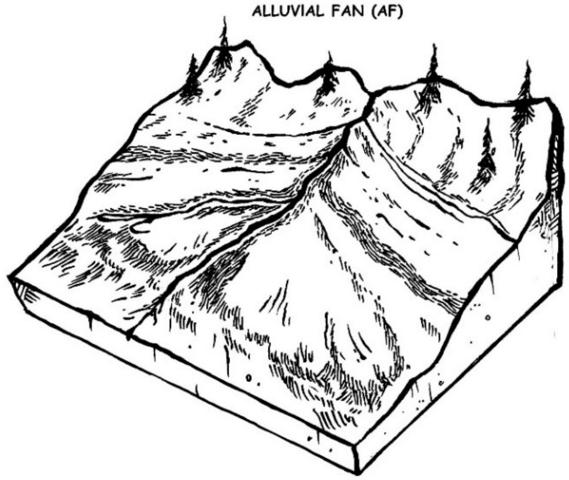
CHANNEL ATTRIBUTES

Stream gradient:	1-12%
Valley shape:	Where hill slopes open into broad valley
Channel pattern:	Single to multiple channels spread across the fan surface
Channel confinement:	Variable
Oregon stream size:	Small to medium
Position in drainage:	Lower end of small tributaries
Dominant substrate:	Fine gravel to large cobble

CHANNEL RESPONSIVENESS

The response of alluvial fans to changes in input factors is highly variable. Response is dependent on gradient, substrate size, and channel form. **Single-thread channels** confined by high banks are likely to be less responsive than an actively migrating multiple-channel fan. The moderate-gradient and alluvial substrate of many fans results in channels with a moderate to high overall sensitivity.

ALLUVIAL FAN (AF)



Large Woody Debris: Variable

In forested basins, these channels are likely to have relatively high wood counts. Those located at the foot of high-gradient channels are especially subject to wood availability. Wood can readily affect channel pattern, location, and dimension. Wood is likely to be a major channel roughness element, although the high sediment supply limits development of pools.

AF – Alluvial Fan

Scale: Full (1:24,000)
Contour Interval: 40 feet

Fine Sediment: Moderate to High

The location of these channels often dictates a high sediment input to the stream. These channels are sediment deposition zones for larger particles, although a significant portion of the fine sediment will be transported through higher-gradient fans. In lower-gradient fans, or those with heavy sediment input loads, the fine- and coarse-sediment deposition promotes channel migration and the development of multiple channels.

Coarse Sediment: High

Alluvial fans are depositional areas for coarse sediment. When the supply of coarse sediment surpasses the transport capabilities of the stream, the channel is vulnerable to widening, lateral movement, side-channel development, and braiding.

Peak Flows: Moderate to High

The capability of alluvial fans to pass large flows is highly variable. As the channel is bedded in alluvial material, high flows are capable of moving the channel bed, particularly in the higher-energy regions at the head of the fan. This often results in downcutting or creation of multiple channels.

RIPARIAN ENHANCEMENT OPPORTUNITIES

As many alluvial fans are actively moving at a rate greater than most channels, they are generally not well-suited to successful enhancement activities. Although they are considered responsive channels, long-term success of enhancement activities is questionable. High sediment loads often limit the success of efforts to improve habitat complexity such as wood placement for pool development.

Source: *Oregon Watershed Assessment Manual*, developed for the Governor's Watershed Enhancement Board, 1999, Watershed Professionals Network.

Appendix B: Developing an Approximation of the Normative Hydrograph at Milton-Freewater

Three channels contribute flows to the Walla Walla River before it leaves the Blue Mountains – the North Fork of the Walla Walla River, South Fork of the Walla Walla River, and Couse Creek. The existing gaging stations on the North Fork and South Fork of the Walla Walla River are located upstream of all major diversions. Only two surface water rights, for diversion of a total of 0.003 cfs, are listed in OWRD's database for points of diversion located upstream of the OWRD gaging stations on the North Fork (station ID 14010800) and South Fork (station ID 14010000). Multiple points of diversion exist for Couse Creek; however, the majority of these diversions would only be used in the summer for irrigation and thus would not influence peak winter flows.

To calculate natural flows coming out of the Walla Walla canyon onto the valley floor, a 47-year period-of-record from WY 1970 to 2016 was created which combined the OWRD gaging data from the North Fork and South Fork, and a synthesized dataset for Couse Creek (CH2M, 2017). This combined dataset, called the "Composite" dataset, captures the temporal variability over almost five decades of nearly natural flows coming out of the mountains onto the valley floor. OWRD operated a gaging station on Couse Creek from 10/1/1969 to 12/19/1978. To extend the Couse Creek dataset, monthly correlation coefficients between the Couse Creek data and North Fork data were calculated. The coefficients were applied to the North Fork daily data for years when no Couse Creek gage was operational (1979-2016) to estimate daily discharge in Couse Creek. To quantify the uncertainty in this approach, the mean daily measured values were compared against the mean derived values for 10/1/1969 to 12/19/1978 (Figures B-1 and B-2). Peak discharges tend to be overestimated by this approach, but the Pearson correlation coefficient of 0.96 and P-value of <0.0001 indicates a strong enough relationship to support using the data in this study. More importantly, out of a 47-year period-of-record, Couse Creek only contributed 3% of the combined flows.

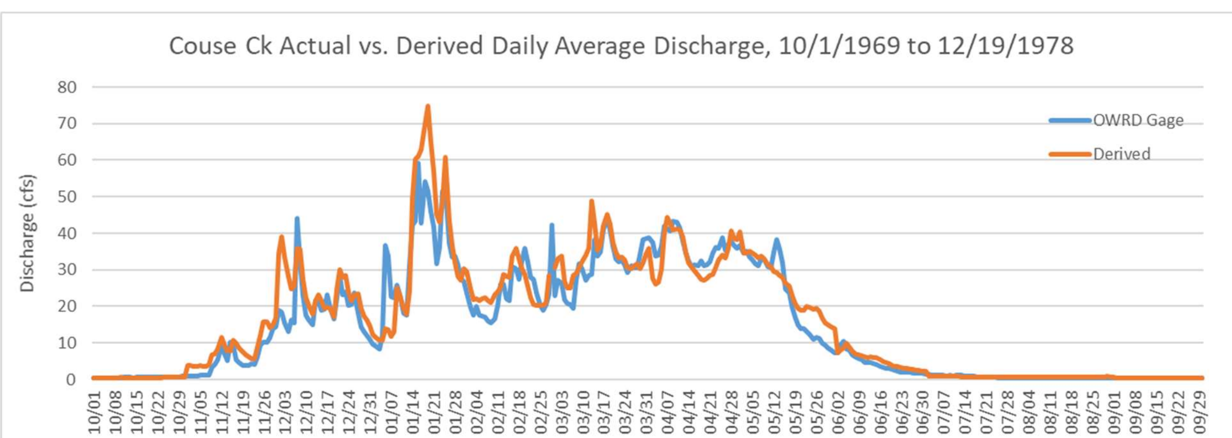


Figure B-1. Daily average discharge, Couse Creek October 1969 to December 1978, actual and derived values.

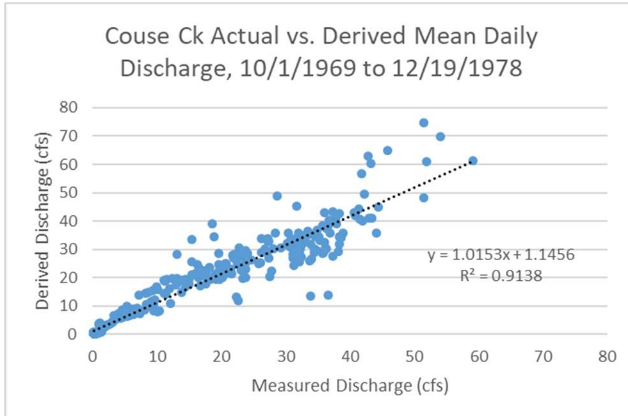


Figure B-2. Regression of daily average discharges actual and derived values, Couse Creek October 1969 to December 1978.

GLO Survey

After the Walla Walla River exits the canyon in the Blue Mountains, historically it divided into multiple channels on the alluvial fan located on the valley flood. Approximating the natural hydrograph of the Walla Walla River at Milton-Freewater, on the alluvial fan, is difficult because by the time discharge began being measured on a routine basis, the distribution of flows to the various channels had already been significantly altered. However, when the General Land Office surveyed section lines in the area in 1864 and 1865, the surveyors measured the width of the six mapped distributary channels. The following information suggests that flows in the distributary channels were essentially unaltered when the surveys were conducted:

- The headgate controlling flows into the Little Walla Walla River had not yet been constructed
- In the 1860 census, the population of “Walla Walla” within Oregon was 317. In contrast, within Walla Walla County in Washington State the population was 1,318 (Superintendent of Census, 1864).
- The only pre-1866 water rights in the Walla Walla River in the 1932 consent decree (Circuit Court of the State of Oregon for Umatilla County, 1932) were for 80.95 acres. In OWRD’s geographic information system database of water rights, the total maximum cumulative diversion for the three water rights (at two locations, one on the North Fork and one on the mainstem in the canyon) with priority dates prior to 1866 was 0.83 cfs.

