DRAFT Lake Cascade Local Synoptic Groundwater Monitoring Project

Cascade and Donnelly, Idaho

State of Idaho

Department of Environmental Quality

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Acknowledgments

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Abbreviations, Acronyms, and Symbols

°C	Celsius
µ	microsiemens
CA	calcium
Cl	chloride
cm	centimeter
bgs	below ground surface
BRO	Boise Regional Office (DEQ)
DEQ	Idaho Department of Environmental Quality
EPA	United States Environmental Protection Agency
ft	feet
L	liter
MCL	maximum contaminant level
mg	milligram
NA	sodium
S	sulfur
SMCL	Secondary Drinking Water Standards maximum containment level
TMDL	Total maximum daily load
TP	Total Phosphorus
USGS	United States Geological Survey
VSWCD	Valley Soil and Water Conservation District

1 Purpose and Background

The Idaho Department of Environmental Quality (DEQ) is responsible for conducting regional groundwater monitoring activities, per the *Idaho Ground Water Quality Plan* (DEQ 1996). DEQ's Boise Regional Office (BRO) develops specific monitoring projects, as necessary, within the region to acquire groundwater quality data.

Cascade Reservoir was formed by a dam constructed in 1948 by the US Bureau of Reclamation on the North Fork Payette River. The reservoir has relatively shallow water and is used for irrigation, flood control, and hydropower. After the North Fork Payette River exits Lake Cascade, it becomes a source of drinking water for systems downstream.

The *Cascade Reservoir Watershed: TMDL Five-Year Review* (section 5), states the following (DEQ 2018):

> While many water quality improvement projects have been implemented in the Cascade Reservoir watershed, instream water quality targets established by the Phase II TMDL are not being met for TP (Total Phosphorus). Cascade Reservoir's chlorophyll a concentration in 2015 and 2016 were below the target established by the Phase II TMDL, but departures from DO and pH criteria are assumed to be associated with excess biological growth in Cascade Reservoir.
>
> (Note: Chlorophyll a is the predominant type of chlorophyll found in green plants and algae.)

With the introduction of nearby Tamarack Resort in 2004, the reservoir's name was unofficially changed to Lake Cascade. The reservoir will be referred to as Lake Cascade throughout this report.

Between 1994 and 2011, various agencies collected samples in the general area of Lake Cascade.

In December 2000, the United States Geological Survey (USGS) began a study to compile and assess nitrate data for groundwater collected from 1961 to 2001 in 25 groundwater quality management areas in Idaho. The data included a total of 8,465 nitrate analyses from 2,931 wells throughout Idaho (Parliman 2002). For the study, USGS collected samples in various areas along Highway 55 and several samples within 1 mile of Highway 55.

In July 2021, the Valley Soil and Water Conservation District (VSWCD) proposed a septic pump-out pilot program to encourage property owners on the south end of Lake Cascade to maintain and repair their aging septic systems. The VSWCD proposed that effluent from poorly maintained septic systems could leach into the groundwater and contribute to the nitrate and phosphorous levels in Lake Cascade. The pilot program consisted of educational brochures, visits to property owners, and partial reimbursement to property owners who agreed to pump out septic systems that had not been pumped for more than 5 years.

While reviewing the Source Water Protection Grant application submitted by the VSWCD in July 2021, DEQ's BRO Groundwater staff researched well logs for a several properties along Lake

Cascade. The staff determined the hydrogeology around the lake and searched for shallow wells that could be affected by improperly maintained septic systems, where effluent could leach into the shallow groundwater, possibly contaminating the groundwater and shallow wells closest to Lake Cascade.

To determine if contaminants in groundwater near the perimeter of Lake Cascade are contributing to the degraded water in Lake Cascade, samples were collected at each location specified in the *Lake Cascade Field Sampling Plan* (DEQ 2021b).

