

TECHNICAL MEMORANDUM

DATE: February 21, 2013 Project No.: 453-02-12-05

TO: Phil Scott, District Manager
Bill Kitajima, Projects Manager

FROM: Vivian Housen, R.C.E. #46324

REVIEWED: Jon Wells, R.C.E. #67782

SUBJECT: 2012 Hydraulic Model Recalibration Effort and Updated CIP

BACKGROUND

The West Bay Sanitary District (District) completed a sewer collection system master plan (Master Plan) in June 2011. Master Plan recommendations were based on results from a hydraulic model that was calibrated to flows collected during the 2009/10 wet weather season. One of the first projects to be recommended by the Master Plan was named the James Avenue Relief Sewer project (later renamed the Marsh Road Diversion project). The purpose of this project was to divert flow from the existing sewer interceptor in Marsh Road, which was predicted to exceed capacity by nearly 4 million gallons per day (mgd) during a 10-year, 6-hour design storm.

Since this time, the District has completed numerous projects to replace aging pipes and thereby reduce inflow and infiltration (I&I). One of these projects included the installation of cured-in-place pipe lining within an existing pipe on Haven Avenue, at the lower end of Marsh Road. After completion of the Haven Avenue project, the District observed a reduction in dry weather flow at the Menlo Park Pump Station (MPPS), which is located at the terminus of the sewer collection system. This flow reduction was confirmed by staff from South Bayside System Authority (SBSA). District staff concluded that the Haven Avenue repair eliminated a significant source of inflow from an adjacent creek. This theory was later confirmed through flow monitoring, as discussed below.

In 2011/12, the District completed a second flow monitoring program to document any flow reductions resulting from the Haven Avenue and other District projects. The hydraulic model was then recalibrated and results re-evaluated to determine whether Master Plan recommendations should be adjusted based on the updated information.

Re-calibration of the hydraulic model was completed in two steps. First, flows within the sewer subcatchment that includes the Marsh Road interceptor, named Basin 2B, were re-evaluated based on 2011/12 flow data. The purpose of this evaluation was to determine whether the decrease in flows resulting from the Haven Avenue repair would change the scope of the Marsh Road Diversion project. Next, flows within the remaining service area were reviewed to evaluate

additional I&I reductions that may have occurred through other recent pipeline replacement projects.

This Technical Memorandum (TM) discusses the 2011/12 flow monitoring data and how this information affected hydraulic model results. This TM also discusses a revised approach to the management and accommodation of wet weather flows, and includes the following sections:

- 2011/12 Flow Monitoring Program and Recalibration of Basin 2B
- Recalibration Results for District Service Area
- Revised Approach to Wet Weather Flow Management
- Updated Capital Improvement Program
- Next Steps

2011/12 FLOW MONITORING PROGRAM & RECALIBRATION OF BASIN 2B (MARSH ROAD)

The District conducted the 2011/12 flow monitoring program between December 21, 2011 and April 1, 2012. The program added four new flow meters and moved two meters from the prior program to better define I&I in the two sewer basins that include Atherton Avenue (Basin 2C) and Portola Valley (Basin 1F). Figure 1 shows meter locations from the 2011/12 program.

The 2011/12 wet weather season was generally dry, with one significant rainfall in mid-January (peaking near midnight on January 20, 2012), a relatively dry February, and several relatively moderate rainfall events in March. The system responded well to the January rainfall event, which was selected as the model recalibration event. Measured rainfall at rain gauge MD6575, located near the corner of Emilie Avenue and Valparaiso Avenue in Atherton, is shown on Figure 2 through Figure 4.

A comparison of data from the two flow monitoring programs showed an average reduction in dry weather flow of up to one mgd at Meter 1, which is located at the northern (downstream) end of Haven Avenue. Meter 1 measures combined flow from Basin 2B (Marsh Road) and the upstream Basin 2C (Atherton Avenue). A further review of comparative flows at Meter 10, which isolates Basin 2C and is located at Atherton Avenue north of Mercedes Lane, showed that dry weather flows did not change in Basin 2C. Therefore, this reduction was likely the direct result of the Haven Avenue project.

To more accurately represent flows measured during the 2011/12 flow monitoring period, Basin 2B (Marsh Road) was recalibrated in the hydraulic model. Recalibration involved reducing dry weather flows and the wet weather I&I component to match flows measured by Meter 1 during the 2011/12 program. After Basin 2B (Marsh Road) was recalibrated in this manner, a 10-year, 6-hour design storm was added to the model.