If stream width was proportional to discharge in 1864 and 1865, it is possible to use the GLO measurements to estimate the historical distribution of flow between the Walla Walla and Little Walla Walla rivers. The extent of alteration to the hydrograph resulting from the elimination of beaver by 1834 and the presence of large numbers of introduced horses and cattle by 1850 owned by tribal members (Ecovista, 2002, Appendix A) is unknown.

The widths of the six distributary channels as measured by the GLO surveyors ranged from 6.6 to 39.6 feet[5]. The map of T 5N R 35E in Oregon shows two channels each in the West Little Walla Walla River, East Little Walla Walla River, and the Walla Walla River. Stream widths varied longitudinally in each channel, ranging from 6.6 to 39.6 feet in the Walla Walla River, 13.2 to 26.4 feet in the West Little Walla Walla River, and 6.6 to 19.8 in the East Little Walla Walla River (Figure B-3). As shown on the GLO maps and in the associated surveyor notes, at the time of the surveys the Walla Walla River was variously called the TumLum River, Tomelon River, or Tomelon Creek and the Little Walla Walla River channels were called the North Branch and South Branch of the Walla Walla River.

The GLO map of T5N, just south of the maps shown in Figure B-3, was not included because the locations of the streams drawn on the map were inconsistent with the measured distances included in the surveyor notes and it was not possible to determine which width was associated with which channel.

Relating Stream Width to Discharge

Stream widths alone, however, are insufficient to develop a normative hydrograph. Discharge rates are needed for each of the six channels. If the differences in measured stream widths were in proportion to differences in discharge, ratios can be used to assign discharge values to each channel. Two types of information suggest stream widths were in proportion to discharge: (1) physical factors influencing water depth and velocity; and (2) historical accounts.

Physical factors controlling water depth and velocity also indicate stream widths were likely in proportion to discharge because the variables influencing depth and velocity were likely similar in each channel. Discharge is a function of wetted width, water depth, and velocity. The width is known, therefore only differences in water depth or velocity between the different channels would indicate the approach of using width as indicator of discharge is inappropriate.

[5] It is unknown if the GLO measured widths are wetted widths or channel widths. The surveyor notes do not specify, nor does the earliest surveyor manual (*Commissioner of General Land Office, 1851*). Given that these surveys were conducted in March, the wetted widths and channel widths may have been equivalent.

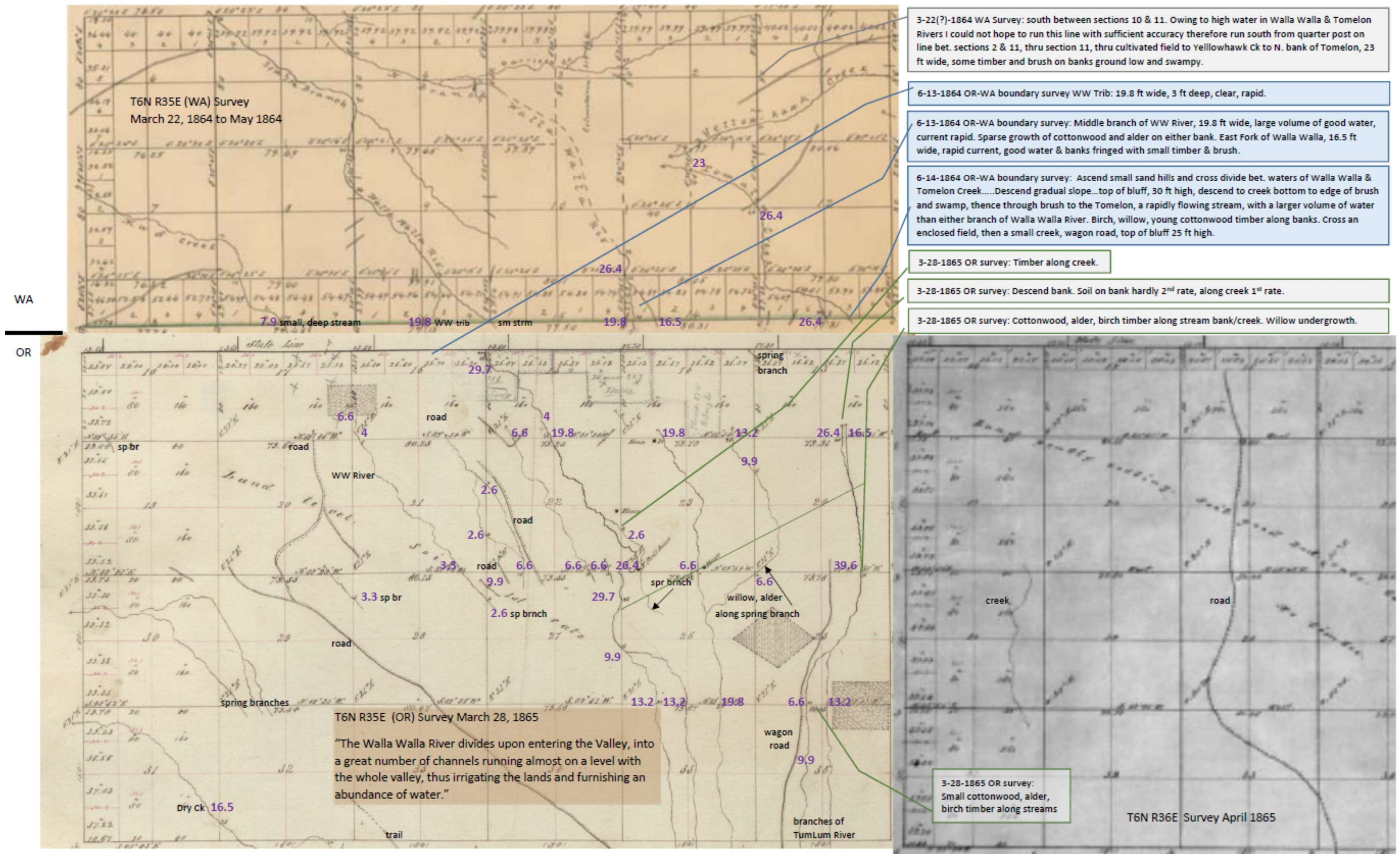


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Figure B-3. GLO survey measured stream widths.

Factors influencing water depth and/or velocity include gradient, channel bed roughness, and the shape of the channel. The shape of the channel is a function of discharge, sediment movement through the channel, and composition of the channel bed and banks. Historical information and known characteristics of the alluvial fan were reviewed to determine if any of these factors were likely to differ between the channels. The results are summarized in Table B-1. Additional details follow.

Table B-1. Factors influencing water velocity and depth in streams.

Factor	Condition
Longitudinal position along the channel	Each set of GLO measurements were at the same latitude
Channel bed roughness, composition of channel bed and banks	Channel beds and banks were all composed of alluvium from same source, the Walla Walla River as it exits the canyon.
Type and amount of sediment being transported through the channel	Same source of sediment
Water slope	Water slope = function of sinuosity + land surface gradient. Land surface gradient comparable at a given latitude across the alluvial fan. Reach-scale sinuosity unknown but similar between the channels as drawn on the GLO maps

Water velocity is known to vary longitudinally within a river, typically increasing with decreasing elevation due to less energy used to overcome friction. The GLO measurements of each of the six channels were at the same of one of three latitudinal positions along the stream profile because the surveyors were establishing the east-west section lines.

Across the alluvial fan, the composition of the channel bed and banks would have been alluvium from the same source – the Walla Walla River as it exits the canyon. An early geological map shows the same type of deposit throughout the entire fan – young alluvium (Newcomb, 1965). One characteristic of alluvial fans is the poor sorting of sediments (Charlton, 2008). Sediment deposition in the active channels would have been equally chaotic and thus resistance to channel erosion broadly comparable. No sorting of sediment based on size would be expected in a horizontal direction across the alluvium fan. Longitudinally, sediments near the lower edge of the fan could be expected to have a higher proportion of fine sediment because the larger sediments would have deposited higher on the alluvial fan.

Sediment moving through each channel also would have come from the same source – the Walla Walla River as it exits the canyon, having mixed the differing sediment sources from the North Fork, South Fork, and Couse Creek into a single channel in the canyon before splitting into distributary channels on the valley floor. Similarly, based on the conical shape of the alluvial fan, all six channels had comparable sediment-transport capabilities over the last 10,000 years – the fan doesn't have any major depressions in it.

The slope of water in these channels was not recorded. Water slope would likely be in rough proportion to the land surface slope given the similarities in channel sinuosity as mapped by the GLO. Although the mapped channels were straighter than modern conditions, meanders and sinuosity are shown on other

GLO survey maps of the area (e.g., T 5N and R 36E, which includes the junction of the North and South Forks of the Walla Walla River), suggesting that if any of the distributary channels had been highly sinuous, the surveyors would have indicated it on the map. To obtain land surface slope in the same locations as the mapped channels, the lines showing the location of the stream channels were digitized into QGIS. Gradient for each channel segment between section lines was calculated using elevation data from GoogleEarth. Gradients ranged from 0.006 to 0.011, with the steepest gradient highest on the alluvial fan (Table B-2).

Table B-2. Gradients of digitized channels mapped by the GLO.

