

Memorandum

To: Rick Eilertson, Paul Woodard
From: Jon Lefers, Rob Montgomery
Date: October 25, 2007
cc:
Re: Jamestown Watershed and Goose Lake Water Level and Rainfall Monitoring

INTRODUCTION & BACKGROUND

The Jamestown Watershed is located in the southwestern portion of Fitchburg, WI (See Figure 1 and Figure 2). Three detention basins within this watershed were designed in the late 1980's and constructed in 1990. The furthest basin downstream, originally called "Jamestown Retention Facility No. 1", is located within the current Quarry Ridge Recreational Area east of Fitchrona Road. For purposes of easy identification, the City of Fitchburg now refers to this basin as the "Quarry Ridge Wet Basin". This basin was designed as a stormwater detention and infiltration basin in an attempt to significantly reduce stormwater runoff volume draining to Goose Lake, a prairie-pothole, which is located in the Town of Verona downstream of Jamestown Watershed.

The approximately 750-acre Jamestown Watershed has urbanized over the past several decades with a mixture of residential, commercial, and arterial road land uses (See aerial photograph history in presentation slides and Figure 1). Active sand and gravel quarries are also located within the watershed, which has produced internally drained areas totaling approximately 50 to 100 acres. The area downstream of the Quarry Ridge Wet Basin but draining to Goose Lake is more dominated by agricultural land use with a mixture of residential and commercial land use.

Concerns with respect to water quantity and quality draining to Goose Lake over the last several years prompted the City to apply for a Wisconsin DNR Urban Non-Point Source Planning Grant and fund a monitoring project for Quarry Ridge Wet Basin and Goose Lake. The DNR did not award the grant, but the City decided to continue with the monitoring study to ascertain the degree to which the overflow from Quarry Ridge Wet Basin is likely a significant contribution to the water quantity and quality issues in Goose Lake.

This memorandum documents the data collected as well as conclusions regarding what the data suggests as to how Quarry Ridge Wet Basin is functioning as a detention / infiltration basin. We have also attached the slides that were presented as part of an informational meeting on July 19, 2006.

SCOPE

Below is a summary of the approved scope as outlined in our proposal to the City dated May 16, 2006 along with subsequent change orders. As the project progressed, revisions to the scope were made, so this memorandum also summarizes in italics the services that were completed, subtracted, or added to the project scope.

Task 1: Initiate public watershed planning process

Task 1 included a kickoff meeting with Montgomery Associates – Resource Solutions (MARS) and Natural Resources Consulting, Inc. (NRC) staff, City staff, and interested stakeholders. The kickoff meeting presentation slides are included as an attachment to this memorandum. Below is a detailed description of the items that were originally to be covered in the presentation as well as a brief statement (in italics) as to whether that item was covered.

- Brief presentation on the watershed and the current level of understanding regarding surface and groundwater impacts on the Jamestown Basin (Quarry Ridge Wet Basin) and Goose Lake; *(Covered during meeting, refer to presentation slides.)*
- Presentation of a proposed planning process for investigating the issues, developing alternatives, and selecting an alternative for water management in the watershed; *(The data collection effort was outlined in the presentation, as shown in the attached presentation slides; however, the development of water management alternatives was not described as at the time, the City was still awaiting results on funding of the DNR Urban Non-Point Source Grant application.)*
- Solicitation of public input regarding problems and potential solutions to water quality and/or flooding problems in the watershed; *(The interested stakeholders who attended the meeting provided input as to their concerns / issues. Concerns listed were:*
 - *Water quality / clarity related to wildlife diversity*
 - *Need to have a regional stormwater approach that looks at all the nearby water resources together*
 - *Runoff from agricultural fields (particularly after manure applications)*
 - *Runoff from Wingra Stone*
 - *Continued increasing water levels in Badger Mill (no diversion from Goose Lake)*
 - *Jamestown Basin (Quarry Ridge Wet Basin) - is it functioning the way it was intended? Either way, is it good or bad?*
 - *Goose Lake - also concerned about too low water levels)*
- Setting up work committees or interest committees on specific issues that may be important, such as observational monitoring of Goose Lake water levels by local residents or other issues; *(Steve Sheets volunteered to monitor water levels on Goose Lake.)*
- Setting up a schedule for the process of analyzing the watershed and selecting an alternative. *(This was not discussed in the meeting as at the time the City was still awaiting results on funding of the DNR Urban Non-Point Source Grant application.)*
- Develop a brief memorandum documenting the activities in the meeting for distribution to attendees and interested parties. *(An email on July 21, 2006 was sent to the City and Steve Sheets following the meeting. This memorandum also summarizes the activities discussed in the meeting.)*

Task 2: Install hydrologic monitoring equipment

Task 2 covered installation of the following monitoring equipment.

