Water Quality Testing in the San Geronimo Valley

sponsored by the

San Geronimo Valley Planning Group

February 6, 2018

Preface

This water quality testing project was initiated in response to Marin County's intent to study the feasibility of a sewage treatment plant at the San Geronimo Golf Course to service portions of Woodacre and San Geronimo. To justify the proposed treatment plant, supporters of the project frequently claimed that the Woodacre Flats was heavily contributing to contaminants in the Lagunitas Creek Watershed. It therefore became critical that the San Geronimo Valley Planning Group (SGVPG) definitively determine the sources of any creek contaminants. After careful consideration it was decided that Lawrence Berkeley Labs would be conducting water sampling collections 4 times between December 2016 and July 2017.

Following the completion of the feasibility study, the County of Marin had begun an Environmental Impact Report (EIR) to study the possible placement of a sewage recycling plant at the Golf Course property directly adjacent to San Geronimo Creek. This proposed plant would only serve a small portion of the larger community despite various contaminant sources being found throughout the SGV watershed.

Despite an EIR being underway there had been no evidence provided that central Woodacre was contributing to creek contaminant levels, nor was there a Memorandum of Understanding (MOU) on file between the County of Marin and the Golf Course owners creating a legally binding agreement between the two parties. The lack of an MOU prior to commissioning an expensive EIR suggests that the process was being rushed at the expense of following proper policy.

In an unexpected turn of events the Golf Course came up for sale in the Spring of 2017. On November 14, 2017, the County of Marin Board of Supervisors unanimously approved the purchase of the San Geronimo Golf Course. Plans for the treatment plant as previously envisioned have been placed on hold pending an additional feasibility study and will likely be redesigned or be abandoned entirely. Also of note is one major technical problem for the sewer plant proposal, the County of Marin Parks Department has no interest in disposing of the resulting recycled water into a newly restored Larsen creek watershed. For now the EIR is currently on hold pending a new feasibility study.

It is the sincere hope of the San Geronimo Valley Planning Group that the results of this study will provide context and a baseline for future research and planning efforts for the San Geronimo Valley.

Historical Background

Commissioned by the County of Marin and prepared by Questa Engineering,
The 2011 Woodacre Flats Wastewater Feasibility Study stated:

"Water quality sampling of Woodacre Creek and local storm drains in recent years has shown elevated levels of coliform bacteria, nitrate, ammonia and surfactants, in some cases exceeding receiving water quality standards. These influences on water quality may be attributable to the high density of older septic systems combined with the difficult drainage and soil conditions in Woodacre, especially in the Flats."

This feasibility study proposed wastewater infrastructure improvements for the community of Woodacre located within the San Geronimo Valley in Western Marin County. As a result of this study the County, with support of a small group of local residents living in Woodacre, determined a recycled wastewater sewer plant located at the nearby San Geronimo Golf Course would be the preferred option. The plant would purify water so that it could be used

to irrigate the Golf Course. As time progressed, the study expanded, increasing the size of the service area and the number of homes it could service. It became known as the Woodacre/San Geronimo Flats Wastewater Recycling Project (the proposed Project). This new preferred option would now require a capital cost of 14 million dollars versus the original capital cost estimate of 6 to 7 million dollars.

The San Geronimo Valley Planning Group, a local volunteer planning and environmental group, has long advocated for creek water quality testing arguing there had been no conclusive evidence that the primary pollutant is human waste. With the advent of a proposal for a larger treatment plant and its associated increased cost, the need for thorough testing became all the more apparent.

In April 2016, Marin Municipal Water District (MMWD) authorized a $50,000 grant to help fund the environmental review. The Planning Group successfully lobbied to make that funding contingent on water source testing.

Marin County officials within the EHS resisted this stipulation. Marin County officials had initially envisioned undertaking two types of testing, Microbial Source Tracking and PhyloChip testing, however a donor who was going to cover the PhyloChip testing ultimately chose not to.

With the County being under fiscal constraints, the San Francisco Regional Water Quality Control Board allowed the County access to a lab in San Francisco free of charge for the tests to do microbial source tracking. Microbial source tracking utilizes one representative microbe per animal to determine whether waste from a given species is present in the water. Identical bacteria are found in multiple species so there is a much higher likelihood for false positive readings using the MST testing method.

Dissatisfied with this proposed testing regimen and using their own limited funds, the San Geronimo Valley Planning Group contracted with Lawrence Berkeley National Laboratory to do detailed analyses of water samples in the area utilizing the "PhyloChip" technology.

