Geosyntec consultants

engineers | scientists | innovators

Friends of the Metolius

Water Quality Analysis

Final Report

Prepared for

Friends of the Metolius
P.O. Box 101
Camp Sherman, OR 97730

Prepared by

Geosyntec Consultants, Inc.
621 SW Morrison St., Suite 600
Portland, OR 97205

Project Number PNW0212

5 December 2014

TABLE OF CONTENTS FOR THE ENTIRE REPORT
(**HIGHLIGHTED ITEMS INCLUDED IN THIS SUMMARY**)

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

1. EXECUTIVE SUMMARY

This report presents statistical findings from the analysis of available monitoring data collected within the Metolius River Basin with the objective to characterize the current state of water quality conditions of the basin and river and to assess any potential trends that may be observed. Data analyzed were collected by Friends of the Metolius (FOM) and combined with the ODEQ LASAR database and range in time from 1969 to 2013. Where statistical methods do not allow for quantitative characterization, qualitative assessments have been provided.
In additional to selected queries, statistical analyses presented herein include the Mann- Whitney Rank Sum Test to evaluate spatial variability between locations, temporal changes in the central tendency of the data and differences between ambient vs. storm event water quality, and the Seasonal Kendall's Tau to more explicitly assess temporal trends.

The analysis found no criticality concerning trends for the Metolius River. Both quantitative and qualitative findings suggest the stream water quality in the Metolius Watershed is in excellent condition, particularly with respect to ODEQ and EPA Ecoregional criteria and water-contact recreation standards. Relatively high nutrient concentrations, which appear to occur as far upstream as the head waters, are likely due primarily to natural geologic conditions. Given the available data and sampling nature, significant quantitative findings that would suggest campgrounds or wildfire have some impact on the water quality are not able to be made currently although the potential and some qualitative assessments are generally supported by literature and case studies.

Following statistical analyses in conjunction with qualitative spatial considerations, initial recommendations with respect to future sampling within the Metolius Watershed include reduction of the number of sampling locations to strategic monitoring points on the main stem of the river and increased sampling at these locations during and after specific events such as fires, storms, and landslides. Additionally, significant increases to sampling documentation and further spatial characterization have also been recommended.

2. INTRODUCTION & BACKGROUND

Although the Metolius River is generally regarded as relatively pristine, water quality data collected over recent decades can be useful to assess whether or not this "condition" has recently changed or is likely to change in the future. The analyses conducted by Geosyntec Consultants (Geosyntec) and presented herein include hypothesis tests and trend analysis that both quantitatively and qualitatively evaluate in-stream water quality, how it is changing over time and space, and what factors potentially drive these changes. For example, the trends and relationships between the water quality constituents of the Metolius River and watershed geology, wildfires, and anthropogenic use (e.g., development and recreational use) are explored to the extent warranted by available data and information.

2.1 Watershed Background

The Metolius River ranks between first and second for water quality in Oregon after sections of the Grande Ronde River (ODEQ, 2013). The Metolius River is a tributary to the Deschutes River, connecting via Lake Billy Chinook (Map A-1). Much of the watershed is protected forest and as a result, the stream's health is pristine. Several studies have investigated water quality in the Metolius River and the surrounding area due to the relatively pristine nature of the stream system and the unique geology of the area (Peterson & Groh, 1972; Sisters Ranger District, 2004). Of note are significant historical volcanic events/activity and a river system fed predominantly by springs rather than surface runoff. Because of these primarily volcanic geological features, the river's water quality characteristics display unusually high levels of phosphorus and nitrogen nutrients (Peterson & Groh, 1972). In addition, the watershed frequently experiences intense wildfires (increasing in intensity over the last century). These wildfires can potentially cause sediment and nutrient rich overland flow (due to mobilization following vegetation loss or the chemical suppressants used in fire operations, which are often nitrate or phosphate based). Several areas around the watershed are used for seasonal recreation and include several campgrounds, summer cabins, and day use facilities.

The geology of the Metolius watershed has been previously studied (Peterson & Groh, 1972; Sisters Ranger District, 2004). Here we present a summary of those findings. The Metolius Springs are in the transition zone between the High Cascades geomorphic province on the west and the High Lava Plains on the east. The oldest rocks consist of alternating layers of basaltic-andesite and breccia and agglomerate typical of these types of volcanic centers. These eruptive rocks cover sandstone, diatomite, and pumice typical of the High Lava Plains to the east. The younger rocks in the region are from the High Cascade province made of variable volcanic and glacial-fluvial material.