1. Automated water level recorder for the Quarry Ridge Wet Basin *(completed)*

2. Manual rain gauge installed at City facility on county highway PD. *(completed but installed north of the Quarry Ridge Wet Basin instead of at the City facility)*
3. Staff gage(s) on Goose Lake to measure the expected full range of water levels *(completed)*

Task 3: Conduct ecological monitoring of Goose Lake

Based on the initial conversations with the interested stakeholders, one concern (also raised in the public meeting) was the ecological integrity of Goose Lake. For that reason, initial ecological monitoring / data reconnaissance was proposed in the original scope, which was to be completed by Natural Resources Consulting, Inc. This scope included:

1. Review available information pertaining to the water quality, water chemistry, and biological communities. It is possible that data exists on Badger Mill Creek associated with the permitting for the MMSD return line outfall. *(This was not completed as the DNR Non-Point Source Grant application was denied. Funds designated for this portion of the scope were transferred to Task 5, see below.)*
2. Perform two half-day walk-over observations on ecological indicators surrounding Goose Lake and in the upper reach of Badger Mill Creek, where overflow from Goose Lake could be discharged. *(One half-day walk-over with Bill Poole of Natural Resources Consulting, Jon Lefers, Steve Sheets, and Dave Caverson (former City of Fitchburg Environmental Project Engineer) was conducted during June, 2006. Initial observations from this walkover indicated that the ecological system was degraded (as expected); however, remnants of higher-value ecological systems remained such as sedges along the northern edge of the lake and turtles were observed in various portions of the lake. A second walkover was not completed, and funds allocated for this effort were transferred to Task 5, see below.)*

Task 4: Communication and data monitoring

Task 4 was for data collection from the beginning of the project through September 30, 2006, which was the expected timeframe for a decision on the DNR Urban Non-Point Source Grant application. *This task was completed (See attached figures) with ongoing monitoring covered under Task 5, see below.*

Task 5: Continued data monitoring, survey, and data summary memorandum

Task 5 covers items not originally authorized in the original scope of work, namely continued data monitoring through the end of June 2007, survey of key elevations, and a memorandum summarizing the findings. *This task was completed as described later in this memorandum.*

Task 6: Evaluate stormwater management plan performance requirements for future development

The scope of Task 6 was developed in consultation with City staff for assistance on reviewing proposed projects within the Jamestown Watershed. *This scope covered initial review and meeting with the City and/or developer to discuss criteria that should be applied to these developments. As part of this scope, MARS also assisted City staff in investigating water quality modeling approaches for the Jamestown Watershed.*

Task 7: In-depth review of Consultants' stormwater management plan submittals

The scope of Task 7 was developed in consultation with City staff for assistance on more in-depth review of specific projects being proposed in the Jamestown Watershed. *This scope covered reviewing a proposed project on King James Way and providing soils description for test pits completed on the site.*

DATA COLLECTION PROCEDURES

Parameters

The following data was collected as part of this study:

- Water levels in Quarry Ridge Wet Basin
- Water levels in Goose Lake
- Rainfall (non-snowfall) measured at Quarry Ridge Wet Basin
- Survey of gage, inlet, and outlet elevations for Quarry Ridge Wet Basin and Goose Lake

These data were supplemented with more regional data such as:

- The NOAA precipitation gage at the UW-Arboretum (daily precipitation and temperature)
- The Weather Underground precipitation gage near the intersection of Lacy and Fish Hatchery Roads (Station No. KWIFITCH4)

Monitoring Period

The instrumentation was installed in late-June 2006 and the instruments were monitored through September 2007.

Instrumentation

Water levels in Quarry Ridge Wet Basin were measured with an automatically-recording depth gage (data point recorded every 15 minutes), and downloaded periodically by MARS staff. Water levels in Goose Lake were measured approximately on a daily basis in Summer-Fall 2006 and infrequently thereafter by Steve Sheets, resident on Goose Lake.

Rainfall was measured with an automatically-recording precipitation gage that measured every 15 minutes or at each hundredth of an inch rainfall, whichever was more frequent. Data was downloaded periodically by MARS staff.

RESULTS

Brief Ecological Survey

Survey

Survey of select locations in the vicinity of Quarry Ridge Wet Basin and Goose Lake were taken on Table 1 summarizes the elevations that were surveyed as part of this study.