1.1 Geology of Lake Cascade[1]

The Cascade area lies along the western margin of the Idaho Batholith, a region of Cretaceous- and Tertiary-age granitic rocks. Mid-Tertiary basaltic lava flows of the Columbia River Group lie above the granites (Manduca et al. 1993; Fitzgerald 1982). The study area is within a Tertiary-age fault-bound depression within the granitic terrain. It forms a unique hydrogeological entity, the Cascade basin, which includes Round Valley in the south, Long Valley to the north, and several smaller peripheral basins to the east. The stratigraphic and structural juxtaposition of Cretaceous granitic rocks with Columbia River basalt and overlying Tertiary sedimentary basin infill suggests the Cascade basin began developing in the mid-Tertiary period.

A compilation of historical geologic studies and field work shows the Cascade area is underlain by crystalline rocks of the Idaho Batholith. The Cascade basin is a structurally controlled feature that includes several nested, interior basins. The interior basins started forming during the mid-Tertiary period and continue to develop today. Depth to bedrock analyses from drill logs and geophysical data show the basins are asymmetric with their west sides generally deeper than the eastern sides. Basin-filling strata include basaltic lavas of the Columbia River Group, clay-rich lacustrine beds, unconsolidated Quaternary alluvium, and recent floodplain deposits. Surface exposures of the basaltic lavas show clay-rich weathering rinds. The Tertiary strata have been partially lithified, a process that generally decreases porosity and permeability.

No flow information was included in this report. It was assumed groundwater flows from the ridges around Lake Cascade down to the lake.

1.2 Current Land Use

The predominant land use around Lake Cascade is a mix of agricultural, recreational, and residential. The Donnelly area is currently undergoing a rise in recreational cabin building on what was previously forested land. Donnelly proper has city sewer available. Some of the newer developments near Donnelly also have city sewer available. Many of the new residential areas are not served by city water or sewer and depend on domestic wells and septic systems.

The city of Cascade is also undergoing a surge in recreational residential building with no city water or sewer for either new construction or previous construction.

[1] Geology information from Idaho Water Resources Research Institute Technical Report 200425.

1.3 Surface and Groundwater Conditions

DEQ began routine monitoring of Lake Cascade in 1989 and increased in frequency with the recognition of harmful algal blooms (HABs) in 1993. Lake Cascade was placed on the 1994 §303(d) list of impaired waters for reasons associated with excessive algal growth and violations of the state's dissolved oxygen and pH criteria. Total maximum daily loads (TMDLs) and implementation plans were written to improve the water quality in Lake Cascade and its tributaries.

The 1996 Total Phosphorus (TP) TMDL developed waste load allocations for point sources and load allocations for nonpoint sources in Lake Cascade. To improve water quality in Lake Cascade and its tributaries, the current contribution of phosphorus from external sources must be reduced by 37%, and this reduction must be maintained for at least 5 years. The target concentration for total phosphorus in Lake Cascade and its tributaries is ≤0.025 milligrams per liter (mg/L) (DEQ 2018).

The *Implementation Plan for the Cascade Reservoir Phase II Watershed Management Plan* (DEQ 2000) estimated septic systems around Lake Cascade contributed 2,205 kilograms per year of total phosphorous to the reservoir.

In June 2022, DEQ sampled 11 private domestic wells in areas upgradient and around the perimeter of the lake to determine if septic systems influenced groundwater flowing into Lake Cascade.

The groundwater samples were collected using procedures outlined in the *Boise Regional Office Local Synoptic Groundwater Monitoring Quality Assurance Project Plan* (DEQ 2021a) and *Lake Cascade Field Sampling Plan* (DEQ 2021b). The depths of the 11 wells sampled ranged from 24 to 84 feet.

DEQ analyzed the groundwater samples for nitrate, nitrite, calcium, potassium, magnesium, sodium, chloride, sulfate, total phosphate, alkalinity, ammonia, and bacteria to assess the water quality in the project area. The Idaho Bureau of Laboratories also reported the wells contained iron above the United States Environmental Protection Agency's (EPA's) Secondary Drinking Water Standards maximum containment level (SMCL).