PhyloChip Technology

The PhyloChip, with a surface bearing 1.1 million different stretches of DNA sequences, can identify 60,000 types of microbes found in the guts of animals. "Current methods look at two or three microbes at the most to indicate there is potential contamination from a fecal source," said Gary Andersen, a microbial ecologist at Lawrence Berkeley National Laboratory. "The PhyloChip that we developed in our laboratory looks at tens of thousands of microbes simultaneously." To identify human fecal contamination, PhyloChip technology looks at 1000 different DNA sequences. The level of sophistication and accuracy of this technology is vastly superior to any method currently in use.

"It's going to be enormously valuable," said Brian Staley, the Planning Group's chairman. "There has been a decades-long discussion at state Regional Water Quality Control Board and county levels about what contaminants are in our watersheds, who is contributing to the problem more, and what the best fixes would be."

MMWD agreed to collect samples for the testing. MMWD would perform the standard fecal indicator bacteria testing, the County would use Microbial Source Tracking (MST), and the Planning Group would utilize the PhyloChip technology.

The County had previously identified sites from which to collect samples. Samples would be taken between December 2016 and summer 2017. The three sites would test water quality flowing out of Woodacre and water quality at the westerly end of the proposed Project.

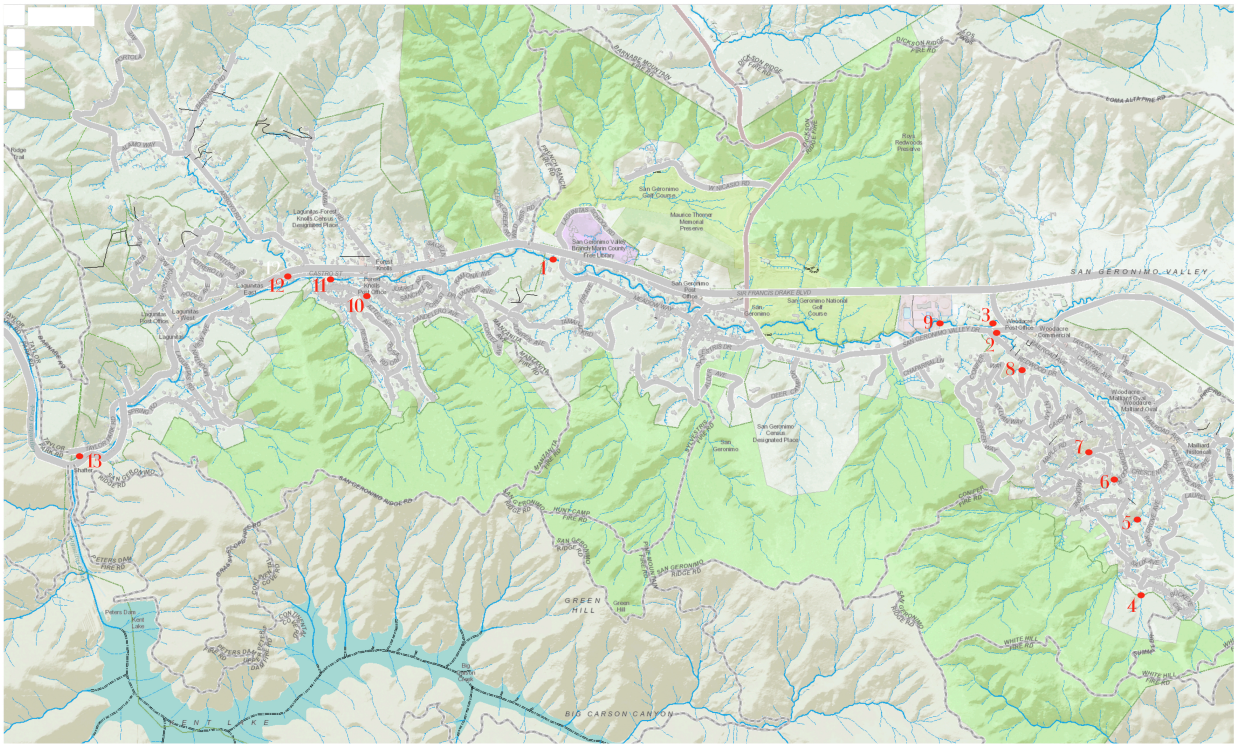
The Planning Group was again not satisfied with this approach. Since the proposed project covered only a small portion of Woodacre and San Geronimo, it seemed important to test the water quality coming into the proposed project area. If the water coming into the proposed project area is not clean, it would negate the justification for the proposed water treatment plant. Additionally, while testing was ongoing we believe that we should be testing water quality throughout the entire Valley watershed. If our goal is to clean up our creeks and by extension Tomales Bay, it seemed inappropriate to limit the testing to only a small portion of the Valley.