Segment	West Little Walla Walla River		East Little Walla Walla River		Walla Walla River (TumLum River)	
	Channel 1	Channel 2	Channel 1	Channel 2	Channel 1	Channel 2
Between T5/6N Line and Hwy 332	0.007	0.009	0.009		0.010	0.011
Between Hwy 332 and Crockett	0.007	0.006	0.007	0.005	0.006	0.006
Between Crockett and Sunquist	0.006		0.007	0.006	0.008	0.007

Given the similarities in land surface slope and substrate composition, it is reasonable to assume channel roughness would have been similar among the channels. Equally broad assumptions are made even in modern modeling of the Walla Walla River. In a recent HEC_RAS model of the Walla Walla River floodplain, a single roughness coefficient (Manning's n value) of 0.10 was selected to represent the portion of the alluvial fan which could flood if the levee failed at a discharge of 8,800 cfs or greater (WEST Consultants, 2008).

No large tributaries were mapped entering any of these six channels in the area of interest – the alluvial fan near Milton-Freewater. So water depths would have been governed by discharges of the Walla Walla River as it left the mountains and groundwater entering the channel as springs or hyporheic flow.

Historical reports provide few descriptions of either channel depth or water depth. GLO surveyor notes include the following:

- The only mention of a specific water depth in the GLO notes among the six distributary channels is for what is now called the West Little Walla Walla River, near the stateline, where the depth was three feet and the width was 19.8 feet.
- "The Walla Walla River divides upon entering the Valley, into a great number of channels **running almost on a level with the whole valley**, thus irrigating the lands and furnishing an abundance of water." [emphasis added]
- In the-now-called West Little Walla Walla River, between sections 22 & 23, "descend bank."
- At Tomelon Creek, between sections 13 and 24, "descend bank."

Descriptions of velocity in the surveyors' notes were the same for channels in the Walla Walla and Little Walla Walla rivers – rapid:

- "Walla Walla tributary 30 lks[6]. Wide, running N., a clear rapid stream of good water"
- "strikes the middle branch of Walla Walla River, 30 lks. wide, course N. by W., large volume of good water, current rapid."
- "E. Fork of Walla Walla, 25 lks. wide, rapid current, good water & banks fringed with small timber & brush"
- "thence through brush 38 chs. to the Tomelon, a rapidly flowing stream, 40 lks. wide and with a larger volume than either branch of the Walla Walla"

Other historical descriptions of stream conditions include the following:

In the 1890 Census of Agriculture, the U.S. Census Office reported the "banks of the Walla Walla River are generally low…" (U.S. Department of the Interior, 1895).

Col. Fremont's journal for October 23, 1843 describes the area after leaving the Walla Walla Canyon as "Crossing the river, we traveled over a hilly country with a good bunch-grass; the river bottom, which generally contains the best soil in other countries, being here a sterile level of rocks and pebbles." Other descriptions in Col. Fremont's journal are consistent with multiple channels mapped by the GLO "In six miles we crossed a principal fork, below which the scattered waters of the river were gathered into one channel…" and "…"immediately below us, was the great Nez Perce (pierced nose) prairie, in which dark lines of timber indicated the course of many affluents to a considerable stream that was pursuing its way across the plain towards what appeared to be the Columbia River. This I knew to be the Walahwalah river, and occasional spots along its banks, which resembled clearings, were supposed to be the mission or Indian settlements; but weather was smoky and unfavorable to far views with the glass." and "Reaching a little eminence over which the trail passed, we had an extensive view along the course of the river, which was divided and spread over its bottom in a network of water, receiving several other tributaries from the mountains." (Fremont, 1852).

In an 1897 reconnaissance report, USGS describes: "On account of filling that is in progress, some of the branches, notably Mill Creek, divide, after the manner of a stream on its delta, and contribute their waters to the Walla Walla through two or more mouths." "This abnormal behavior of the Walla Walla and its branches has led to legislative enactments which determine what proportion of the waters should be allowed to flow through certain of the bifurcating channels." "During high water stages, I have been informed, expansions of the stream occur which resemble lakes. The expanded waters of the creeks are then united and much of the individuality of the various channels is lost." (USGS, 1897, pp. 22-23).

Considering all of the above, there are no evident reasons to conclude depths or velocities would have been substantially different in any of the six channels. Therefore, to estimate historical discharge, first

[6] Note: lks = links = 0.66 ft. chs = chains = 66 ft.

the width of all six channels was summed at each section line. Then the width of each channel was divided by the summed width. The resulting ratios were averaged by river (Table B-3).

Table B-3. Stream widths in 1864 and projected discharges in July and August.

Latitude	Stream widths in 1865		
	West LWWR	East LWWR	TumLum
Hwy 332, Sunnyside Rd (northern edge of sections 35 & 36)	2 channels, each 13.2 ft	19.8 ft	2 channels, 6.6 ft + 13.2 ft
Proportion of total width	*40%*	*30%*	*30%*
Crockett Rd (northern edge of sections 25-27)	26.4 ft	2 channels, each 6.6 ft	39.6 ft
Proportion of total width	*33%*	*17%*	*50%*
Sunquist Rd (northern edge of sections 22-24)	19.8 ft	2 channels, 19.8 ft + 13.2 ft	2 channels, 26.4 ft + 16.5 ft
Proportion of total width	*21%*	*34%*	*45%*
Average proportion of total width	*58%*		*42%*

Hydrograph

The last step in developing a normative hydrograph for the river near Milton-Freewater was to apply the 42:58 proportions to the 47-year dataset. The results are hydrographs with the same frequency of peak flows as the 47-year record but at a lower magnitude, reflecting the estimated 42% of total discharge going to the Walla Walla River and 58% to the Little Walla Walla River. Table B-4 summarizes the results by month.

Table B-4. Average monthly discharges for 47-year composite dataset and estimated natural discharges in the Walla Walla River and Little Walla Walla River.

Monthly average flow (cfs)			
Month	Composite Dataset: S Fk + N Fk + Couse	Walla Walla River	Little Walla Walla River
		42% of flow goes to Tumalum R	58% of flow goes to LWWR
Oct	119	50	69
Nov	172	72	99
Dec	232	98	135
Jan	282	118	164
Feb	305	128	177
Mar	362	152	210
Apr	432	182	251
May	419	176	243
Jun 1-15	268	113	155
Jun 16-30	186	78	108
Jul	127	53	74
Aug	118	49	68
Sept	114	48	66

The above analysis does not consider two critical features of the Milton-Freewater reach – the variable but sometimes very high seepage losses and the loss of distributary channel function.

The following suggest the reach had naturally high seepage losses:

1. The substrate through which the channel passes is composed of recently deposited alluvium which is predominantly gravel-to-cobble sized sediments across much of the alluvial fan.
2. Col. Fremont's description from 1843 (published in 1852) "Crossing the river, we traveled over a hilly country with good bunch-grass; the river bottom, which generally contains the best soil in other countries, being here a sterile level of rocks and pebbles."
3. Tamalám means "rocky bar in river, dry stream, gravel bar, rocks by a creek, pile of rocks, rocky bottom, gravel" (*Umatilla Dictionary*, Confederated Tribes of the Umatilla Indian Reservation in association with the University of Washington Press, 2014).

Therefore, the estimates of historical flows were not adjusted to attempt to account for seepage losses. This analysis assumes flows in the river downstream of Milton-Freewater decreased naturally due to seepage losses until the area near Tumalum Bridge where groundwater upwelling directly into the channel or from springs would have increased flows, similar to modern patterns.

A significant data gap is in developing the natural hydrograph is how much water from the frequent flooding across the roughly 10 mi^2 alluvial fan would have returned as hyporheic flow to the WWR and LWWR. At least four past assessments considered the alluvial fan to be a floodplain or equivalent to a floodplain:

> (1) In Newcomb's geologic map of the Walla Walla basin, the alluvial fan is mapped as "younger alluvium." In the map legend, "younger alluvium" is described as "Gravel and gravelly silt *underlying flood plains*. Largely thin veneer less than 10 feet thick over Pleistocene gravel (Qcg). Water bearing in most places." His report further states on page 26 "The gravel and silt laid down by the present streams comprise the Recent alluvium. Recent alluvial material now above the reach of the streams is called "older alluvium"; *that submerged by the streams in flood is referred to in this report as "younger alluvium.* " (Newcomb, 1965, p. 26). [emphasis added].
>
> (2) In USDA's *Report of Survey Walla Walla River Watershed Washington and Oregon, For Runoff and Waterflow Retardation and Soil Erosion Prevention for Flood Control Purposes*, Appendix I, page 3 states "Mill Creek and the Walla Walla River form a large valley with a flood plain 10 to 12 miles wide below the towns of Walla Walla and Milton-Freewater. Near Touchet this flood plain narrows to a width of about 4 miles" (USDA, 1950). The reference to a flood plain width of 10 to 12 miles indicates the authors were referring to the width of the valley where the Mill Creek and Milton-Freewater alluvial fans are located, since no other part of the Walla Walla Valley near Walla Walla or Milton-Freewater is that wide.
>
> (3) In Piper *et al*., "Upstream from Milton for several miles the canyon of the river is floored by a flood plain 0.1 to 0.5 mile wide, *this plain being correlative with the alluvial fan*. Below the fan, the Walla Walla River and its several distributaries have developed flood plains which generally are less than 0.5 mile wide…." (Piper et al., 1933, p. 20) [emphasis added]