2 Methods and Results

2.1 Method

Wells were identified as potential sites for sample collection based a review of the following information.

- Availability of well driller's reports.
- First opening to groundwater was 60 feet or less below ground surface.
- Preference was given to wells with owners who occupy the site year-round.

- Except for control wells, the wells sampled were downgradient from one or more homes served by a septic system.
- Wells were upgradient of Lake Cascade.

DEQ identified 32 wells within the Lake Cascade designated monitoring area as described in the in the *Lake Cascade Field Sampling Plan* (DEQ 2021b). DEQ received permission to sample 13 wells; however, two wells could not be sampled when the sampling team arrived on site because the power to the well was either shut off or the well stopped pumping after a few minutes. Tables 1 and 2 outline results for 11 wells.

2.2 Water Quality Field Parameters

Table 1 provides the water quality field parameters for the Lake Cascade project.

Table 1. Water quality field parameters—Lake Cascade monitoring project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Water Temperature (°C)	Specific Conductance (µS/cm)	pH	Dissolved Oxygen (mg/L)
3188	76	06/06/2022	9.55	75	6.14	4.05
3190	24	06/06/2022	8.31	253	6.78	3.15
3191	60	06/06/2022	6.92	78	6.43	6.40
3192	84	06/06/2022	8.88	123	5.96	9.20
3193	48	06/06/2022	9.52	82	5.67	4.34
3195	48	06/06/2022	8.92	44	5.76	5.95
3196	30	06/06/2022	8.04	69	5.77	7.04
3197	49	06/06/2022	7.71	62	5.94	4.87
3198	30	06/06/2022	8.70	74	5.94	3.95
3199	27	06/06/2022	9.05	96	5.98	2.07
3200	38	06/06/2022	10.22	101	5.78	2.73

Notes: ft bgs = feet below ground surface; °C = degrees Celsius; µS/cm = microsiemens/centimeter; pH = standard pH units; mg/L = milligrams per liter.

2.3 Nutrient Results

Table 2 provides the nutrient and related isotope results for the Lake Cascade project.

Table 2. Nutrient and nutrient-related isotope results—Lake Cascade monitoring project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Nutrient Concentration			Isotopes
			Nitrite[a]	Nitrate[a]	Ammonia	$\delta^{15}N$
				(mg/L)		(‰)
Water Quality Standard:			**1.0**	**10**	**No Stand.**	**No Stand.**
3188	76	06/06/2022	<0.30	0.0883J	<0.050	—
3190	24	06/06/2022	<0.30	<0.18	<0.050	—
3191	60	06/06/2022	<0.30	0.0818J	<0.050	—
3192	84	06/06/2022	<0.30	3.19	<0.050	—
3193	48	06/06/2022	<0.30	0.0839J	0.054	—
3195	48	06/06/2022	<0.30	0.99	<0.050	—
3196	30	06/06/2022	<0.30	1.21	<0.050	—
3197	49	06/06/2022	<0.30	0.247	<0.050	—
3198	30	06/06/2022	<0.30	<0.18	0.099	—
3199	27	06/06/2022	<0.30	<0.18	0.22	—
3200	38	06/06/2022	<0.30	0.0839J	0.054	—

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; ‰ = permil; (-) = Not Analyzed; No Stand = Drinking Water Regulation currently established. J: "Lab reported value below the practical quantitation limit and above method detection limit."
a. Contaminant with a National Primary Drinking Water Regulation standard.

2.3.1 Nitrate Results

Of the 11 wells sampled at Lake Cascade, none had nitrate concentrations greater than half the maximum containment level (MCL) or nitrate concentrations exceeding the MCL of 10mg/L. The nitrate concentrations for the 11 wells ranged from < 0.18 mg/L to 3.19 mg/L. Figure 1 shows the location of the wells that were sampled and the nitrate concentrations for each well.

2.3.2 Nitrogen Isotope Results

Nitrogen isotope samples were not analyzed because no wells had nitrate concentrations of 5 mg/L or greater.