The predicted design storm wet weather response at Meter 1 is shown in Figure 5. Figure 5 also compares the new wet weather response to the predicted response using 2009/10 flow monitoring data. As shown in Figure 5, predicted design storm peak flow from Basin 2B (Marsh Road) decreased by approximately 4 mgd. Based on this updated result, it appeared that the Marsh Road interceptor pipeline should have sufficient capacity to convey wet weather flows during the design storm event, and the planned Marsh Road Relief Sewer project may no longer be required¹. These preliminary results were provided to the District on July 24, 2012.

Following this effort, the entire system was recalibrated to the 2011/2012 flows. Results from this system-wide recalibration shed uncertainty on the initial conclusions that were drawn for Basin 2B (Marsh Road) as discussed further in this TM.

RECALIBRATION RESULTS FOR DISTRICT SERVICE AREA

System-wide recalibration was completed by adjusting modeled flows in all of the District's sewer basins to closely match measured wet weather flows from the 2011/12 flow monitoring program. The primary purpose of this effort was to obtain a new total system flow for use in sizing the planned upgrade for the MPPS. It was expected that predicted flows at the terminus of the system would decrease by approximately 4 mgd, reflecting the decrease in flows that were observed in Basin 2B (Marsh Road).

The system recalibration effort yielded unexpected results, in that predicted flows from the design storm decreased by over 6 mgd, with reduced flows found in every sewer basin. A review of pipeline rehabilitation projects that were completed between 2010 and 2012 did not support this system-wide decrease in flows. Table 1 lists the completed projects and their associated sewer basins. In addition to the projects listed, the District completed pipe patch repairs in over 500 locations throughout the service area.

As shown in Table 1, pipeline improvements were not completed in all sewer basins. In some basins without major pipeline replacement projects listed, the District may have completed pipe patch repairs. Although these repairs will reduce I&I, it is unlikely that they can create significant reductions in wet weather flow unless other, more significant pipeline replacement projects are completed within the same basin.

However, the model predicted I&I reductions in a number of basins that did not have associated pipeline improvements. These basins include Basin 1A (north of Highway 101), Basin 1C (including Ringwood Avenue), Basin 3 (including Greenwood Drive), and Basin 4 (Lower Valparaiso Avenue). This result indicates that pipeline replacements were not the only reason for the I&I reductions that were observed in the 2011/12 flow monitoring program.

¹ During the 2009/10 flow monitoring program, the source of Basin 2B I&I was not known. Therefore, I&I was distributed throughout the basin. When design storm rainfall was added to the model, flows increased basin-wide, overwhelming the Marsh Road Interceptor. It is now known that a substantial portion of the I&I was contributed by the Haven Avenue pipeline. This I&I has been removed through the Haven Avenue CIPP project. Therefore, remaining basin-wide I&I, and predicted peak wet weather flows in the Marsh Road Interceptor should decrease.

| Table 1. Sewer Rehabilitation Projects Completed Between 2010 and 2012 | |
|---|---|
| Sewer Basin | Projects Completed |
| 1A (North of Hwy 101) | None |
| 1B (Willow Road) | Willow Road point repairs |
| 1C (Ringwood Ave) | None |
| 1D (South of Santa Cruz) | Oak Avenue/Bay Laurel Drive/University Avenue pipeline replacements |
| 1E (Ladera) | Ladera Outfall rehabilitation |
| 1F (Portola Valley) | Alpine and Portola Road pipeline projects |
| 2A (North of Valparaiso) | Oak Grove and Encinal Avenue rehabilitation |
| 2B (Marsh Road) | Haven Avenue rehabilitation |
| 2C (Atherton Ave) | Atherton Avenue, Fletcher Drive rehabilitation projects |
| 3 (Greenwood Drive) | None |
| 4 (Lower Valparaiso) | None |