Table 1: Summary of Surveyed Elevations

Location	Elevation
Quarry Ridge Wet Basin Water Level Recorder Datur	965.8
Quarry Ridge Wet Basin Overflow Elevation	~970.75
Culvert under Fitchrona Road	959.5 (upstream), 959.2 (downstream)
Goose Lake Staff Gage Datum	951.5
Overflow Culverts South of Goose Lake	959.0 – 959.2

Rainfall

Figure 3 displays the rainfall data for both the Quarry Ridge Wet Basin gage and two nearby precipitation gages (UW-Arboretum and near Lacy Road/Fish Hatchery Road). When the data sets overlap, the data suggests that the gages correlate fairly well.

Using the best-available data (Quarry Ridge Wet Basin then UW-Arboretum then Fitchburg, shown in Figure 5) for a one-year period beginning on July 1, 2006 and ending on June 30, 2007, the total precipitation was 37.1 inches, which is much wetter than normal (approximately 31 inches). Using a similar one-year period of October 1, 2006 through September 30, 2007 (2007 water year), the total precipitation for Water Year 2007 was 38.27 inches. According to the best-available rainfall data, a precipitation event exceeding 1 inch in a 24-hour period occurred at least 12 times during the monitoring period with several more events approaching 1 inch. The wettest month by far was August 2007, which recorded over 12 inches of rainfall.

The two largest events occurred in late August 2006 and in August 2007. In August 2006, over 4 inches of rain fell in the span of three days. In August 2007, the highest 10-day total was over 6 inches. (Note that rain gage readings by Steve Sheets at his home indicate that the 10-day rainfall total at Goose Lake could have been as high as 13.5 inches.) Depending on the data set, time period, and rainfall depth-frequency chart used, the recurrence interval will vary; however, it appears that these events correspond to roughly the 5- to 10-year event but could be greater than the 100-year event if the rainfall data from Steve Sheets is utilized. (Note: there is no readily-available recurrence interval data available for longer than 10-day precipitation totals.) Table 2 and Table 3 summarize the maximum rainfall depth-duration for a select number of durations for the two events along with the corresponding recurrence interval as estimated by Huff and Angel's Bulletin 71.

Table 2: Summary of Late August 2006 Rainfall Event

Duration	Rainfall Depth	Recurrence Interval
~16 hours	3.73 inches	~10-year event
~36 hours	4.32 inches	~10-year event

Table 3: Summary of August 2007 Rainfall Event (mid- to late-August)

Duration	Rainfall Depth	Recurrence Interval
5 days	4.3 inches (Fitchburg gage)	2- to 5-year event
10 days	6.55 inches (Fitchburg gage)	~10-year event
10 days	13.5 inches (Sheets gage)	>100-year event

Quarry Ridge Wet Basin Water Levels

The Quarry Ridge Wet Basin stage data is shown in Figure 4, which illustrates the wide stage fluctuation that the basin experiences. Gaps in the data are due to either corrupted data during download or vandalized water level recorder.

Quarry Ridge Wet Basin Rainfall-Runoff

Figure 5 compares both the best-available precipitation record with the Quarry Ridge Wet Basin stage fluctuation. The data indicates that the basin overflowed to Goose Lake three times. Two of the overflow events occurred in late summer 2006, and the third event occurred in spring 2007. A minor fourth overflow event may have also occurred later in spring 2007. However, when compared to the volume of runoff completely stored and dissipated via infiltration and evaporation (as evidenced by the frequent 1- to 2-foot stage fluctuations

following a rain event), the volume of overflow is quite modest compared to the total runoff entering Quarry Ridge Wet Basin.

Although rainfall-runoff response varies depending on the antecedent moisture condition (i.e. how wet or dry the soil is prior to the start of a precipitation event), it appears that typically, one inch of rainfall raises the basin stage approximately one foot. Based on a 650-acre watershed (assuming 100 acres is internally drained to the existing quarries) and a pond area of 6.2 acres, the 1-foot stage increase from a 1-inch rainfall translates to approximately 0.1 inch of runoff over the entire watershed reaching Quarry Ridge Wet Basin, which is perhaps less than one would expect. For the larger events, it is more difficult to estimate a runoff volume, as these events triggered an overflow event.

Quarry Ridge Wet Basin Seepage / Evaporation

Overall loss rates from the basin appear to be 0.07 to 0.15 feet ft/day, which includes both evaporation and seepage. Seepage is by far the more dominant factor in the loss rate as evaporation rates are typically less than 6 inches per month (<0.017 ft/day) even during the summer months, which leaves seepage rates that vary between 0.05 ft/day at lower stages to as high as 0.14 ft/day at higher stages (non-winter conditions). This almost three-fold difference in seepage rates indicates that the margins of the basin are likely accounting for a majority of the seepage. One very interesting observation that seems to substantiate this hypothesis is that while the surface of Quarry Ridge Wet Basin was frozen (ice depth of approximately 1 foot), the rate of stage decrease is significantly less than when the basin surface was not frozen. Screening-level estimates of evaporation rates does not account for the drastic change between "ice off" and "ice on" conditions.