(4) A HEC-RAS model of the flooding potential of > 8,800 cfs flows found the width of the area with modeled water depths of at least one foot extended to approximately 5,500 feet from the river channel. Past that distance, areas were mapped as having shallow flooding of less than one foot *to the extent of the alluvial fan* (WEST Consultants, Inc., 2008). [emphasis added]

Alluvial Fan Flood Characteristics

Flood Geomorphology, Baker et al. 1988 "Flooding on alluvial fans is difficult to assess because channel avulsion is common – the plugging of the active channel with sediment and diversion of waters to alternate channels…Throughout their recent geomorphologic histories most fans have experienced such changes frequently, usually during floods…resulting in a roughly equal distribution of sediment across their surfaces…Present geomorphic theory does not provide for the calculation of the probability that any particular distributary channel will receive flow. On natural fan surfaces the flood hazard is therefore largely indeterminant. The common engineering and planning solution is to design and maintain a single channel for flow, an approach that usually requires trapping and artificial removal of sediments delivered to the fan apex from the upstream watershed…" p. 235. "When floods disgorge onto the nearly flat surfaces of alluvial plains, also known as alluvial aprons…their waters spread laterally into wide zones of very shallow flow."

Because of the potential magnitude of recharge to the alluvial aquifer from frequent floods of such a large area, and the unknown influence such recharge would have on flows in the rivers on the lower portions of the alluvial fans (where some groundwater is forced to the surface, appearing as springs), natural flows at the state line were not estimated.

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Appendix C: Indicators of Hydrologic Alteration

Version 7.1 of The Nature Conservancy's software program Indicators of Hydrologic Alteration (IHA) was used to quantify the differences between the estimated natural hydrograph and modern altered hydrograph of the Walla Walla River. Examples of rivers on which IHA has been used include the McKenzie River in Oregon (USGS, 2010), Middle Fork of the Willamette River in Oregon (Opperman, 2006), and the Trinity River Basin in Texas (USGS, 2003). Comparing pre- and post-alteration IHA parameters estimates the magnitude and type of alterations. Model results are grouped into two categories: (1) indicators of hydrologic alteration (IHA); and (2) environmental flow components. Environmental flow components group results by type of flow (high, low, floods, etc.) allowing for a comparison of specific flow components between pre- and post-alteration conditions.

The software includes built-in statistics to determine if the post-altered IHA parameter falls within the range of variability of the pre-altered condition. The output from the software quantifies 33 IHA parameters (such as monthly flow, minimum and maximum flows over different durations, number and frequency of pulses, etc.) and 34 environmental flow components (such as minimum or maximum flow timing and duration). Some of the indicators are repetitive, characterizing the same type of feature.

Both parametric and nonparametric analyses were run. Nonparametric analyses were run because discharge data are typically non-uniformly distributed but also to ensure the flow duration curves were comparable to other published curves. Parametric analyses were run because mean monthly flows are often used for decision-making purposes, such as comparison to target flows.

Hydrologic Alteration Indicators (IHA) parameter group	Hydrologic parameters	Ecosystem influences
1. Magnitude of monthly water conditions	Mean or median value for each calendar month	* Habitat availability for aquatic organisms * Soil moisture availability for plants * Availability of water for terrestrial animals * Availability of food/cover for fur-bearing mammals * Reliability of water supplies for terrestrial animals * Access by predators to nesting sites * Influences water temperature, oxygen levels, photosynthesis in water column
2. Magnitude and duration of annual extreme water conditions	Annual minima, 1-day mean Annual minima, 3-day means Annual minima, 7-day means Annual minima, 30-day means Annual minima, 90-day means Annual maxima, 1-day mean Annual maxima, 3-day means Annual maxima, 7-day means Annual maxima, 30-day means Annual maxima, 90-day means Number of zero-flow days Base flow index: 7-day minimum flow/annual mean flow	* Balance of competitive, ruderal, and stress-tolerant organisms * Creation of sites for plant colonization * Structuring of aquatic ecosystems by abiotic versus biotic factors * Structuring of river channel morphology and physical habitat conditions * Soil moisture stress in plants * Dehydration in animals * Anaerobic stress in plants * Volume of nutrient exchanges between rivers and floodplains * Duration of stressful conditions such as low oxygen and concentrated chemicals in aquatic environments * Distribution of plant communities in lakes, ponds, floodplains * Duration of high flows for waste disposal, aeration of spawning beds in channel sediments
3. Timing of annual extreme water conditions	Julian date of each annual 1-day maximum Julian date of each annual 1-day minimum	* Compatibility with life cycles of organisms * Predictability/avoidability of stress for organisms * Access to special habitats during reproduction or to avoid predation * Spawning cues for migratory fish * Evolution of life history strategies, behavioral mechanisms
4. Frequency and duration of high and low pulse	Number of low pulses within each water year Mean or median duration of low pulses (days) Number of high pulses within each water year Mean or median duration of high pulses (days)	* Frequency and magnitude of soil moisture stress for plants * Frequency and duration of anaerobic stress for plants * Availability of floodplain habitats for aquatic organisms * Nutrient and organic matter exchanges between river and floodplain * Soil mineral availability * Access for waterbirds to feeding, resting, reproduction sites * Influences bedload transport, channel sediment textures, and duration of substrate disturbance (high pulses)
5. Rate and frequency of water condition changes	Rise rates: Mean or median of all positive differences between consecutive daily values Fall rates: Mean or median of all negative differences between consecutive daily values Number of hydrologic reversals	* Drought stress on plants (falling levels) * Entrapment of organisms on islands, floodplains (rising levels) * Desiccation stress on low-mobility stream edge (varial zone) organisms

Reprinted from *Development of an Environmental Flow Framework for the McKenzie River Basin, Oregon*, USGS, 2010.

Figure C-1. Summary of indicators of hydrologic alteration, by parameter group.

Environmental flow component type	Hydrologic parameters	Ecosystem influences
1. Monthly low flows	Mean or median values of low flows during each calendar month	* Provide adequate habitat for aquatic organisms * Maintain suitable water temperatures, dissolved oxygen, and water chemistry * Maintain water table levels in floodplain, soil moisture for plants * Provide drinking water for terrestrial animals * Keep fish and amphibian eggs suspended * Enable fish to move to feeding and spawning areas * Support hyporheic organisms (living in saturated sediments)
2. Extreme low flows	Frequency of extreme low flows during each water year or season Mean or median values of extreme low flow event: * Duration (days) * Magnitude (minimum flow during event) * Timing (Julian date of event)	* Enable recruitment of certain floodplain plant species * Purge invasive, introduced species from aquatic and riparian communities * Concentrate prey into limited areas to benefit predators
3. High flow pulses	Frequency of high flow pulses during each water year or season Mean or median values of high flow pulse event: * Duration (days) * Magnitude (maximum flow during event) * Timing (Julian date of peak flow) * Rise and fall rates	* Shape physical character of river channel, including pools, riffles * Determine size of streambed substrates (sand, gravel, cobble) * Prevent riparian vegetation from encroaching into channel * Restore normal water quality conditions after prolonged low flows, flushing away waste products and pollutants * Aerate eggs in spawning gravels, prevent siltation * Maintain suitable salinity conditions in estuaries
4. Small floods	Frequency of small floods during each water year or season Mean or median values of small flood event: * Duration (days) * Magnitude (maximum flow during event) * Timing (Julian date of peak flow) * Rise and fall rates	Applies to small and large floods: * Provide migration and spawning cues for fish * Trigger new phase in life cycle (for example, insects) * Enable fish to spawn in floodplain, provide nursery area for juvenile fish * Provide new feeding opportunities for fish, waterfowl * Recharge floodplain water table * Maintain diversity in floodplain forest types through prolonged inundation (for example, different plant species have different tolerances) * Control distribution and abundance of plants on floodplain * Deposit nutrients on floodplain
5. Large floods	Frequency of large floods during each water year or season Mean or median values of large flood event: * Duration (days) * Magnitude (maximum flow during event) * Timing (Julian date of peak flow) * Rise and fall rates	Applies to small and large floods: * Maintain balance of species in aquatic and riparian communities * Create sites for recruitment of colonizing plants * Shape physical habitats of floodplain * Deposit gravel and cobbles in spawning areas * Flush organic materials (food) and woody debris (habitat structures) into channel * Purge invasive, introduced species from aquatic and riparian communities * Disburse seeds and fruits of riparian plants * Drive lateral movement of river channel, forming new habitats (secondary channels, oxbow lakes) * Provide plant seedlings with prolonged access to soil moisture

Reprinted from *Development of an Environmental Flow Framework for the McKenzie River Basin, Oregon*, USGS, 2010.

Figure C-2. Summary of environmental flow components.