After further review of the collected data, it appears that there is uncertainty about either the 2010 or 2012 results. For example, during the 2009/10 calibration event, the Menlo Pump station pumps appear to have been turned off for a period of time, causing surcharging in the system upstream of the pump station. At the same time, SCADA information is unavailable for the pump station. It is possible that calibrating the hydraulic model to flows that were measured during this period created unnecessary conservatism in the results. Alternatively, there is a possibility that dry antecedent conditions in 2011/2012 may have resulted in I&I volumes that were lower than the District would have seen if the ground were saturated. If the native soils were not fully saturated prior to the January 20, 2012 rainfall event, a greater percentage of rainfall would have percolated into the soil in lieu of entering the sewer pipes as I&I. Design storm events are typically preceded by smaller storms which saturate existing soils. When the design storm occurs, rainfall is no longer able to percolate into the ground, and thus enters the sewer pipes as I&I. Calibrating the hydraulic model to the January 20, 2012 rainfall event may have under-predicted the amount of I&I as a percent of rainfall, and thereby caused the model to under-predict I&I that would occur during the design storm.

In order to understand the difference in peak flows that were predicted in the original 2011 model and the recalibrated 2012 model, it is recommended that the District collect one additional year of flow information. This third data point will enable the District to determine which of the 2011 or 2012 hydraulic model calibration results are more reliable. It is important that the third dataset captures a substantial rainfall event with enough preceding rainfall to create saturated conditions.

REVISED APPROACH TO WET WEATHER FLOW MANAGEMENT

SBSA operates the MPPS and is in the process of upgrading this facility. In order to accommodate the schedule established by SBSA for the MPPS upgrade, the District was required to provide pump station peak flow requirements to SBSA in December 2012. The Master Plan estimates peak wet weather flow (PWWF) of 26.5 mgd during the design storm. This value does

not consider any reductions in I&I that have already been achieved through the projects listed in Table 1, or from similar future projects.

Given the short timeframe provided to update PWWF criteria for the MPPS, and the limitations presented by recent wet weather flow data, an empirical approach was used to establish a more realistic PWWF estimate of 22 mgd. The concept of accounting for I&I reduction as a component of long-term planning is becoming more prevalent in the Bay Area. For the District's flows, the future peak wet weather flow estimate was derived using the following process:

- The District has the authority to replace mainline pipes, and not the upper or lower lateral. Therefore, replacement of all system pipes will achieve no greater than 50 percent I&I reduction.
- The current hydraulic model predicts 26.5 mgd of peak wet weather flow (PWWF) during the design storm, based on average dry weather flow (ADWF) of 4.6 mgd. The ratio of PWWF to ADWF equates to a wet weather peaking factor of 5.76.
- The Haven Avenue project reduced dry weather flow by up to one mgd. Using a conservative average of 0.5 mgd flow reduction, and applying a wet weather peaking factor of 5.76, projected PWWF without additional I&I improvements would be 23.6 mgd.
- If the District repairs 1.5 percent of the system or 3 miles of pipe per year, and replacement of 1.5 percent of the system achieves ¾ percent I&I reduction, the District should expect to reduce peak wet weather I&I by 177,000 gallons per day (gpd), or by 1.8 mgd in ten years. This reduction would lower predicted PWWF to 21.8 mgd in ten years. The District has established sufficient funding to achieve this level of replacement².
- The District's replacement program targets the worst pipes first. Therefore, near-term I&I reduction should occur at an accelerated rate, enabling the District to reduce PWWF below 22 mgd within the five to ten years that SBSA requires to complete its capital program. Following this approach, PWWF of 22 mgd is a reasonable assumption for the MPPS design³.

Also, the entire 2.9 mgd in peak flow reduction described above (26.5 mgd PWWF from the Master Plan less 23.6 mgd adjusted PWWF) is the result of reduced ADWF in Basin 2B (Marsh Road). In order to avoid the Marsh Road Diversion project, an additional one mgd in I&I reduction is needed.

² It should be noted that if pipeline replacements are not continued at the planned rate, then I&I reductions will likely be lower and wet weather flows higher than described. The resulting flows may necessitate a future expansion of the MPPS beyond the 22 mgd capacity that is described in this TM. In addition, the District would require increased wet weather storage.

³ As part of the Menlo Park Pump Station design project, consideration should be given to changing the existing wet well configuration to relieve the hydraulic constriction that is created where flows enter the wet well structure.