The seepage rate is also substantially less than one might expect based on the soils present below the ground surface, which are primarily sands and gravels (with typical infiltration rates of over 3 inches per hour), possibly indicating that the basin is connected to the groundwater system, and therefore, subsurface flow from the pond is primarily horizontal versus vertical flow through an unsaturated zone as would be the case for a conventional, properly-constructed infiltration basin.

Goose Lake Water Levels

From the available data, it appears that during the summer, watershed runoff is minimal as evidenced by the mid-July 2006 ~1.5-inch rainfall event raising the pond stage approximately 2 inches (See Figure 6). Large stage increases appear to be due primarily to Quarry Ridge Wet Basin overflow events (seven of which occurred during the course of the monitoring period, of which four occurred during the August 2007 rainfall events).

Loss rates from Goose Lake (evaporation and seepage) totaling 0.01 to 0.02 ft/day also appear to be significantly lower than Quarry Ridge Wet Basin. This is not unexpected due to the likely more fine-grained soils that underlie Goose Lake compared to Quarry Ridge Wet Basin. The more rapid loss rate during August 2007 was at least partially due to the fact that Goose Lake was overflowing to the south via the culverts.

CONCLUSIONS

Although June and July 2007 were unusually dry, overall the conditions during the monitoring period were much wetter than normal, with possibly an event greater than the 100-year event occurring during the monitoring period (August 2007). These conditions led to several overflow events from Quarry Ridge Wet Basin draining to Goose Lake, and an extended overflow event of Goose Lake to the south. Quarry Ridge Wet Basin

captures a vast majority of the runoff entering the basin; however, the overflow events seem to be a significant portion of the inflow hydrologic budget of Goose Lake.