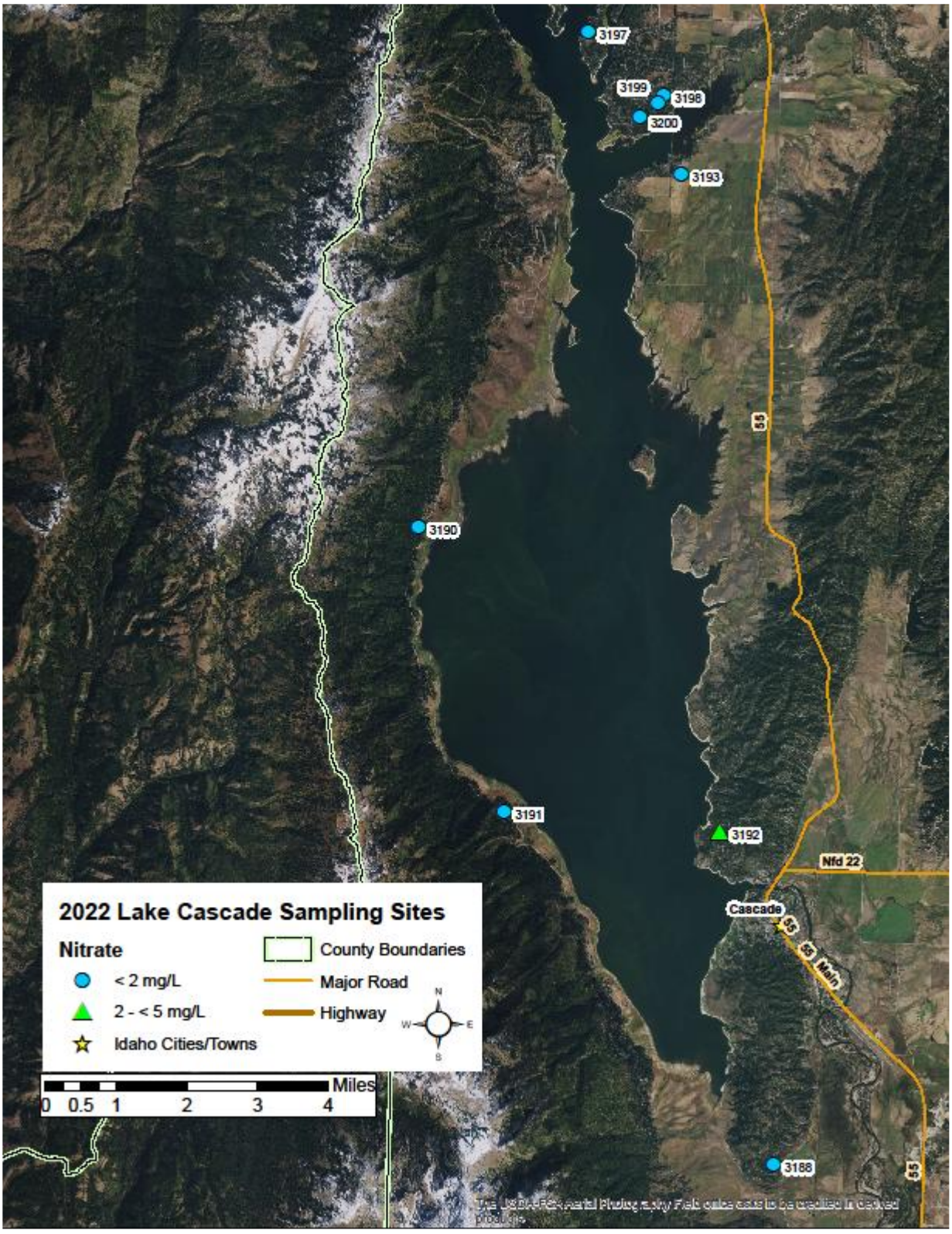

Figure 1. Sample locations and nitrate concentrations—Lake Cascade monitoring project.