Due to the cost and community impact that would be created by the Marsh Road Diversion project, it would be reasonable to defer the project until design storm peak flows in the existing Marsh Road interceptor are confirmed. Confirmation will involve re-calibration of the hydraulic model to 2012/13 wet weather flow data (or otherwise sufficient flow data as described above). The District is planning to rehabilitate aging pipe within the Burns easement, upstream of Marsh Road. It is possible that the I&I reduction achieved through this project, when combined with I&I reductions from the Haven Avenue project and Atherton Avenue improvements, will be sufficient to reduce predicted PWWF below the level that would trigger the need for the Marsh Road Diversion project.

UPDATED CAPITAL IMPROVEMENT PROGRAM

The original intent of this project was to update the Master Plan and Capital Improvement Program (CIP) based on results from a recalibrated hydraulic model. The hydraulic model update has been deferred until after the 2012/13 flow monitoring period, or a subsequent flow monitoring period, during which the District can collect more extensive wet weather flow information.

To complete this phase of the project, the CIP was updated to document projects that have been completed since 2010, and projects that have been added based on new pipeline condition information gathered through the District's closed circuit television inspection program. The updated CIP is shown in Table 2.

The updated CIP assumes that the Marsh Road Diversion Project is not required within the CIP timeframe, and adjusts the pipeline rehabilitation project list to reflect the District's current plan for pipeline replacements. Changes made include the following:

- Documentation that the following projects have been completed: Fletcher, Atherton, Ladera Outfall, Willow, Corte Madera Forcemain, Haven. Also completed were the Bay-Laurel projects and the Cotton Street pipeline repair;
- Renaming and deferral of project costs for the Marsh Road Diversion Project (previously the James Avenue Diversion Project) beyond the CIP timeline;
- Adjustment of costs for the Bayfront Expressway project to reflect actual bid results (\$1.5M in current and future years. Engineering costs were expended in prior years);
- Addition of the Willow Road pump station upgrade (\$110,000);
- Supplementing the Carlton Madera Easement project with the Eastside Triangle project (\$6.8M), which includes more extensive repairs;
- Addition of the Burns Easement/Marsh Road pipeline repair using CIPP (\$2.5M);
- Addition of the Laurel Easement Relief Sewer Project (\$500k);
- Consolidation and renaming of capacity improvement projects by District staff:
 - Upper and Lower Ringwood costs augmented to \$1.5M and \$1.2M, respectively
 - Upper and Lower Valparaiso combined and renamed Valparaiso
 - Upper and Lower Santa Cruz-Avy combined