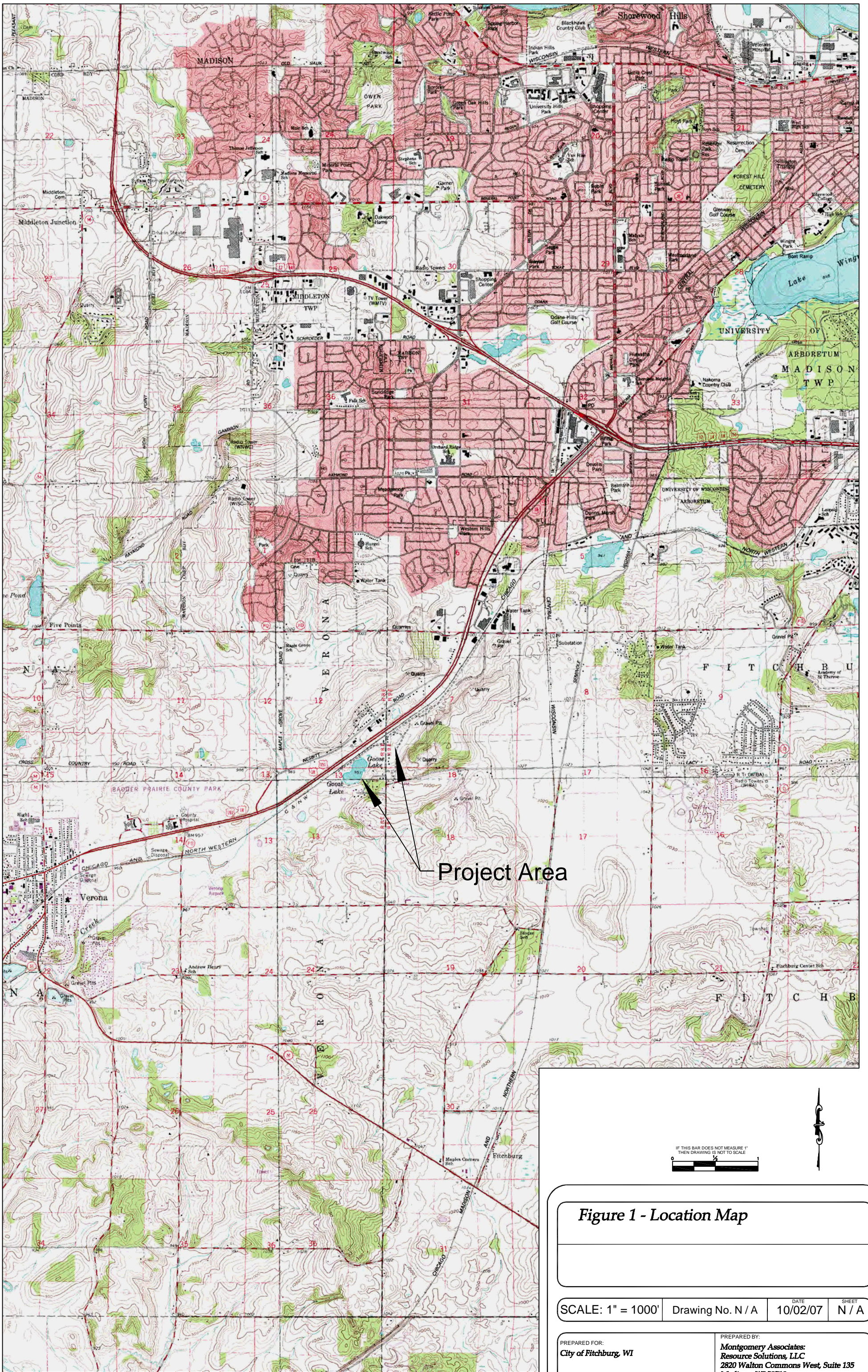
FUTURE CONSIDERATIONS

Although much of the Jamestown Watershed is already developed, future development may have the potential to increase the frequency of overflow events to Goose Lake. The largest tracts of land yet to be developed are the existing sand and gravel pits (two south and east of Quarry Ridge Wet Basin and one north of PD). If extensive infiltration practices are not implemented for these areas when they develop, the relative frequency of overflow from Quarry Ridge Wet Basin to Goose Lake is likely to increase. It is unknown at this time to what degree the frequency would increase or whether increasing the frequency of overflow events to Goose Lake would be beneficial or detrimental to the lake.