Black Butte is in the historical path and generally represents the headwaters of the Metolius River. The rocks that make up Black Butte are basaltic andesite typical of the High Cascades Water that once flowed overland now percolates downward though the permeable sands and gravels beneath Black Butte and then surfaces again at the lowest point north of Black Butte at the current day Metolius Springs (Peterson & Groh, 1972). Given the river is predominantly spring fed and not characterized with significant "flushing", high flow events, it is vulnerable to sedimentation, particularly in the upper watershed because of the lack of flood events with enough hydraulic force needed to flush gravel and finer sediments downstream. The Metolius Springs have been identified as a possible source of both high phosphorus and high nitrogen concentrations in the river downstream (Sisters Ranger District, 2004). The high phosphorus concentrations are attributed to the geology, whereas the nitrogen source is unknown at the time of writing (Sisters Ranger District, 2004).

The Metolius watershed experiences frequent burning in the form of wildfires with increasing intensity over the last century. Although Geosyntec make no explicit conclusions on the reasons for this trend, potential explanations could include changes to watershed vegetation cover (generally characterized by loss of lodge pole forests and conversion to dense shrub-like cover), changes to the hydrologic/meteorological regime and anthropogenic sources. In the past 20 years the watershed has experienced 17 wildfires larger than a Class D (100 acres or more burned) based on US Forest Service fire data. Several studies have shown that wildfires can raise in-stream phosphorus and nitrogen concentrations by considerable amounts for periods up to several years (Smith, Sheridan, Lane, Nyman, & Haydon, 2011). FOM has also expressed concern that phosphorus based fire suppressants could influence in-stream water quality. The influence of wildfires on water quality has become an important concern given the extent and intensity of the more recent wildfires, such as the 2003 the Bear Butte Fire and the Booth Fires (BB).

The relatively small number of campgrounds, recreational sites, and limited residential areas in the basin are likely the sole dischargers of pathogens and other pollutants from anthropogenic sources. Important to note is that for pathogens in particular (typically measured as fecal coliform or E. coli as an indicator) any warm-blooded animal can release pathogens to the environment. For this reason, true sources of pathogens are difficult to identify without bacterial source tracking (a form of DNA fingerprinting). Anthropogenic sources could include, but are not limited to, leaking septic systems, dispersed camp latrines, pet waste, trash, and roadway pollution. Given that there are no other major anthropogenic sources of pathogens identified in the basin (e.g., wastewater plant discharges), these sources, though limited in number and size, are of interest for this pristine river system.

3. DATA ANALYZED AND PREPROCESSING

The following analyses considered several data sources to help provide a better understanding of the baseline water quality and potential changes in quality of the Metolius watershed. Water quality data sources included the FOM database (the data sources are described below) and the Oregon Department of Environmental Quality (ODEQ) Laboratory Analytical Storage and Retrieval (LASAR) database. Stream flow and precipitation data were obtained from the United States Geological Survey (USGS) and United States Department of Agriculture (USDA), respectively. Here we describe how the data were processed (if any) and any special considerations made, such as removal of data points.

3.1 Water Quality Data

The sections below briefly describe each independent data set and how these were combined when appropriate to produce a comprehensive dataset used in subsequent analyses.

3.1.1 FOM Data

Data acquired from the FOM (on 9 April 2014) ranged from 1995 to 2013. These data are a compilation of data from FOM, the United States Forest Service, ODEQ, Portland General Electric Company, and The Confederated Tribes of Warm Springs. The data were standardized where appropriate to remove duplicate constituent names or units (e.g., "Phosphorus – Total" and "Total Phosphorus") based on conversations with Umpqua Research, the primary lab used for sample analysis. Datasets were grouped for analysis based on location ID, constituent name, and measurement unit. A complete list of constituents at each location, number of non-detects (ND), total sample size, and temporal extent of data in the FOM database are found in Appendix A: Data Summary.