Table 2. Updated Capital Improvement Plan

| Project Name | Estimated Cost | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | Future |
|--|----------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Fletcher (2011/12) | Complete | | | | | | | | | | | | |
| Atherton (2011/12) | Complete | | | | | | | | | | | | |
| Ladera Outfall (2011/12) | Complete | | | | | | | | | | | | |
| Willow (2011/12) | Complete | | | | | | | | | | | | |
| Corte Madera Forcemain (2011/12) | Complete | | | | | | | | | | | | |
| Sausal Vista PS and Forcemain | 1,300,000 | | 300,000 | 1,000,000 | | | | | | | | | |
| North Palo Alto Concrete | 1,665,000 | | 1,665,000 | | | | | | | | | | |
| Fair Oaks | 2,000,000 | | | | | | | | | 2,000,000 | | | |
| Santa Cruz | 1,004,000 | | | | | | | | 1,004,000 | | | | |
| Roble | 2,630,000 | | | | | | | 2,630,000 | | | | | |
| Stevenson | 1,155,000 | | | | | | 1,155,000 | | | | | | |
| Elena | 1,621,800 | | | | | | | | 1,621,800 | | | | |
| Carlton-Madera Easements | 2,504,000 | | | | | 1,150,000 | 1,354,000 | | | | | | |
| College Park North | 2,213,000 | | | | | | | | | | 2,213,000 | | |
| Oak Grove | 1,261,000 | | | | | | | | | | | | 1,261,000 |
| Encinal A | 2,289,000 | | | | | | | | | | | | 2,289,000 |
| Oak Knoll | 845,000 | | | | | | | 845,000 | | | | | |
| Encinal B | 2,170,000 | | | | | | | | | | | | 2,170,000 |
| Bayfront Expressway | 1,250,000 | 1,250,000 | | | | | | | | | | | |
| Menalto Easements | 788,000 | | | | | | | | | 788,000 | | | |
| Berkeley | 1,213,000 | | | | | | | | | | | | 1,213,000 |
| Frederick | 559,000 | 559,000 | | | | | | | | | | | |
| Haven (different than 2011 emergency repair) | 400,000 | | | | | | | 400,000 | | | | | |
| Suburban Park | 1,500,000 | 1,500,000 | | | | | | | | | | | |
| Willow Road Pump Station | 110,000 | 110,000 | | | | | | | | | | | |
| Hamilton Henderson Pump Station (Generator) | 155,000 | | 155,000 | | | | | | | | | | |
| Stowe Lane Pump Station | 1,003,000 | | | 200,600 | 802,400 | | | | | | | | |
| Village Square (Generator) | 80,000 | | 80,000 | | | | | | | | | | |
| Marsh Road/Burns Easement CIPP | 3,000,000 | | 1,000,000 | | 1,000,000 | 800,000 | 200,000 | | | | | | |
| Eastside Triangle (adjacent to Carlton-Madera Easements) | 6,990,000 | | 250,000 | 2,250,000 | 1,800,000 | 1,650,000 | 1,040,000 | | | | | | |
| Laurel Easement Relief Project | 500,000 | | | | | | | | | | 500,000 | | |
| Pump Stations (Miscellaneous) | 575,000 | | | | 150,000 | 150,000 | | 75,000 | | | 200,000 | | |
| Point Repairs (Miscellaneous) | 600,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 | 50,000 |
| Subtotal R&R | \$ 41,380,800 | \$ 3,469,000 | \$ 3,500,000 | \$ 3,500,600 | \$ 3,802,400 | \$ 3,800,000 | \$ 3,799,000 | \$ 4,000,000 | \$ 2,675,800 | \$ 2,838,000 | \$ 2,963,000 | \$ 50,000 | \$ 6,983,000 |
| Marsh Road Diversion (formerly James Avenue) | Under Review | | | | | | | | | | | | |
| Lower Ringwood | 1,200,000 | | | | | | | | 1,200,000 | | | | |
| Valparaiso | 450,000 | | | | | | | | | | 450,000 | | |
| Willow Gravity Main | 200,000 | | | | | | | | | | 200,000 | | |
| Upper Ringwood | 1,500,000 | | | | | | | | 125,000 | 1,375,000 | | | |
| Atherton Avenue East (2011/12) | Complete | | | | | | | | | | | | |
| Santa Cruz-Avy | 1,100,000 | | | | | | | | | | | 1,100,000 | |
| Cambridge Laurel | 3,300,000 | | | | | | | | | | | 3,300,000 | |
| Middlefield at Fair Oaks | 502,000 | | | | | | | | | | 502,000 | | |
| Subtotal Capacity | \$8,252,000 | - | - | - | - | - | - | - | 1,325,000 | 1,375,000 | 1,152,000 | \$ 4,400,000 | \$ - |
| Total CIP | \$ 49,632,800 | \$ 3,469,000 | \$ 3,500,000 | \$ 3,500,600 | \$ 3,802,400 | \$ 3,800,000 | \$ 3,799,000 | \$ 4,000,000 | \$ 4,000,800 | \$ 4,213,000 | \$ 4,115,000 | \$ 4,450,000 | \$ 6,983,000 |

- Upper and Lower Willow PS Gravity Main combined and renamed Willow Gravity Main
- Atherton Avenue East deleted
- Cambridge Laurel added for \$3.3M
- Reallocation of costs to maintain approximately \$3.5M in the first three years of the program, increasing to \$3.8M in years four through six, \$4.0M in years 7 through 9, and \$4.2M through the remainder of the planning period.