2.4 Chemistry Results

Table 3 provides the cation (calcium, potassium, magnesium, and sodium) and iron results, and Table 4 provides the anion and alkalinity results for the Lake Cascade monitoring project.

Table 3. Cation and iron results—Lake Cascade monitoring project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Calcium (mg/L)	Potassium (mg/L)	Magnesium (mg/L)	Sodium+ (mg/L)	Iron (mg/L)
Water Quality Standard:			**No Stand.**	**No Stand.**	**No Stand.**	**No Stand.**	**2.0**
3188	76	6/6/2022	5.7	0.53	0.68	8	3.62
3190	24	6/6/2022	31	1.6	1.8	16	NA
3191	60	6/6/2022	8.1	0.53	2.4	3.2	NA
3192	84	6/6/2022	10	0.92	1.5	9.2	NA
3193	48	6/6/2022	5.6	0.88	1.3	6.7	2.17
3195	48	6/6/2022	3.8	0.75	0.75	2.2	NA
3196	30	6/6/2022	5.7	0.84	0.98	3.6	NA
3197	49	6/6/2022	4.6	0.77	1.0	4.0	NA
3198	30	6/6/2022	4.0	0.97	1.1	4.5	3.39
3199	27	6/6/2022	5.2	1.2	1.4	5.3	4.48
3200	38	6/6/2022	6.4	1.0	1.5	5.2	2.17

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; #= Secondary Drinking Water Standard; No Stand (Standard) = No Primary or Secondary Drinking Water Regulation or Idaho Ground Water Quality Rule standard currently established.

Table 4. Anion and alkalinity results—Lake Cascade monitoring project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Chloride (mg/L)	Sulfate (mg/L) Secondary	Total Phosphorous (mg/L)	Alkalinity (mg/L)
Water Quality Standard:			**No Stand.**	**No Stand.**	**No Stand.**	**No Stand.**
3188	76	6/6/2022	0.877	0.841	0.12	35.7
3190	24	6/6/2022	7.01	24.8	0.022	90.8
3191	60	6/6/2022	0.516	0.771J	0.027	38.3
3192	84	6/6/2022	6.63	2.52	0.12	32.6
3193	48	6/6/2022	12.9	1.2	0.054	20.4
3195	48	6/6/2022	0.393J	1.10	0.028	13.3
3196	30	6/6/2022	2.18	0.888	0.018	21.4
3197	49	6/6/2022	0.358J	0.523J	0.096	25.5
3198	30	6/6/2022	1.52	0.674J	0.11	26.5
3199	27	6/6/2022	3.03	0.124J	0.12	31.6
3200	38	6/6/2022	12.9	1.12	0.054	20.4

Notes: ft bgs = feet below ground surface; mg/L = milligrams per liter; (-) = Not Analyzed; No Stand (Standard) = No Primary or Secondary Drinking Water Regulation or Idaho Ground Water Quality Rule standard currently established.

2.4.1 Iron Results

Five of the 11 wells (3188, 3193, 3198, 3199, and 3200) tested contained iron levels above EPA's SMCL of 2 mg/L (Table 3). The SMCLs are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL.

Elevated iron in well water may cause rusty color, sediment, metallic taste, and reddish or orange staining.

2.4.2 Total Phosphorus Results

The TMDL reservoir target of 0.025 mg/L of total phosphorus is used for the tributaries, and the total phosphorus target and pH criteria are used for the West Mountain tributaries (DEQ 2018).

Nine of the 11 wells sampled at Lake Cascade had total phosphorus levels higher than the TMDL target of < 0.025 mg/L set for the reservoir and tributaries (Table 4).

2.4.3 Elevated Specific Conductivity

Eight of the 11 wells sampled at Lake Cascade had a specific conductivity of less than 100 microsiemens per centimeter (µS/cm). The remaining three wells (3190, 31925, and 3200) had

conductivity ranging from 101 to 253 µS/cm. Elevated specific conductivity is a reliable indicator of septic effluent influence on groundwater (Iverson et. al. 2020).