The periods of record where data are suspected as being erroneous were removed from the dataset entirely. These include data points reported to be below the detection limit and those not flagged as a lab estimate (Figure 1). Only Nitrate as N and Orthophosphate as P sampled collected prior to the year 2000 at Locations 1, 3, 4, 7, 9, 11, 12, and 18 were affected. In total, 195 data points of 14,509 data points were removed.

3.1.2 LASAR Data

ODEQ LASAR data were retrieved 28 May 2014 from station 10690 Metolius River north of Camp Sherman (Bridge 99, Lat: 44.5565, Long:-121.6195) (ODEQ, n.d.). The dataset contained 71 water quality constituents, with samples ranging from 1969 to 2012, containing greater than 7,000 data points. Data were filtered and edited to combine duplicate locations, constituents, and standardize the units as described below. A complete list of constituents at each location, total sample size, and temporal extent of data in the LASAR database are found in Appendix A: Data Summary.

3.1.3 Combined Dataset

Following review and analyses of the independent datasets, a combined water quality dataset containing data received from FOM and ODEQ LASAR database was produced for subsequent analyses. Data were filtered and edited to combine duplicate locations, constituents, and standardize the units between the FOM and DEQ data, as some of these data were already included in the FOM dataset. ODEQ LASAR data were added to Monitoring Location 13. In addition, Locations 12, 13, and 18 where combined into a single location (Location ID 13), as the locations other than the original Location 13 had few data points and were reasonably close to Location 13 to combine the datasets. Table 1 shows a list of the constituents from both the FOM and LASAR database after translation to common terms. However, due to limited data at some locations not all of these constituents were used in each analysis.

Table 1: Constituent list for the combined FOM and LASAR database.

Total List of Constituents Analyzed			
E. coli	Calculated Dissolved Hardness as $CaCO_3$	Ammonia	Total Recoverable Calcium
Nitrate	Total Coliform	Ammonia as N	Total Recoverable Hardness as $CaCO_3$
Total Phosphorus	Fecal coliform	Total Organic Carbon	Total Recoverable Antimony
Ortho Phosphorus	Calculated Un-ionized Ammonia as N	Field Alkalinity as $CaCO_3$	Total Recoverable Arsenic
pH	Dissolved Sodium	Field pH	Total Recoverable Barium
Dissolved Oxygen	Dissolved Potassium	Field Temperature	Total Recoverable Beryllium
Nitrate as N	Color	Field Turbidity	Total Recoverable Cadmium
Orthophosphate as P	Field Alkalinity as $CaCO_3$	Nitrate/Nitrite as N	Total Recoverable Chromium
Biochemical Oxygen Demand 5 Day Un-Diluted	Total Phosphate as PO_4	Percent Saturation Field Dissolved Oxygen	Total Recoverable Copper
Biochemical Oxygen Demand Stream	Nitrite as N	Pheophytin a	Total Recoverable Iron
Chlorophyll-a	Total Calcium	Total Kjeldahl Nitrogen	Total Recoverable Lead
Dissolved Orthophosphate as P	Dissolved Calcium	Total Solids	Total Recoverable Manganese
Chemical Oxygen Demand	Dissolved Magnesium	Total Suspended Solids	Total Recoverable Nickel
Conductivity	Enterococcus	Turbidity	Total Recoverable Selenium
Field Conductivity	Stream Field Stage Instantaneous	Orthophosphate as PO_4	Total Recoverable Silver
Field Dissolved Oxygen	Temperature	Chloride	Total Recoverable Zinc
Alkalinity as $CaCO_3$	Total Recoverable Magnesium	Sulfate	Total Recoverable Thallium

7. CONCLUSIONS AND RECOMMENDATIONS

Following all statistical analyses performed in space and time, the Metolius watershed and River appear to be in good standing with respect to those water quality constituents analyzed and regional in-stream standards. The primary exception to this conclusion would be the nutrient parameters, phosphorus and to a lesser extent, nitrate which do exceed regional standards. However, given the available data and literature findings, it’s likely these parameters are predominantly naturally occurring and therefore not likely concerns for the Metolius River itself (not considering potential effects from wildfires). Although the relative load contributions from the Deschutes River are substantially greater than those for the Metolius River, Lake Billy Chinook clearly experiences seasonal algae blooms to which both rivers contribute (phosphorus typically being the limiting parameter for algae).