A Partnership

The Planning Group in conjunction with Lawrence Berkeley Labs chose an additional 10 sites for testing for a total of 13. The new sites were chosen to test water in a pristine site above the proposed project area as well as testing 3 tributaries that flow into Woodacre Creek around the Woodacre portion of the proposed project area. An additional site was also chosen downstream from Woodacre but was still within the proposed Project area. The rest of the Valley sites tested tributaries along San Geronimo Creek in Forest Knolls and Lagunitas, as well as a site on San Geronimo Creek itself. A final site was chosen at the Ink Wells located at the end of the Valley just before Samuel P Taylor State Park.

The location of the additional 10 sites was not determined until after the December sampling had occurred. With the exception of site 13 located at the Ink Wells, all of the sites were sampled 3 times between February and July. The Ink Wells site was only sampled in May due to access problems during high water flows.

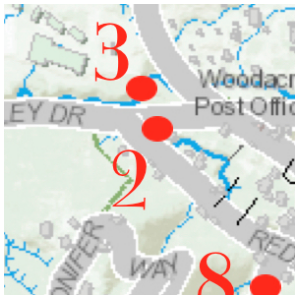
The following map shows the location of the sampling sites 1-13



PhyloChip Sample Sites defined

The following is a listing of each sampling site along with a description and GPS coordinates.

1. San Geronimo Creek at Meadow Way. Downstream side of bridge. **<u>MST Sample site 1</u>. 38.015753, -122.676198**

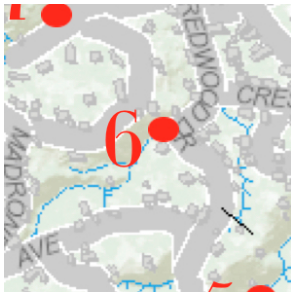


2. Woodacre Creek above confluence with San Geronimo Creek. Near bridge for San Geronimo Valley Drive **<u>MST Sample site 2</u>; 38.012869, -122.646995**

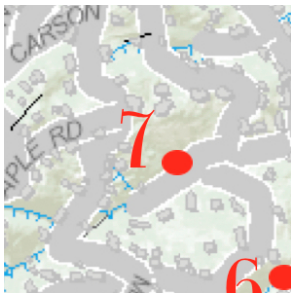
3. San Geronimo Creek above confluence with Woodacre Creek and below inflow from Spirt Rock. **<u>MST Sample site 3.</u> 38.013241, -122.647169.**

4. Pristine sample site. Intersection Redwood Dr. and Laurel Ave crossing Woodacre Creek East Fork. Collect sample upstream side of the road and upstream from 6-8 inch pipe draining Buckeye Circle. **37.9994; -122.6369**

5. Upstream 68 Oak Grove, below confluence of East and West fork Woodacre Creek. **38.00217; -122.63665**

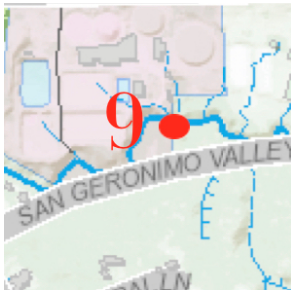


6. Tributary to Woodacre Creek: behind garage at 256 Redwood Dr. Approximately 25 yards above the intersection of Crescent Dr. and Redwood Dr. **38.00509; -122.63873**.