2.5 Bacteria Results

Well 3200 had detections for both total coliform and *Escherichia coli* (*E. coli*) (Table 5). The property where Well 3200 is located is in the early stages of building and does not have a septic system installed. However, the property has neighboring properties with septic systems installed.

The remaining 10 wells did not have total coliform or *E. coli* detections.

Table 5. Bacteria results—Lake Cascade monitoring project.

DEQ Site ID	Well Depth (ft bgs)	Sample Date	Bacteria Concentrations[a]	
			E. coli	Total Coliform
			(MPN/100 mL)	
Water Quality Standard:			**<1**	**<1**
3188	76	6/6/2022	<1	<1
3190	24	6/6/2022	<1	<1
3191	60	6/6/2022	<1	<1
3192	84	6/6/2022	<1	<1
3193	48	6/6/2022	<1	<1
3195	48	6/6/2022	<1	<1
3196	30	6/6/2022	<1	<1
3197	49	6/6/2022	<1	<1
3198	30	6/6/2022	<1	<1
3199	27	6/6/2022	<1	<1
3200	38	6/6/2022	5	5

a. Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary groundwater quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in colony forming unit per 100 milliliters, analytical results provided in most probable number per 100 milliliters are acceptable for comparison to the standard.

3 Methods for Determining Septic Effluent Influence on Groundwater

Flint Hall from the DEQ Idaho Falls Regional Office, conducted a methodical study in Island Park, Idaho, to determine the source of bacterial contamination in private domestic wells (DEQ 2021c).

DEQ considers the following chemical signatures as septic effluent influence on groundwater:

- Presence of total coliform and *E. coli*
- Sites with the lower calcium/sodium (Ca/Na) or sulfur/chloride (S/Cl) ratios combined with lower Na/Cl ratios and total phosphorus > 0.1 mg/L
- Sites with elevated specific conductance relative to control sites

A review of the bacterial, conductivity, anion, and cation results by Flint Hall and Rebecca Goehring, DEQ Boise Regional Office (BRO), resulted in the following determinations:

- Well 3200 had total coliform and *E. coli* present in the water sample.
- Wells 3199 and 3192 have lower S/Cl ratios combined with Na/Cl ratios and total phosphorus > 0.1 mg/L
- Wells 3190, 3192, and 3200 have elevated conductivity.

Of the wells sampled, the chemical signatures of Wells 3190, 3192, 3199, and 3200 suggest the groundwater is likely septic influenced. A map of these systems is provided in Figure 2.