If maintaining at least the status quo for overflow events to Goose Lake is determined to be the objective for as the watershed continues to develop, one alternative could be to retro-fit Quarry Ridge Wet Basin to improve its functionality to eliminate or reduce the need to provide extensive stormwater management facilities in areas of high development potential.

Attachments: **Figure 1 – Location Map**
 Figure 2 – Goose Lake Watershed Map
 Figure 3 – Comparison of Rainfall Data
 Figure 4 – Quarry Ridge Wet Basin Stage
 Figure 5 – Quarry Ridge Wet Basin Stage and Rainfall
 Figure 6 – Goose Lake Stage and Rainfall

Powerpoint Slides from July 19, 2006



Project Area

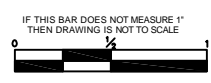
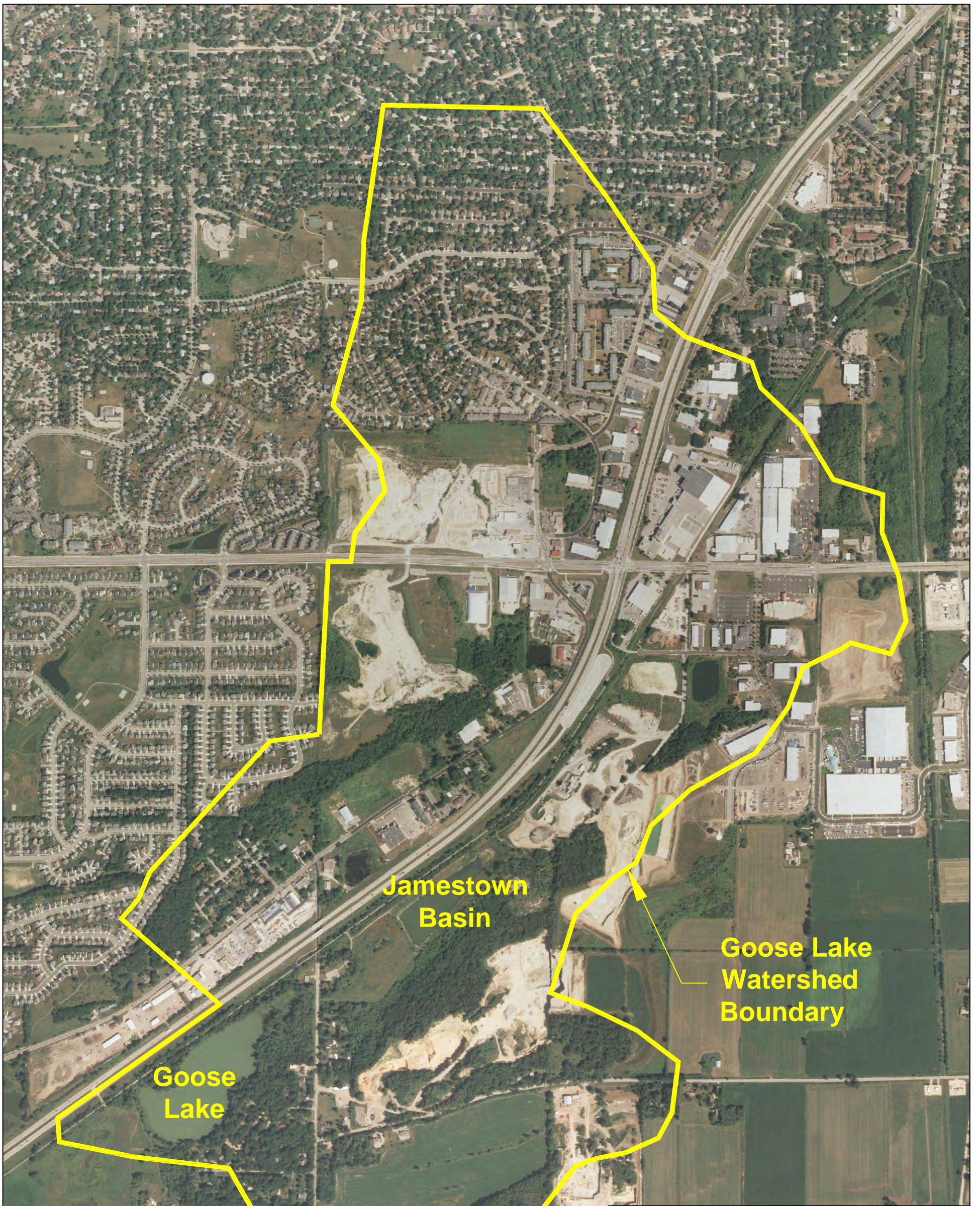