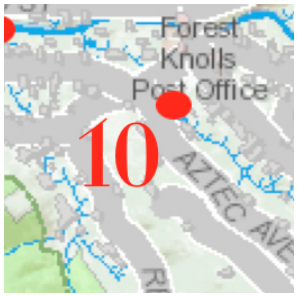


7. Unnamed tributary to Woodacre Creek: upstream of culvert under intersection of Carson and Rock Ridge Rd. **38.00528; -122.64014**

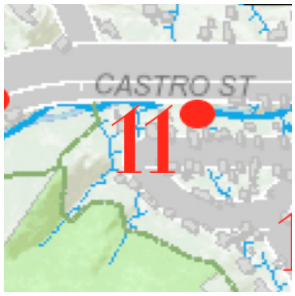
8. Unnamed tributary to Woodacre Creek: 55 Park Rd. at post along drainage ditch in front of house. **38.01058; -122.64529**



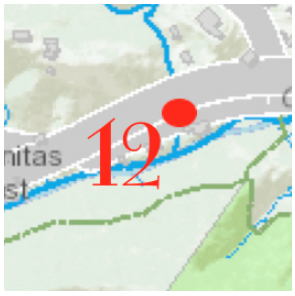
9. San Geronimo Creek upstream side of bridge entrance to MMWD Plant. *Prep for later analysis*. **38.01314; -122.65081**.



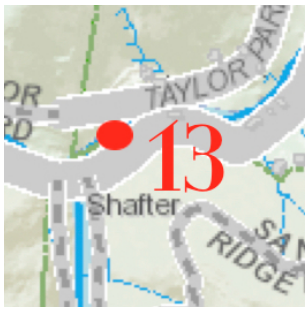
10. Montezuma Creek just upstream on Aztec Ave at intersection with Guadalupe Ave. **38.01419; -122.6898.** This site was chosen because it is a tributary flowing into San Geronimo Creek in Forest Knolls.



11. San Geronimo Creek at Castro Street and Arroyo Rd. **38.01499, -122.69315.** This site was chosen to measure San Geronimo Creek below Forest Knolls.



12. Arroyo Creek upstream side of bridge over Castro Street. **38.01463; -122.69457.** This site was chosen because it is a tributary flowing into San Geronimo Creek in Forest Knolls.



13. Inkwells, under bridge. Same sample site as Beach Monitoring. **38.00498; -122.70822.** This site was chosen but only tested once in May due to access problems.

Water Testing Results

Reading the data

The PhyloChip results are reported as a value between 0.0 and 1.0. A value of 1.0 for a particular fecal source indicates the bacterial signal in the sample can be entirely attributed to that source (highest possible). A value of 0.0 indicates no signal from that source (lowest possible). As the source material is diluted and degraded in the receiving water the values typically will decrease. Values of 0.2 and above indicate a strong signal and a high likelihood that the source is present. Values less than 0.1 indicate that the source is absent in the sample. Values between 0.1 and 0.2 indicate a marginal source signal; in this case the source cannot be ruled out, but attribution of the signal to the indicated source uncertain and more testing is warranted.

***** *For this report we have focused on human signals however we also tested for other animal signals.*

December 2016

The December testing was performed during a severe flood event that caused flooding in many parts of the San Geronimo Valley and throughout Marin County. It should also be noted that between November 2016 and February 2017, the Marin Independent Journal reported the Ross Valley Sanitary District spilled 122,000 gallons of sewage. Marin's 27 other agencies spilled an additional 41,000 gallons of sewage in the same time period. In times of severe weather and high water flow, municipal sewage systems are not without their own set of problems.

A flooded car photographed on Castro Street one day before the December sampling. This is approximately 1 mile downstream of sample site #1, one of three sites sampled at that time.

December 2016

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.04	0.04	0.11	0.38	0.03	0.06	site 02
0.13	0.04	0.11	0.20	0.06	0.22	site 03
0.10	0.04	0.09	0.28	0.03	0.15	site 01

Results:

- Site #1 at the Western end of the proposed Project shows a strong human source signal of 0.28 on a scale of 0.20 to 1.00.
- Site #2-the mouth of Woodacre Creek shows a strong human source signal of 0.38 on a scale of 0.20 to 1.00
- Site #3-San Geronimo Creek before the confluence of Woodacre Creek shows a strong human source signal of 0.20 on a scale of 0.2 to 1.00
- Site #3 also shows a strong ruminant source signal of 0.22 on a scale of 0.20 to 1.00

Observations:

The fact that there is human marker in the water during this high water period is not a surprise. Since only three sites were tested we have no idea what amount of human signal flowed into Woodacre Creek from above the Flats project or from the 3 tributaries that feed into it. The human marker degrades from 0.38 at Site #2 (Woodacre Creek) to 0.28 by site #1 (San Geronimo Creek at Meadow Way). The marker is being diluted and degraded as it flows downstream. It is not being increased by additional human input. The elevated ruminant signal is an indication of the volume of surface runoff water carrying surface contaminants that empty into the creeks during heavy rains.