This analysis found no critically concerning trends for the Metolius River. Fires, based on the limited data, may have affected the overall water quality of the basin over the time range of the data. It is likely that fires affect water quality greater in the short term and during storm events; however, this study could not verify those trends based on the available data. In terms of overall water quality, there were minimal difference between different monitoring locations except for monitoring locations near developed areas and monitoring locations not near developed sites, and the most upstream monitoring locations and most other downstream monitoring locations (which showed statistical difference for several constituents). Developed areas, such as recreational areas and campgrounds, minimally influenced water quality with the exception of E. coli. This constituent showed increasing trends at most monitoring locations near developed areas, but was still considerably under all of the comparison criteria and requirements at all locations. Other trends were limited to specific constituents primarily at Monitoring Location 13. Increasing trends included: orthophosphorus (Location 3), pH (Location 13), turbidity (Locations 13 & 17), and conductivity (Location 13). Decreasing trends included: orthophosphorus (Location 1), ammonia (Location 13), dissolved orthophosphorus (Location 13), TSS (Location 13), and total Kjehldahl nitrogen (Location 13).

The summary statistics provided in the supporting information, the above trends and relationships, and comparisons of the data to current water quality criteria and standards should adequately provide a baseline to compare future water quality data in the Metolius River. In addition to these analyses, below are a brief set of recommendations to improve the current understanding of the water quality in the Metolius Basin.