Figure 1 - Location Map

SCALE: 1" = 1000'	Drawing No. N/A	DATE: 10/02/07	SHEET: N/A
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Goose Lake

Jamestown Basin

Goose Lake Watershed Boundary

Notes:
1. Watershed Boundary based on USGS Quadrangle Maps.

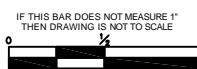


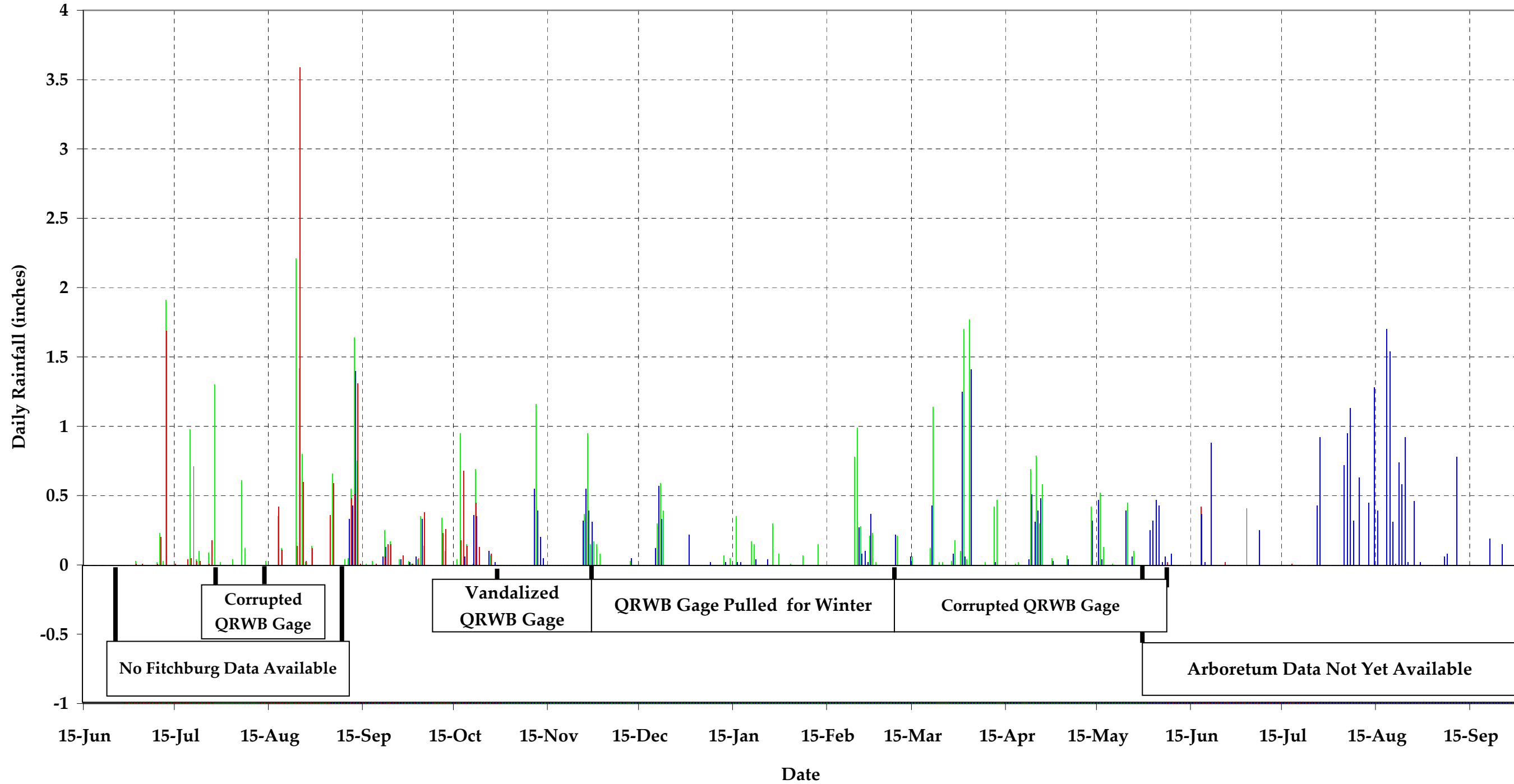
Figure 2 - Goose Lake Watershed Map

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Figure 3
Comparison of Rainfall Gages



■ Arboretum Daily Rainfall ■ Jamestown Basin Daily Rainfall ■ Fitchburg Weather Underground Station KWIFITCH4