Further testing is needed to better understand where the pollutants are coming from and whether they are an anomaly. Additional sampling sites along this section of creek could more accurately pinpoint potential problem areas.

February 2017

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.05	0.02	0.04	0.15	0.03	0.07	site 01
0.05	0.02	0.04	0.22	0.02	0.03	site 02
0.04	0.03	0.05	0.05	0.03	0.08	site 03
0.08	0.03	0.06	0.07	0.02	0.05	site 04
0.02	0.01	0.00	0.01	0.00	0.01	site 05
0.11	0.05	0.06	0.18	0.02	0.06	site 06
0.02	0.01	0.01	0.01	0.00	0.02	site 07
0.04	0.02	0.07	0.04	0.02	0.02	site 08
0.03	0.01	0.00	0.02	0.00	0.01	site 09
0.03	0.01	0.01	0.19	0.00	0.01	site 10
0.05	0.06	0.02	0.25	0.03	0.06	site 11
0.01	0.02	0.01	0.03	0.00	0.01	site 12

Results:

- Site #1 Meadow Way site shows marginal human source signal of 0.15 on a scale of 0.10 to 0.19
- Site #2 Mouth of Woodacre Creek shows a strong human source signal of 0.22 on a scale of 0.20 to 1.00
- Site #6 Tributary to Woodacre Creek at 256 Redwood Drive shows a marginal human source signal of .0.18 on a scale of 0.10 to 0.19.
- Site #10 Montezuma Creek in Forest Knolls shows a marginal human signal 0.19 on a scale of 0.10 to 0.19
- Site #11 San Geronimo Creek shows a strong human source signal of 0.25 on a scale of 0.20 to 1.00

Observations:

- Site #1 Meadow Way site, the strong human source signal at the mouth of Woodacre Creek (0.22) has diluted and degraded to a marginal human source signal reading of 0.15 at this site. This is a similar pattern as to what happened in December. Human input between site #2 (Woodacre Creek) and site #1 (Meadow Way) downstream seems to be marginal.
- Site #2 Mouth of Woodacre Creek shows a strong human source signal of 0.22 on a scale of 0.20 to 1.0. See notes from Site #1.
- Site #6 Tributary to Woodacre Creek: behind garage at 256 Redwood Dr. Although the reading is in marginal signal range it shows tributaries have an influence on Woodacre Creek.
- Site #11, San Geronimo Creek shows a strong human source signal 0.25 on a scale of 0.20 to 1.00 indicating that there are occasional point sources throughout the entire Valley and are not

limited to particular areas. The signal at Site #1 approximately 1 mile upstream was a marginal human source signal of 0.15 on a scale of 0.10 to 0.19. It would appear human input is entering the creek between these two sites.

May 2017

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.04	0.01	0.01	0.01	0.00	0.01	site 01
0.04	0.03	0.02	0.03	0.00	0.02	site 02
0.05	0.01	0.00	0.01	0.00	0.01	site 03
0.04	0.02	0.01	0.00	0.00	0.01	site 04
0.03	0.02	0.02	0.04	0.00	0.02	site 05
0.03	0.02	0.03	0.02	0.01	0.02	site 06
0.06	0.04	0.04	0.06	0.02	0.07	site 07
0.01	0.01	0.01	0.00	0.00	0.00	site 08
0.06	0.03	0.04	0.08	0.03	0.05	site 09
0.03	0.13	0.04	0.82	0.07	0.13	site 10
0.03	0.02	0.01	0.04	0.01	0.01	site 11
0.07	0.06	0.06	0.12	0.03	0.09	site 12
0.04	0.02	0.02	0.03	0.01	0.02	site 13

Results:

- Site #10 Montezuma Creek in Forest Knolls shows an unusually high human source signal of 0.82! The scientists at the Lab state this is the highest reading they have ever seen in the wild!
- Site #11 San Geronimo Creek shows a human source unlikely to be present signal reading of 0.04.
- Site #12 Arroyo Creek shows a marginal human source signal of 0.12.