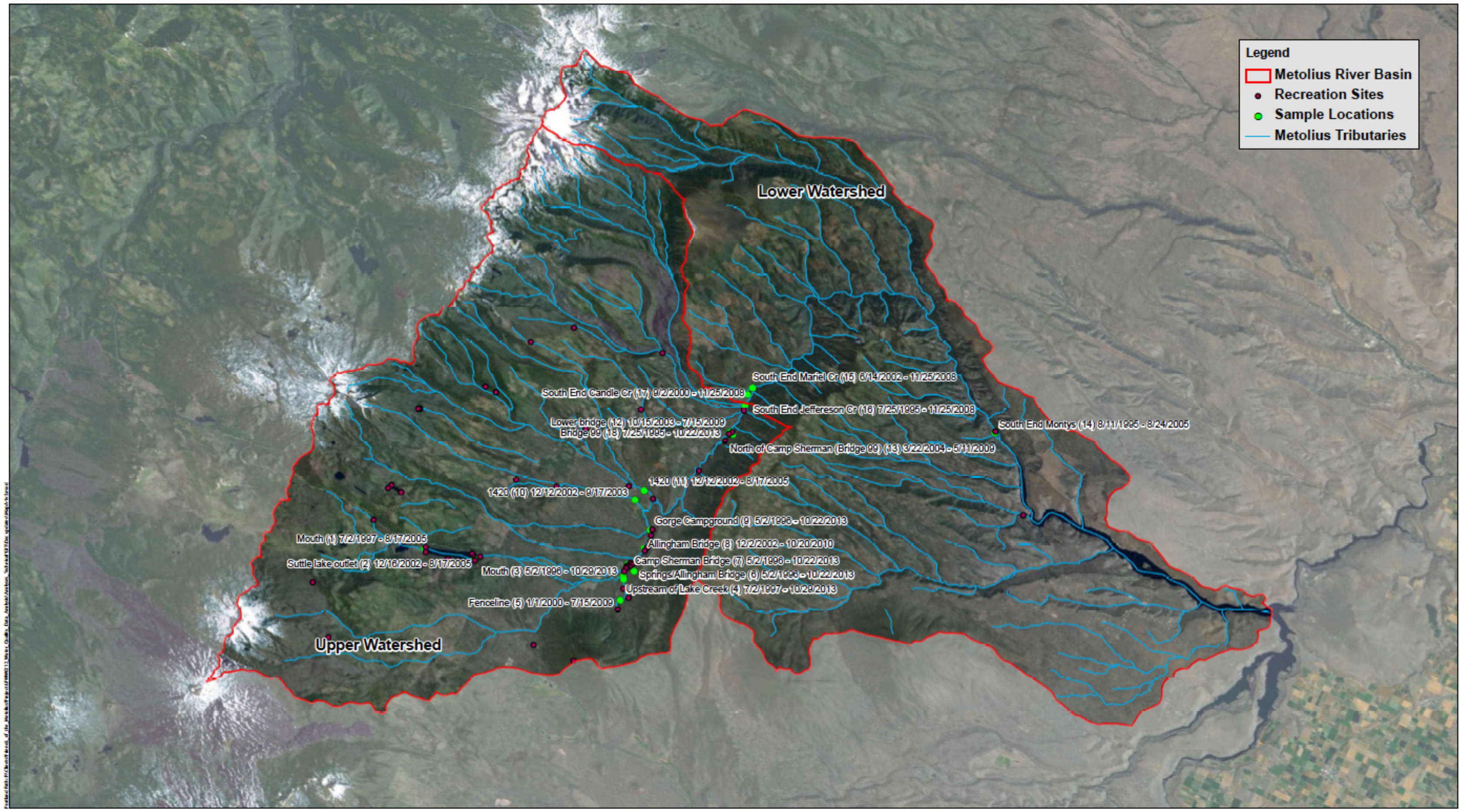
7.1 Recommendations

All of the above findings could be considerably influenced by sampling times, sampling protocols, systematic and random error from various personnel, techniques and instrumentation, and the inherent variability of grab samples in a natural system. While the analyses attempted to characterize the effects of storm events by correlating flow with a nearby rain gauge, the steep rain gradient in the basin likely causes significant variability in the mobilization of constituents between certain individual monitoring locations (specifically after fire events). Based on these limitations and the results comparing the statistical similarity of monitoring locations, the following recommendations for monitoring conducted within the Metolius watershed to assess in-stream water quality include:

1. Substantially increase the sampling documentation to include factors that could affect the quality of the grab sample, such as:
    a. Personnel, time, ambient conditions, depth, notes on specific location, photos, calibration of instruments, methods, storage, handling, changes to protocols, etc.

2. Decrease the current number of sampling locations to include only the current locations along the main stem of the river.
   a. Unless able to capture some local effects from fires, particularly in the western upper watershed.
3. Reduce the monitored constituents to the following:
   a. Lab parameters:
      i. Total Suspended Solids,
      ii. Total Kjehldahl nitrogen,
      iii. Nitrate + nitrite,
      iv. Total Phosphorus,
      v. Soluble Reactive Phosphorus (SRP) instead of Orthophosphorus,
      vi. E. coli,
      vii. Biological oxygen demand
      viii. Dissolved organic carbon
   b. b. Field parameters:
      i. Dissolved oxygen,
      ii. pH,
      iii. Turbidity,
      iv. Temperature
4. Modify the sampling routine to include both wet weather and dry weather sampling conditions at the head waters and one or more sampling locations downstream.
   a. Wet weather sampling should occur at least 1 hour after the start of a storm and target storms greater than 0.25 inches in total depth.
5. Increase the sampling frequency of nitrogen and phosphorus directly after a burn event for a period of approximately three weeks (or enough to capture the first storm event) at one or more sampling locations downstream of the burn in addition to collecting reference samples upstream of the burn.
   a. If possible these sampling events should occur during the first precipitation events that cause overland flow, as the primary nutrient flux (not from ash) will likely occur at this time. Thus, the same wet weather sampling procedures as above should be followed.
6. Work with the United States Forest Service and Sisters Ranger District to document fire management operations, fire location, fire extent and type of fire- suppressants used.

In addition to the above recommendations efforts to better characterize the highly variable rain gradient such as local and spatially explicit hydrologic monitoring, and better understand stormwater and groundwater interactions are recommended. Such efforts for the characterization of the highly variable rain gradient could include a localized network of low-cost rain gauges and/or interpolation from other datasets (such as those available from http://www.prism.oregonstate.edu/). Given the geology of the Metolius watershed, significant groundwater contributions to the river and generally isolated anthropogenic use, it is likely that ground and surface water interactions and pathways could influence how anthropogenic impacts are assessed. Although significant characterization of this interaction would likely incur substantial costs (monitoring wells, surface water/groundwater model, etc.) time-correlated samples of surface flow and interflow could be a useful metric.



Notes
1. Coordinate system GCS North American 1983
2. Sample location labels indicate:
Location name, location ID, period of record

3 1.5 0 3 Miles

N

Water Quality Sample and Recreational Site Locations for the Metolius Watershed

Metolius Watershed, Oregon

Geosyntec consultants

Portland, OR

02-Dec-2014

Map

A-1