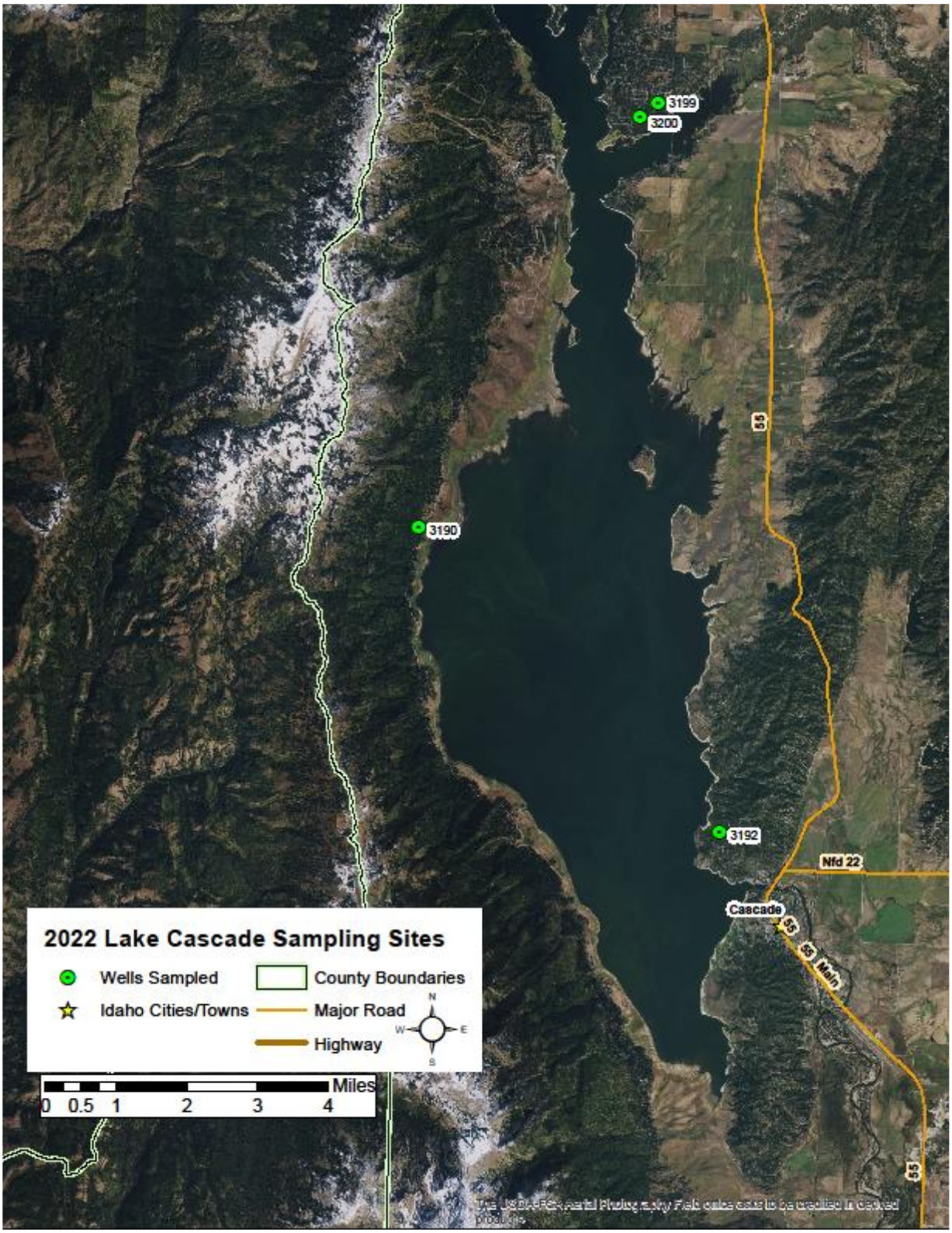

Figure 2. Wells that suggest septic effluent influence—Lake Cascade monitoring project.

4 Conclusions

Groundwater temperatures from all wells sampled were less than 10.5°C (Table 1). Groundwater flowing into the lake is unlikely to raise the temperature of the lake.

Of the 11 wells sampled, the chemical signatures of Wells 3190, 3192, 3199, and 3200 suggest septic effluent influence on groundwater.

- Well 3200 had total coliform and *E. coli* present in the water sample.
- Wells 3199 and 3192 have lower S/Cl ratios combined with Na/Cl ratios and total phosphorus > 0.1 mg/L
- Wells 3190, 3192, and 3200 have elevated conductivity.

Septic effluent influence may be due to several different septic system malfunctions. Four of the most common malfunctions are listed below.

- Inadequate septic tank size
- Inadequate septic system design
- Inadequate septic system maintenance
- Septic system failure

5 Recommendations

Many sources contribute to elevated phosphorus levels in Lake Cascade. Alternatives to non-enhanced septic systems around Lake Cascade could be evaluated or implemented to achieve reductions in phosphorus from septic leachate, as recommended in the *Implementation Plan for the Cascade Reservoir Phase II Watershed Management Plan* (DEQ 2000)

DEQ may consider sampling additional Lake Cascade wells in the future, with an emphasis on wells located in subdivisions on the southernmost end of the lake. The VCSWD has obtained permission to collect groundwater samples from some well owners in this area.

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