Assumptions

For the Milton-Freewater ASR ecological flow analysis, with one exception the software's default settings were used to define the different flow categories:

Low flow	Less than the average flow, the dominant condition in most rivers
Extreme low flow	Less than the 10 percentile flows, typically associated with drought periods
High flow	Greater than 75 percentile flows. Begins when flow increases by more than 25% per day and ends when flow decreases by less than 10% per day.
High flow pulse	Water rises that do not overtop the channel banks
Large floods	Typically rearranges biological and physical structure of a river and its floodplain. Peak flow greater than 10-year return interval.
Small floods	All river rises that overtop the main channel but does not include large floods. Small flood min peak flow = all high flow events w a peak >= this value are assigned to small flood class.

The exception: the default definition of a small flood is a peak flow with a recurrence interval greater than two years. For the purposes of this analysis, a 1.25-year return interval was used instead. As described below, under modern conditions within the levee and natural conditions much of the available information indicates bankfull occurred every year (Q1). Because a bankfull flow is by definition less than a small flood, a return interval of 1.25 was used to indicate the frequency of small floods, since the magnitude of flows associated with a 1.25 return interval (Q1.25) would be slightly greater than a 1.0 return interval.

Modern conditions suggesting bankfull conditions occur almost yearly within the levee reach:

(1) The bankfull recurrence interval of the Walla Walla River at Touchet was 1.03 as determined by physical examination of bankfull indicators and gaging data;

(2) Measured bankfull cross-sectional areas in the levee reach were 153 to 176 ft^2 (ODEQ temp TMDL). Using Manning's equation for estimating discharge, the geomorphic parameters provided in the TMDL (Table 2-2 of the Appendix), and assuming Manning's n ranged from 0.04 to 0.07, the calculated discharges for these cross-sectional bankfull areas are 720 to 900 cfs which occur slightly more often than yearly but less often than every other year;

(3) In the GeoEngineer's HEC-RAS model, the Q1.25 of 1,821 cfs occurred at cross-sectional areas of 320--592 ft^2 under existing conditions; if the measured bankfull cross-sectional areas in the ODEQ temperature TMDL were roughly accurate, peak flows which occur every 1.25 years exceed bankfull.

(4)) In the basis of design for an emergency design at Nursery Bridge, the designed bankfull channel for the Nursery Bridge site was 400 cfs; above 400 cfs water will begin spilling onto floodplain contained between the levees (GeoEngineers, 2014, p. 6). In USACE's sediment study, a peak flow of 400 cfs has an approximate return period of 1.01 years.

Natural Conditions

(1) In the Walla Walla River below the existing flood-control project through Freewater, "…flood damages may be expected every year. This damage area extends for 38 miles along the river from a point 2.1 miles downstream from Freewater." (USACE, 1948, p. 2371).
(2) "Winter and spring floods occur in much of the agricultural area one or more times annually." (USDA, 1950, p. 9)
(3) Peak flow recurrence intervals of less than 1 under natural flow conditions based on the following equations:

    The channel potential width [potential = condition where human caused stresses are minimized] in ODEQ's Temperature TMDL, using the equation in Figure 3-9 for C-Type Rosgen channels is 159 ft^2

    $y=0.3637x + 100.1$ where y is bankfull cross-sectional area (ft^2) and x is drainage area (mi^2)

    $y=0.3637*(162)+100.1 = 159$ sq ft.

    The range of bankfull discharges estimated by the equation $Qbf=(W/2.03)^2$ (where W is width and Qbf is the bankfull flow) and based on the GLO measured widths is 53 to 381 cfs for the Walla Walla River, which has a return intervals of less than one year using the peak curve in the USACE's sediment study.

Output

Table C-1 and C-2 replicate the scorecards generated by the software for the non-parametric analysis. Because monthly average flow values are used commonly in the basin, the monthly average values from the parametric analysis are also replicated (Table C-3).

Table C-1. Non-parametric IHA scorecard

Non-Parametric IHA Scorecard								
Walla Walla River at Milton-Freewater								
Normative				DS POD minus Eastside Upriver Diversions				
Pre-impact period: 1970-2016 (47 years)				Post-impact period: 1970-2016 (47 years)				
NormalizationFactor	1			1				
Mean annual flow	102.5			173.6				
Non-Normalized Mean Flow	102.5			173.6				
Annual C. V.	0.78			1.15				
Flow predictability	0.64			0.46				
Constancy/predictability	0.73			0.43				
% of floods in 60d period	0.37			0.37				
Flood-free season	91			80				
	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR		SIGNIFICANCE COUNT	
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #1								
October	47.8	36.2	0.225	0.7928	0.2426	2.524	0.00	0.002002
November	60.27	91.8	0.2906	0.6019	0.5231	1.071	0.00	0.00
December	71.82	148.5	0.5205	0.5554	1.068	0.06703	0.00	0.8118
January	84.04	186.1	0.6892	0.6668	1.214	0.03237	0.00	0.8809
February	110.2	242.8	0.4912	0.4824	1.204	0.01802	0.00	0.958
March	143.1	312	0.4201	0.5229	1.181	0.2445	0.00	0.2923
April	162.2	308.3	0.4083	0.5575	0.9001	0.3655	0.00	0.1502
May	159.8	274.4	0.5966	0.8765	0.717	0.4691	0.001001	0.09209
June	85.22	70.1	0.6254	1.573	0.1774	1.515	0.4064	0.001001
July	54.31	23	0.2343	0.7783	0.5765	2.321	0.001001	0.00
August	48.59	25.74	0.1677	0.6799	0.4703	3.055	0.00	0.00
September	47.8	25.48	0.161	0.7673	0.4669	3.766	0.00	0.00
Parameter Group #2								
1-day minimum	43.93	3.3	0.1797	3.636	0.9249	19.23	0.09109	0.00
3-day minimum	44.25	5.333	0.1797	2.525	0.8795	13.05	0.08509	0.00
7-day minimum	44.71	8.971	0.1764	1.583	0.7993	7.975	0.06607	0.00
30-day minimum	45.68	19.1	0.169	1.038	0.5818	5.144	0.02202	0.00
90-day minimum	49.93	24.41	0.1805	0.6443	0.5111	2.57	0.00	0.00
1-day maximum	510.6	1140	0.5512	0.6243	1.233	0.1327	0.00	0.6416
3-day maximum	445.8	991.5	0.5426	0.591	1.224	0.08936	0.00	0.7267
7-day maximum	345.6	723.3	0.5042	0.6198	1.093	0.2293	0.00	0.3984
30-day maximum	232.2	470.6	0.3785	0.3876	1.026	0.02405	0.00	0.9149
90-day maximum	184.2	379.4	0.2956	0.3407	1.06	0.1526	0.00	0.4324
Number of zero days	0	0	0	0				
Base flow index	0.4361	0.04945	0.1586	1.917	0.8866	11.09	0.3193	0.00
Parameter Group #3								
Date of minimum	275	195	0.1148	0.2623	0.4372	1.286	0.00	0.002002
Date of maximum	47	47	0.235	0.2268	0	0.03488	0.9479	0.8208
Parameter Group #4								
Low pulse count	5	3	0.8	0.6667	0.4	0.1667	0.001001	0.6056
Low pulse duration	12.5	17.5	1.36	2.886	0.4	1.122	0.05405	0.05405
High pulse count	7	3	0.2857	1.333	0.5714	3.667	0.00	0.00
High pulse duration	5	21	0.6	4.476	3.2	6.46	0.00	0.05405
Low Pulse Threshold	51.07							
High Pulse Threshold	128.6							

Table C-2. Environmental flow components, non-parametric.