Observations:

Something is going on at Montezuma Creek! Interestingly the human marker of .82 at site #10 has dropped off the charts by the next site, #11 with a human source unlikely to be present- signal reading of 0.04. Arroyo Creek shows a very marginal human source signal of 0.12 on a scale of 0.10 to 0.19

July 2017

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.04	0.01	0.01	0.00	0.00	0.01	site 01
0.03	0.05	0.04	0.07	0.02	0.04	site 02
0.07	0.02	0.01	0.03	0.00	0.02	site 03
0.05	0.02	0.02	0.04	0.01	0.03	site 04
0.09	0.02	0.05	0.06	0.02	0.06	site 05
0.04	0.03	0.05	0.06	0.02	0.04	site 06
NA	NA	NA	NA	NA	NA	site 07
0.05	0.44	0.06	0.10	0.03	0.06	site 08
0.03	0.01	0.01	0.04	0.00	0.02	site 09
NA	NA	NA	NA	NA	NA	site 10
0.12	0.01	0.00	0.00	0.00	0.01	site 11
0.04	0.01	0.01	0.01	0.01	0.01	site 12
NA	NA	NA	NA	NA	NA	site 13

Results:

- Site #8 unnamed tributary at 55 Park St shows a strong dog source signal of 0.44 on a scale of 0.20 to 1.00

Observations:

There is a strong dog source signal dog of 0.44 which seems to be a one time only event.

Observation Summary

The following are points of interest we feel should be emphasized
We are limited to data for three sites in December as opposed to 13 sites for the other three testing events.

- In December water flow was extremely high when human source signal was detected. Approximately 1 mile downstream from Site #1(Meadow Way) in Forest Knoll the area was flooded. Pleased refer to the photo on page 7.
- There was a strong human source signal detected in February at the mouth of Woodacre Creek (Site #3) and in San Geronimo Creek (Site #11) near Forest Knolls.
- Both in December and February the strong human source signal at the mouth of Woodacre creek (Site #3) was dispersed and diluted. The strength of the signal dropped from a strong human source signal to a marginal human source signal (possible source, additional testing recommended) by the time if reached Site #1 meadow way.
- In February readings at site #1 were marginal (possible source, further testing recommended) but jumped to strong human signal source at site #11 1 mile downstream in Forest Knolls.
- There were no identifiable human source signals detected in May and July with the exception of an unusual anomaly at Site #10 (Montezuma Creek) in May.
- The level of human input is not as great along the creek in San Geronimo before Forest Knolls.
- There is additional human input entering San Geronimo creek in Forest knolls.

Conclusions:

We now have a clearer understanding of the impact septic systems have in our watershed. By undertaking this study we have identified both potential problem areas as well as shown how surprisingly clean our watershed is during certain times of the year.

As noted, the December sampling results were taken in a period of unusually heavy rainfall. Average rainfall at Lake Lagunitas from 7/1/2017 to 1/28/2018 is 29.16 inches. Rainfall for the same time period this year is 19.60 inches. Rainfall for the same time period last year was 55.90 inches. It is easy to see how varying rainfalls totals from year to year can affect the results of these studies.

From previous studies we know there are problem septic systems throughout the Valley. However based on our study it does not appear septic systems are the severe watershed pollutant we thought they were. To achieve a proper and effective solution to the problems of pollutants in the watershed we need to understand exactly what the level of pollution is and where and what source it comes from. The eastern ridge of the San Geronimo Valley consists of large rock formations. With septic systems sitting on this much rock, it is possible older systems built in this area do not allow proper aerobic treatment of effluent before it enters the waterways of the Valley.

Further testing would be required to identify contaminant sources. This first round of testing has simply identified the problem areas. More specific testing will be needed to draw any final determinations.

We should again note a Marin Independent Journal article titled “Ross Valley sewage agency reports fewer spills despite rains”. This article, dated 2/22/17 and referenced on page 7 of this report, stated that Ross Valley and Marin’s other agencies spilled a total of 163,000 gallons of sewage between November 2016 and February 2017. Although this discharge takes place in the Corte Madera watershed, the information is important in determining relative comparable conditions.

Recommendations:

We strongly recommend that the Environmental Health Department (EHS) in conjunction with MMWD continue our work collaborating with Lawrence Berkeley Labs using the PhyloChip technology. With an additional round of testing we feel confident that any contaminant sources can be identified and mitigated. Although our findings have provided a clearer picture and dispelled some erroneous assumptions that have been made, we did show that there are issues requiring attention which were previously unknown.

Further testing and locating more specific sampling sites would be helpful to understand and identify the sources of human signals. Understanding the hydrology of the area would also further help focus where potential sources of pollution are located. Since this first round of testing has been completed; we know some of the homes within the proposed Service District may not need to be served and some homes outside the proposed district have problems that clearly need to be addressed.