Figure 4
Quarry Ridge Wet Basin Stage Data Summary

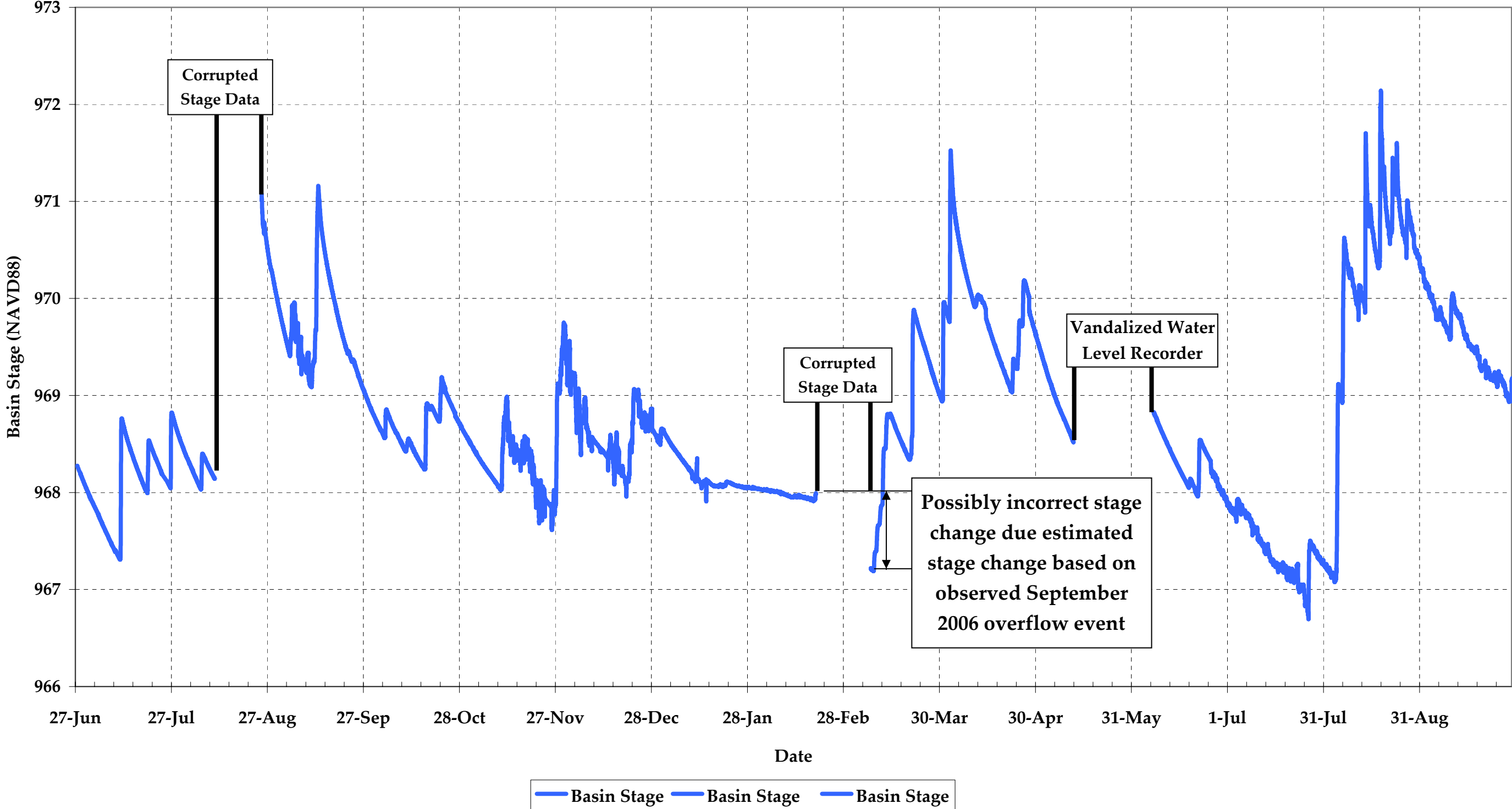


Figure 5
Quarry Ridge Wet Basin Stage and Rainfall

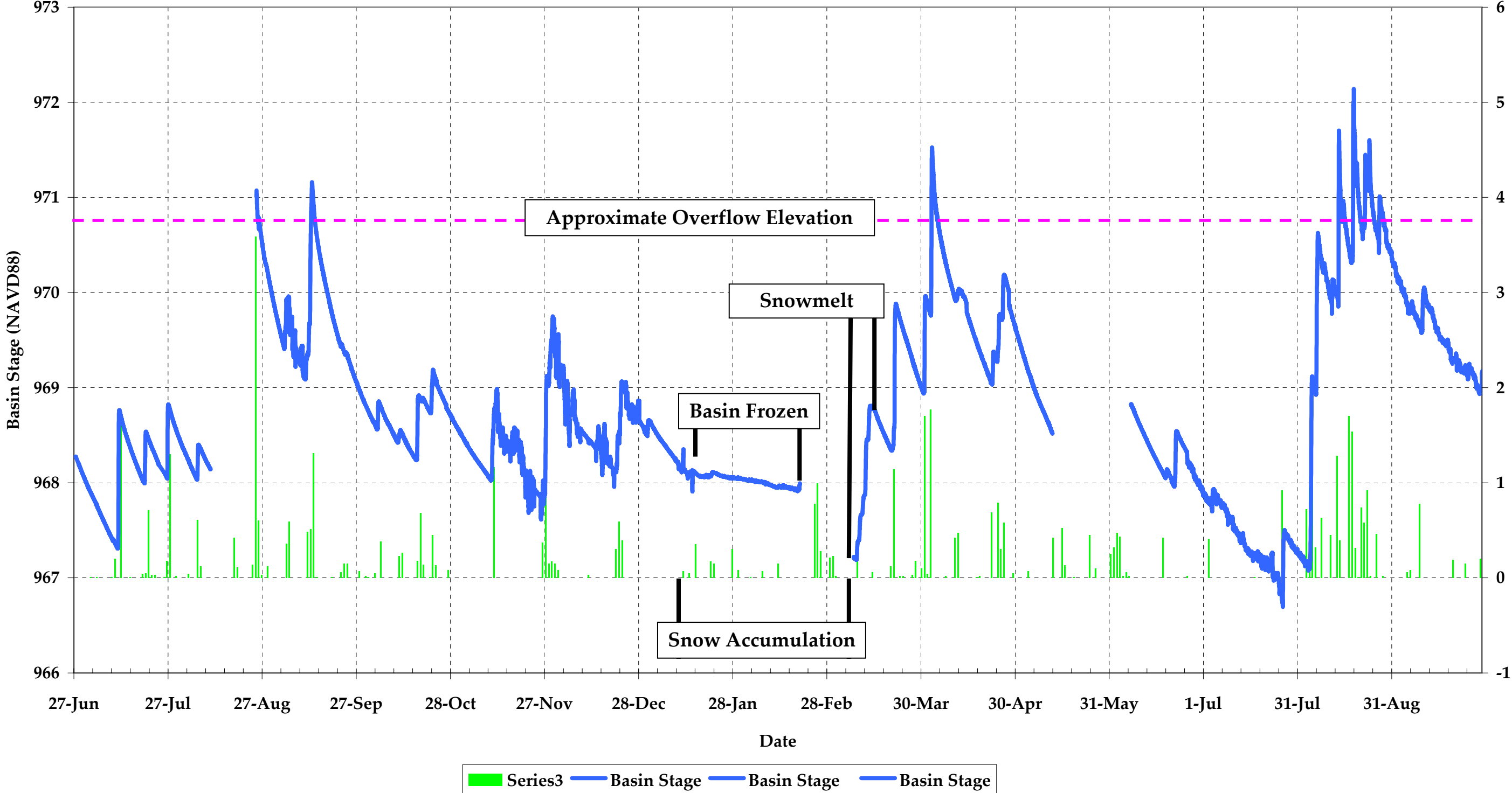


Figure 6
Goose Lake Stage and Rainfall