	MEDIANS		COEFF. of DISP.		DEVIATION FACTOR	SIGNIFICANCE COUNT		MEDIANS
	Pre	Post	Pre	Post	Medians	C.D.	Medians	C.D.
Parameter Group #5								
Rise rate	3.864	6.2	0.8315	0.5081	0.6046	0.389	0.00	0.1431
Fall rate	-2.436	-7.2	-0.75	-0.4028	1.956	0.463	0.00	0.06807
Number of reversals	95	116	0.1053	0.09483	0.2211	0.09914	0.00	0.6456
EFC Low flows								
October Low Flow	50.09	55.78	0.1391	0.3254	0.1135	1.34	0.003003	0.00
November Low Flow	57.96	76.6	0.2261	0.4014	0.3216	0.7756	0.00	0.001001
December Low Flow	69.07	106	0.3521	0.1429	0.5347	0.5941	0.00	0.008008
January Low Flow	77.32	115.4	0.2227	0.2021	0.4925	0.09242	0.00	0.6807
February Low Flow	87.15	116	0.32	0.1199	0.3305	0.6254	0.00	0.03403
March Low Flow	99.06	112	0.1999	0.1532	0.1307	0.2337	0.01401	0.4925
April Low Flow	116.1	111.6	0.1826	0.2052	0.03849	0.124	0.6547	0.6717
May Low Flow	108.9	89.55	0.2309	0.2627	0.178	0.1379	0.004004	0.5365
June Low Flow	79.49	86.75	0.4194	0.361	0.0914	0.1393	0.3253	0.4915
July Low Flow	54.47	58.7	0.2113	0.592	0.07758	1.802	0.1101	0.001001
August Low Flow	49.92	47.95	0.1178	0.1335	0.03941	0.1331	0.2332	0.7207
September Low Flow	49.81	49.95	0.09696	0.2898	0.00277	1.989	0.9209	0.01201
EFC Parameters								
Extreme low peak	43.09	24.4	0.04386	0.9016	0.4338	19.56	0.006006	0.00
Extreme low duration	5	15	1.55	3.667	2	1.366	0.00	0.1572
Extreme low timing	254	234	0.224	0.2568	0.1093	0.1463	0.2062	0.5596
Extreme low freq.	1	4	5	1	3	0.8	0.00	0.02402
High flow peak	172.3	159	0.3587	0.3846	0.07711	0.0721	0.1371	0.7748
High flow duration	4	3	0.5	1	0.25	1	0.08208	0.008008
High flow timing	55.5	346	0.1885	0.2514	0.4126	0.3333	0.007007	0.04705
High flow frequency	6	1	0.5	3	0.8333	5	0.00	0.00
High flow rise rate	33.76	34.04	1.088	1.316	0.00818	0.2098	0.98	0.2843
High flow fall rate	-15.55	-17.93	-0.6722	-0.9001	0.1532	0.339	0.4324	0.2693
Small Flood peak	484.5	574.7	0.33	0.2999	0.1861	0.09109	0.009009	0.7487
Small Flood duration	30.5	38.25	1.131	1.278	0.2541	0.1296	0.4795	0.6647
Small Flood timing	67.5	35.5	0.1653	0.223	0.1749	0.3492	0.01001	0.2573
Small Flood freq.	1	1	1	2	0	1	0.01702	0.001001
Small Flood riserate	73.98	77.52	0.8313	1.609	0.04795	0.9354	0.7978	0.01702
Small Flood fallrate	-30.45	-21.87	-0.7226	-1.512	0.2817	1.093	0.05706	0.008008
Large flood peak	978.1	1331	0.292	0.462	0.3603	0.5824	0.004004	0.09109
Large flood duration	23.5	160	1.543	0.575	5.809	0.6272	0.00	0.1512
Large flood timing	10	41	0.1182	0.2186	0.1694	0.8497	0.05305	0.09309
Large flood freq.	0	1	0	1				
Large flood riserate	238.6	34.65	0.7653	1.093	0.8548	0.4284	0.06106	0.6196
Large flood fallrate	-48.23	-14.39	-1.438	-1.403	0.7016	0.02472	0.09109	0.971
EFC low flow threshold:								
EFC high flow threshold:		128.6						
EFC extreme low flow threshold:		44.81						
EFC small flood minimum peak flow:		347.8						
EFC large flood minimum peak flow:		876.2						

Table C-3. Excerpt from parametric scorecard

IHA Parametric Scorecard								
WW River at M-F parametric								
	MEANS		COEFF. of VAR.		DEVIATION FACTOR		DEV. of C.V.	
	Pre	Post	Pre	Post	Magnitude	%	Magnitude	%
Parameter Group #1								
October	49.98	38.1	0.1565	0.5521	-11.88	-23.77	0.3956	252.9
November	72.05	114.6	0.3758	0.602	42.5	58.99	0.2263	60.22
December	97.5	209.8	0.4559	0.5156	112.3	115.2	0.05971	13.1
January	118.4	265.8	0.4179	0.4517	147.3	124.4	0.03375	8.076
February	128.1	296	0.4283	0.4435	167.8	131	0.01524	3.558
March	152	332.8	0.3104	0.3672	180.8	118.9	0.0568	18.3
April	181.6	349.2	0.2874	0.3813	167.6	92.25	0.09393	32.68
May	176.1	299.7	0.3779	0.5488	123.5	70.13	0.1709	45.22
June	102.7	108.8	0.4605	0.975	6.153	5.994	0.5146	111.8
July	55.83	25.14	0.1867	0.7193	-30.7	-54.98	0.5326	285.2
August	49.43	23.93	0.1329	0.5659	-25.5	-51.59	0.433	325.7
September	47.99	27.44	0.1317	0.55	-20.55	-42.82	0.4183	317.6

A comparison of almost four years of the pre- and post-alteration hydrographs illustrates how the large flood criteria, high flow pulse, and extreme low flow thresholds are applied in the IHA software (Figures C-3 and C-4). The dotted horizontal lines indicate the various flow thresholds (low, high flow pulse, etc.), which are the same in both graphs. Thus the differences between the natural and altered hydrographs in the timing of high flows and small floods is a result of categorizing much larger post-alteration flows using the pre-alteration thresholds. The timing and variability in timing of water coming out of the mountains is the same in the natural hydrograph as in the 47-year “composite” dataset.

Figures C-5 through C-12 illustrate some of the charts created by the software.

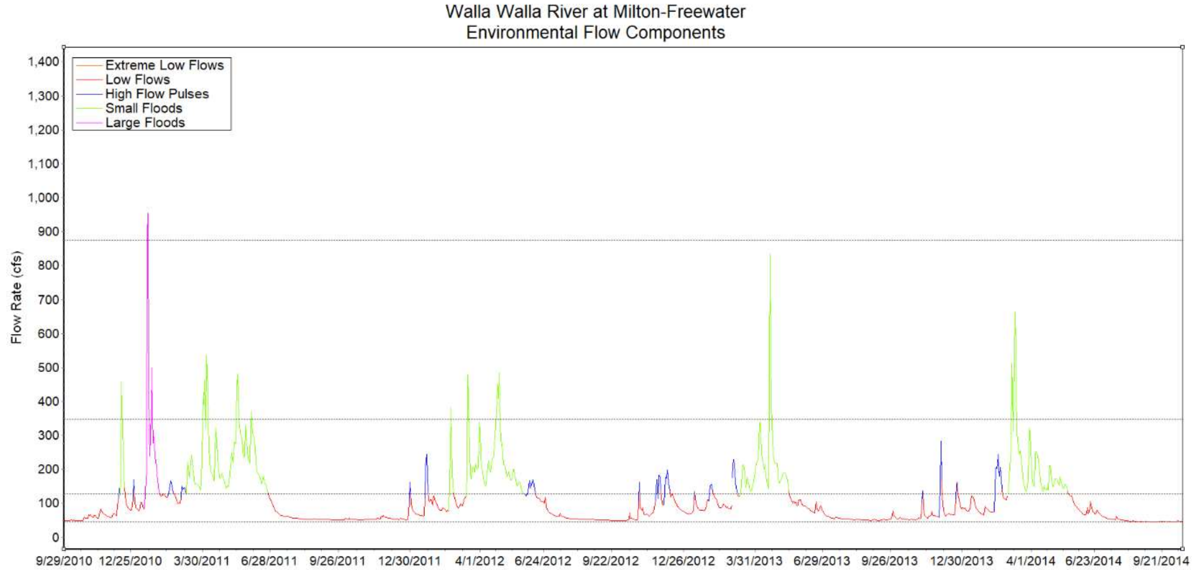

Figure C-3. Environmental flow components for four years of the estimated natural hydrograph.

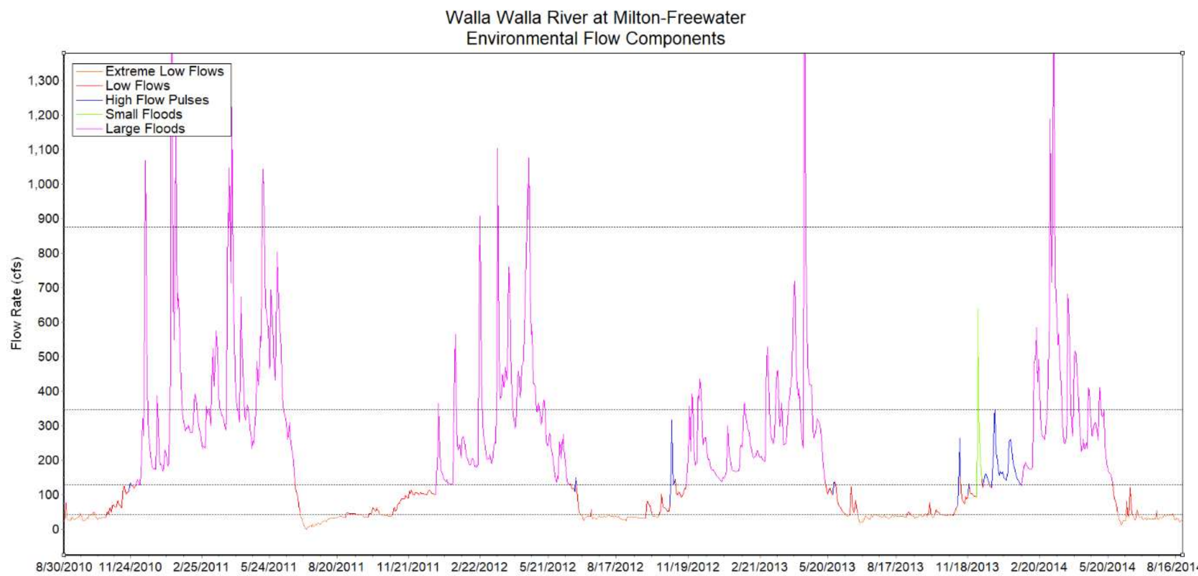

Figure C-4. Environmental flow components for four years of the modern, altered hydrograph.