To determine the best solution we need to understand all of the variables and identify the real problems without making unfounded assumptions. We sincerely hope this study helps government agencies select optimum sites to perform further testing. We believe that without continued monitoring of the watershed, the same problems will simply recur indefinitely.

If State and County monies are to be used for building sewage infrastructure, we would suggest that the entire Valley be studied prior to designing any community sewage fixes. Localized sewage infrastructure would likely be ineffective at addressing contaminants throughout the San Geronimo Creek systems without the entirety of the San Geronimo Valley watershed being properly studied.

In the future we sincerely hope proper process is adhered to in the advent of any new studies being performed by the County of Marin and that all relevant parties have a full and complete understanding of the construction proposals, their impacts, and potential costs. These types of procedural mistakes often cause protracted legal entanglements for everyone concerned.

Our Thanks:
The San Geronimo Valley Planning Group would like to thank Dr Gary Anderson and Dr Eric Dubinsky of the Lawrence Berkeley National laboratory for their help and assistance in making this water-testing project possible.

The members of the Creek Water Testing Committee of the San Geronimo Valley Planning Group look forward to working with the residents of the Valley, the County and State Agencies that share our common goal of clean water, sustainable living and open space.

Resources:
For your reference we have included the source identification summary report prepared by Dr Eric Dubinsky of Lawrence Berkeley Labs:

San Geronimo Valley Planning Group
Source Identification Study
Summary Report

Prepared by Eric Dubinsky
Lawrence Berkeley National Laboratory / UC Berkeley
eadubinsky@lbl.gov
November 28, 2017

Introduction

The Andersen Laboratory at Lawrence Berkeley National Laboratory (LBNL) conducted PhyloChip source tracking analysis of 38 water samples collected from the San Geronimo Creek and tributaries between December 2016 and July 2017. Sample dates were December 16, 2016 (3 samples), February 15, 2017 (12 samples), May 10, 2017 (13 samples) and July 20, 2017 (10 samples). A list of sampling locations is attached.

PhyloChip microbial source tracking uses DNA microarray technology to probe samples for specific fecal sources. The test used in this study probes for the following fecal source animals: human, ruminant (e.g. cattle), horse, pig, birds and dogs. The PhyloChip contains approximately 1.1 million DNA probes that target 60,000 types of bacteria. Previous work has identified a core set of bacteria that are diagnostic for each fecal source type. Once the DNA composition of the sample is profiled by the microarray, the proportion of the detected signal that can be attributed to a particular source is estimated using a machine learning classifier called SourceTracker. A detailed background on the laboratory and statistical methods are found in Dubinsky et al. 2016. *Water Research* 105:56-64.

PhyloChip Sample Sites

1. San Geronimo Creek at Meadow Way. Downstream side of bridge. **MST Sample site 1**. **38.015753, -122.676198**

2. Woodacre Creek above confluence with San Geronimo Creek. Near bridge for San Geronimo Valley Drive **MST Sample site 2; 38.012869, -122.646995**

3. San Geronimo Creek above confluence with Woodacre Creek and below inflow from Spirt Rock. **MST Sample site 3. 38.013241, -122.647169.**

4. Pristine sample site. Intersection Redwood Dr. and Laurel Ave crossing Woodacre Creek East Fork. Collect sample upstream side of the road and upstream from 6-8 inch pipe draining Buckeye Circle. **37.9994; -122.6369**

5. Upstream 68 Oak Grove, below confluence of East and West fork Woodacre Creek. **38.00217; -122.63665**

6. Tributary to Woodacre Creek: behind garage at 256 Redwood Dr. Approximately 25 yards above the intersection of Crescent Dr. and Redwood Dr. **38.00509; -122.63873**.

7. Unnamed tributary to Woodacre Creek: upstream of culvert under intersection of Carson and Rock Ridge Rd. **38.00528; -122.64014**

8. Unnamed tributary to Woodacre Creek: 55 Park Rd. at post along drainage ditch in front of house. **38.01058; -122.64529**

9. San Geronimo Creek upstream side of bridge entrance to MMWD Plant. *Prep for later analysis*. **38.01314; -122.65081**.