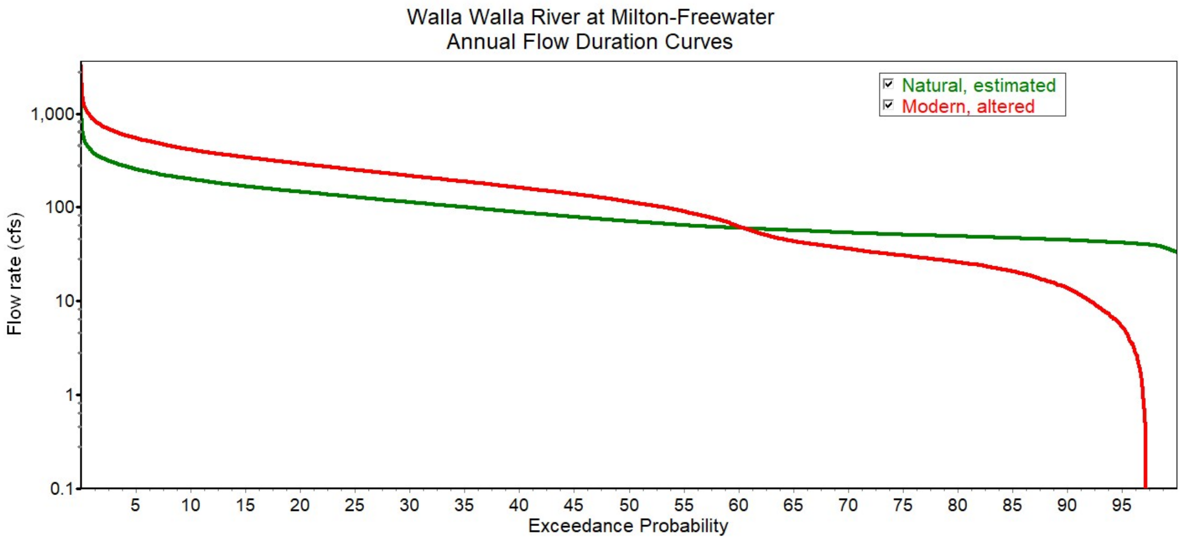

Figure C-5. Flow duration curves, estimated natural and modern altered hydrographs.

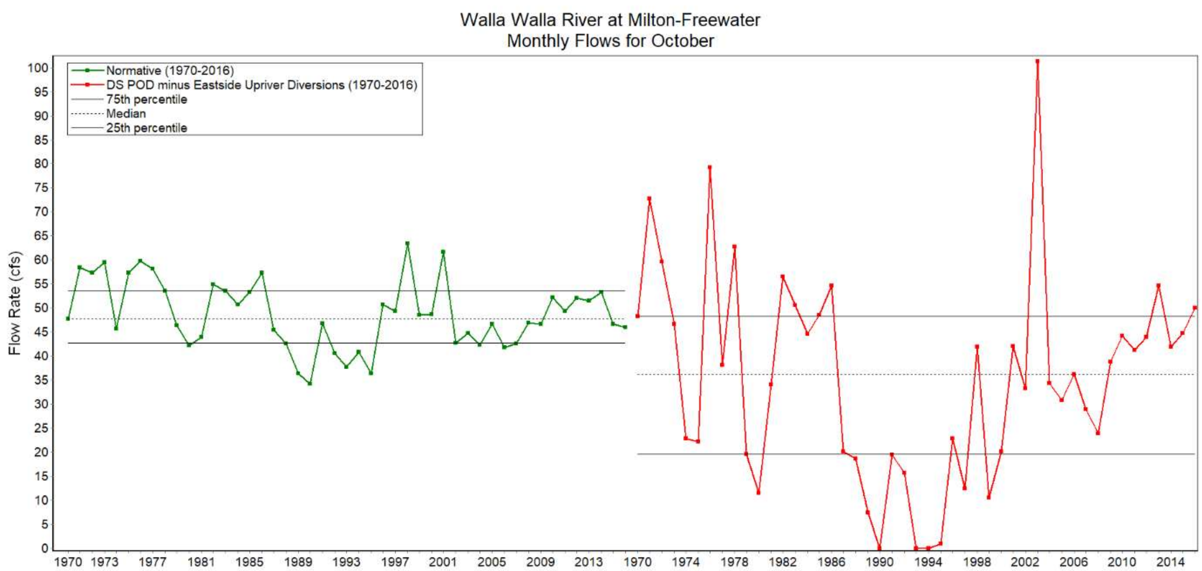

Figure C-6. Monthly average flows in October, estimated natural and modern altered hydrographs.

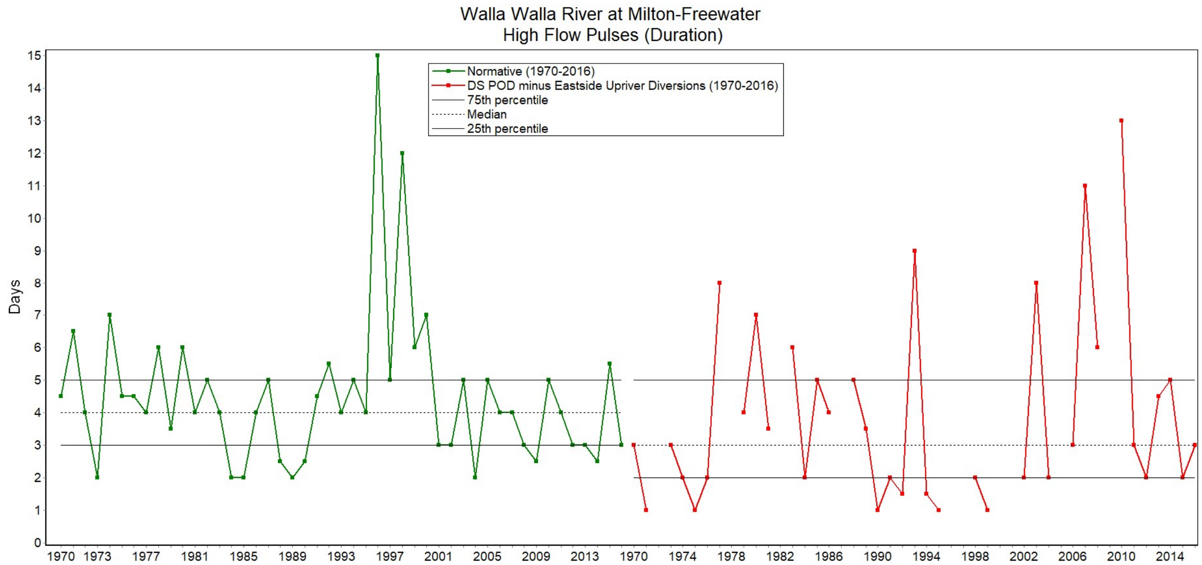

Figure C-7. High flow pulse duration, estimated natural and modern altered hydrographs.

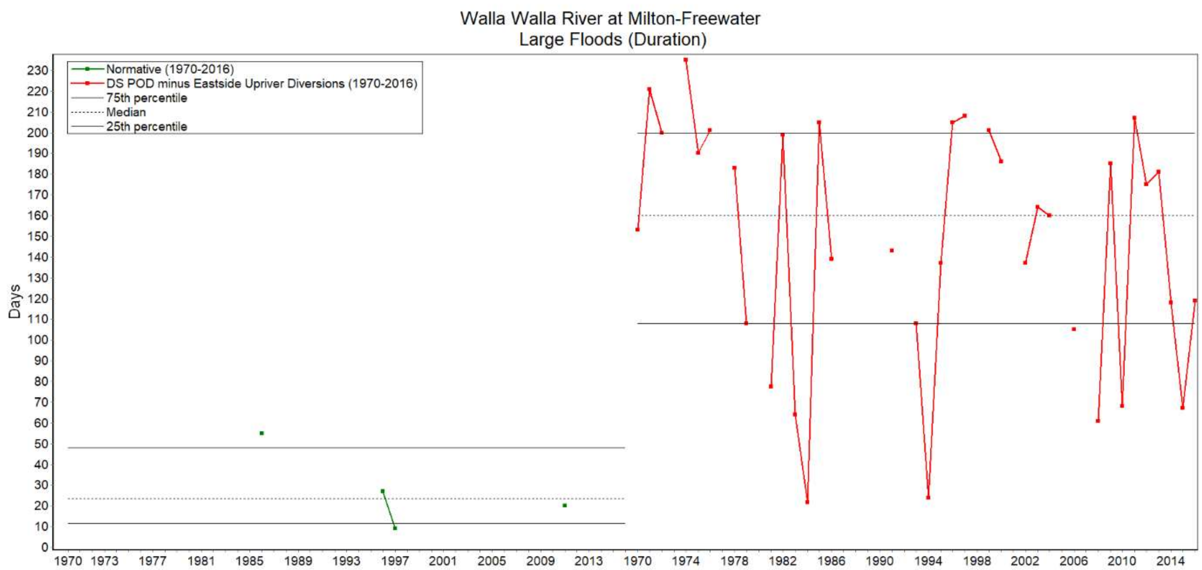

Figure C-8. Large flood duration, estimated natural and modern altered hydrographs.

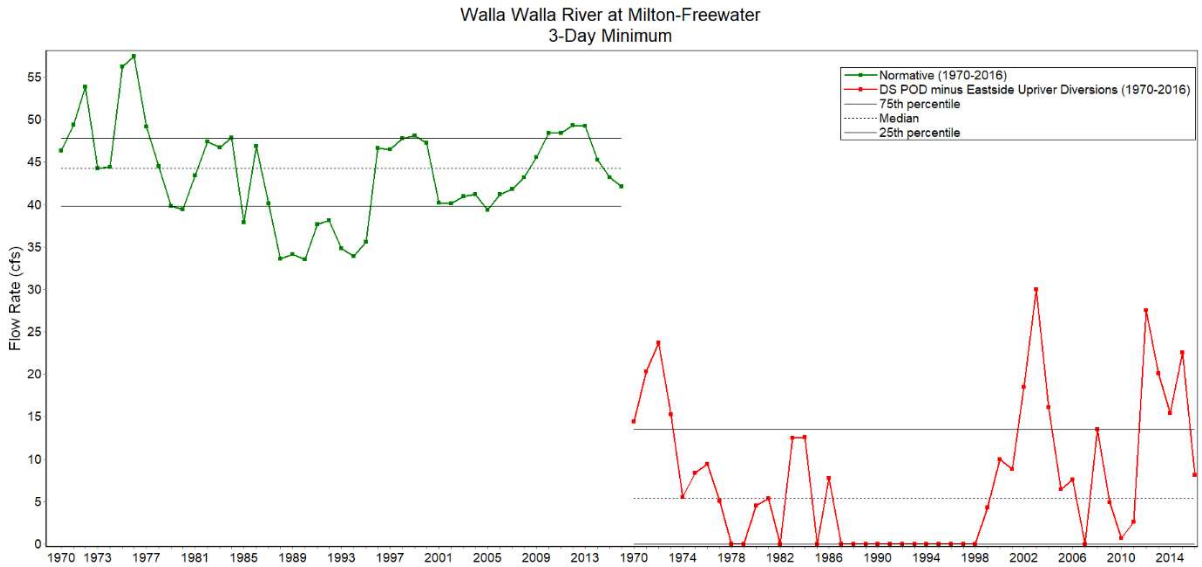

Figure C-9. Three-day minimum flows, estimated natural and modern altered hydrographs.

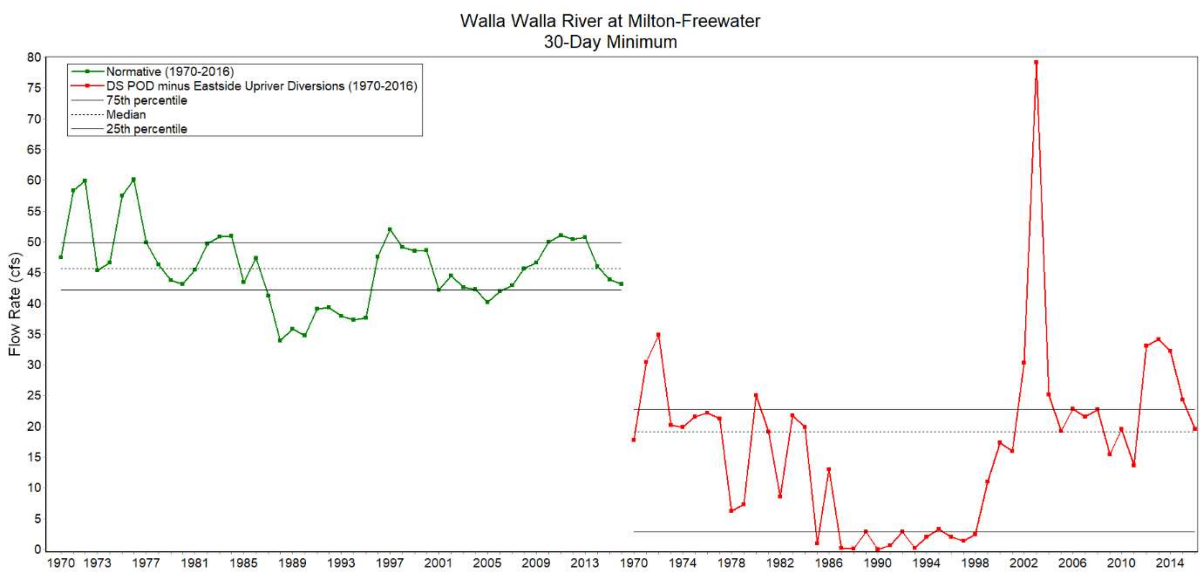

Figure C-10. Thirty-day minimum flows, estimated natural and modern altered hydrographs.

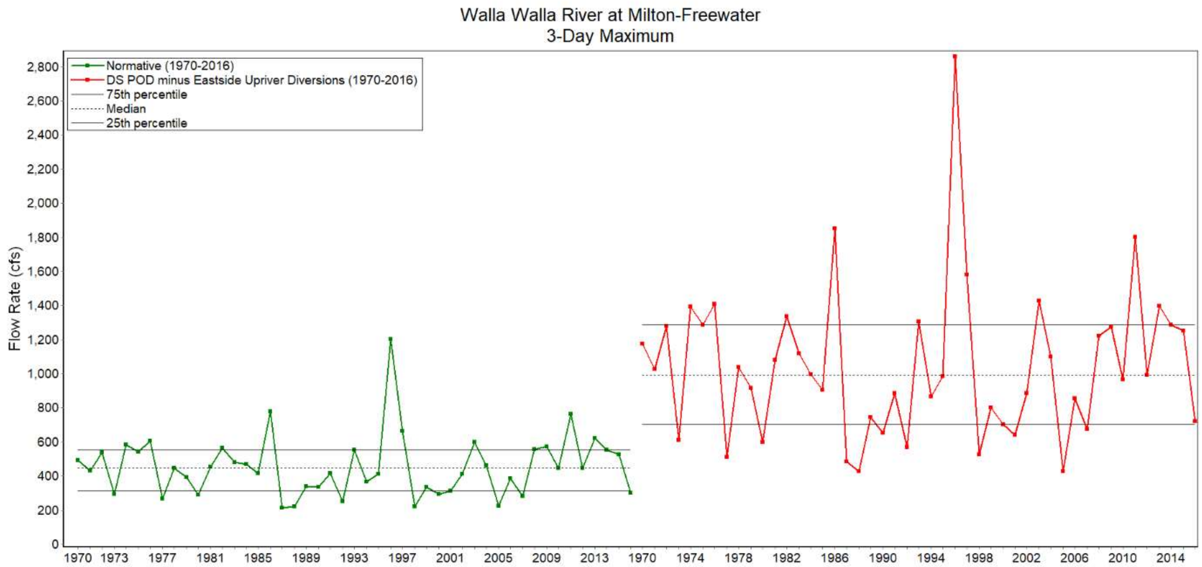

Figure C-11. Three-day maximum flows, estimated natural and modern altered hydrographs.

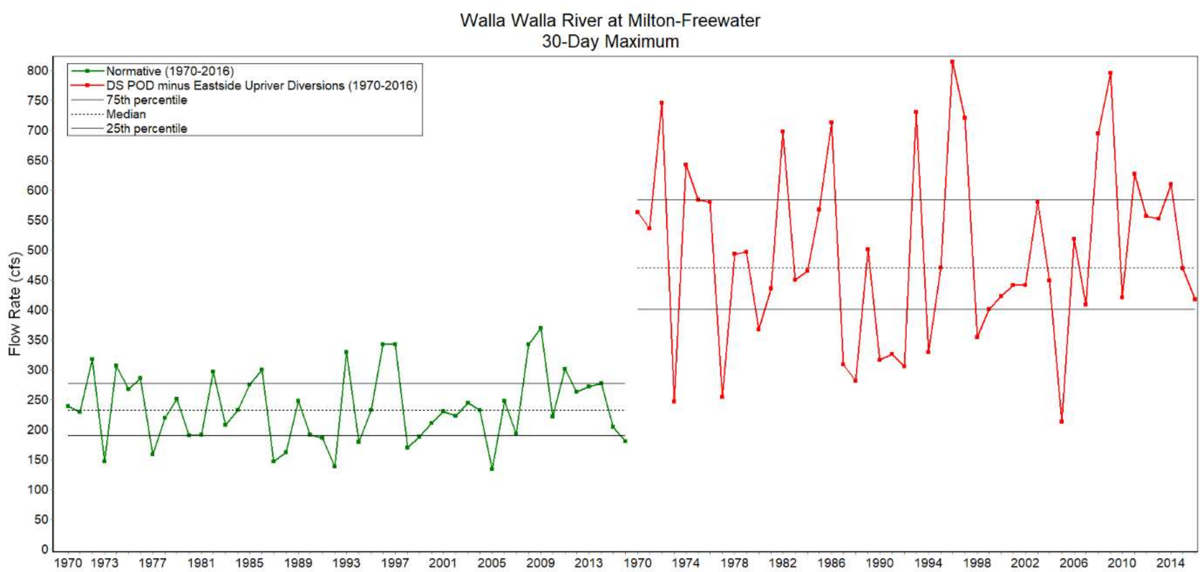

Figure C-12. Thirty-day maximum flows, estimated natural and modern altered hydrographs.

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