10. Montezuma Creek just upstream on Aztec Ave at intersection with Guadalupe Ave. **38.01419; -122.6898**

11. San Geronimo Creek at Castro Street and Arroyo Rd. *Prep for later analysis.* **38.01499, -122.69315**

12. Arroyo Creek upstream side of bridge over Castro Street. **38.01463; -122.69457**

13. Inkwells, under bridge. Same sample site as Beach Monitoring. **38.00498; -122.70822**

Results

The results are attached as Appendix 1. For each source type, the results are reported as a value between 0.0 and 1.0. A value of 1.0 for a particular fecal source indicates the bacterial signal in the sample can be entirely attributed to that source. A value of 0.0

indicates no signal from that source. As the source material is diluted and degraded in the receiving water the values will decrease. Values of 0.2 and above indicate a strong signal and a high likelihood that the source is present. Values less than 0.1 indicate that the source is likely absent in the sample. Values between 0.1 and 0.2 indicate a marginal source signal; in this case the source cannot be ruled out, but attribution of the signal to the indicated source uncertain and more testing is warranted.

PhyloChip analysis of the San Geronimo Creek samples found strong fecal signals from human sources in five samples, ruminant in one sample and dog in one sample. Marginal fecal signal from human was detected in six samples, ruminant in two samples, horse in two samples and bird in two samples. Fecal signals were more frequently detected in wet season months (December and February), with the notable exceptions of a strong human signal in Montezuma Creek (site 10) in May and dog in an unnamed tributary to Woodacre Creek at 55 Park Rd (site 8) in July.

December 2016

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.04	0.04	0.11	0.38	0.03	0.06	site 02
0.13	0.04	0.11	0.20	0.06	0.22	site 03
0.10	0.04	0.09	0.28	0.03	0.15	site 01

February 2017

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.05	0.02	0.04	0.15	0.03	0.07	site 01
0.05	0.02	0.04	0.22	0.02	0.03	site 02
0.04	0.03	0.05	0.05	0.03	0.08	site 03
0.08	0.03	0.06	0.07	0.02	0.05	site 04
0.02	0.01	0.00	0.01	0.00	0.01	site 05
0.11	0.05	0.06	0.18	0.02	0.06	site 06
0.02	0.01	0.01	0.01	0.00	0.02	site 07
0.04	0.02	0.07	0.04	0.02	0.02	site 08
0.03	0.01	0.00	0.02	0.00	0.01	site 09
0.03	0.01	0.01	0.19	0.00	0.01	site 10
0.05	0.06	0.02	0.25	0.03	0.06	site 11
0.01	0.02	0.01	0.03	0.00	0.01	site 12

May 2017

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source, recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.04	0.01	0.01	0.01	0.00	0.01	site 01
0.04	0.03	0.02	0.03	0.00	0.02	site 02
0.05	0.01	0.00	0.01	0.00	0.01	site 03
0.04	0.02	0.01	0.00	0.00	0.01	site 04
0.03	0.02	0.02	0.04	0.00	0.02	site 05
0.03	0.02	0.03	0.02	0.01	0.02	site 06
0.06	0.04	0.04	0.06	0.02	0.07	site 07
0.01	0.01	0.01	0.00	0.00	0.00	site 08
0.06	0.03	0.04	0.08	0.03	0.05	site 09
0.03	0.13	0.04	0.82	0.07	0.13	site 10
0.03	0.02	0.01	0.04	0.01	0.01	site 11
0.07	0.06	0.06	0.12	0.03	0.09	site 12
0.04	0.02	0.02	0.03	0.01	0.02	site 13

July 2017

Values <0.1 indicate low source signal. Unlikely source.
Values >0.1 and <0.2 (yellow) indicate marginal source signal: Possible source recommend additional testing.
Values >0.2 (red) indicate strong source signal. (Likely source)

Bird	Dog	Horse	Human	Pig	Ruminant	
0.04	0.01	0.01	0.00	0.00	0.01	site 01
0.03	0.05	0.04	0.07	0.02	0.04	site 02
0.07	0.02	0.01	0.03	0.00	0.02	site 03
0.05	0.02	0.02	0.04	0.01	0.03	site 04
0.09	0.02	0.05	0.06	0.02	0.06	site 05
0.04	0.03	0.05	0.06	0.02	0.04	site 06
NA	NA	NA	NA	NA	NA	site 07
0.05	0.44	0.06	0.10	0.03	0.06	site 08
0.03	0.01	0.01	0.04	0.00	0.02	site 09
NA	NA	NA	NA	NA	NA	site 10
0.12	0.01	0.00	0.00	0.00	0.01	site 11
0.04	0.01	0.01	0.01	0.01	0.01	site 12
NA	NA	NA	NA	NA	NA	site 13