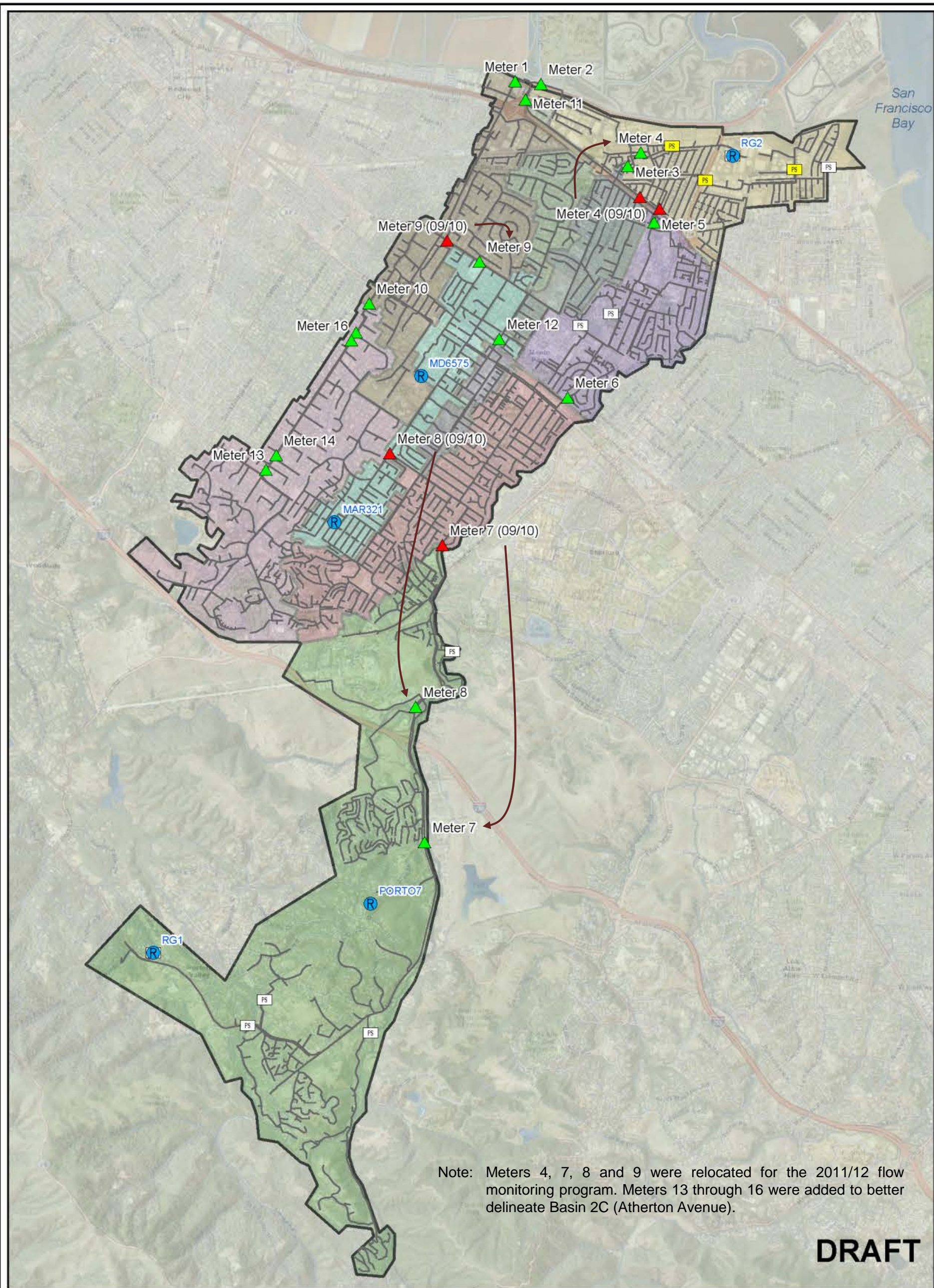
This revised CIP will be further updated and included in a future revision to the District's Master Plan. In addition to provided updates to the listed CIP projects, the updated Master Plan will recognize any changes in flows and capacity that have resulted from the District's large diameter pipeline cleaning program, which is ongoing⁴. It is anticipated that the Master Plan revision will be completed in late 2013, after completion of the 2012/13 flow monitoring program and subsequent hydraulic model update.

NEXT STEPS

Recommended next steps include the following:

- Conduct wet weather flow monitoring during 2012/2013 or a subsequent year with substantial rainfall preceded by sufficient rainfall to create saturated conditions. This effort will provide a 3rd data point to improve accuracy in calibration results.
- Recalibrate the hydraulic model using the new flow data and review associated capital improvement needs. The recalibrated model will also be used to confirm projected flows at the MPPS.
- Update the Sewer Collection System Master Plan to integrate results from this TM and results from updated calibration and system analysis.
- Continue with CIP implementation, including completion of the Bayfront Expressway project (under construction) and Frederick Avenue pipeline repairs (in design), as well as designs for additional projects shown in Fiscal Year 2013/14 of the updated CIP.

⁴ Beginning in 2010 and 2011, the District started cleaning its larger pipelines, creating additional capacity and possibly improving system hydraulics. In 2013, the District plans to clean the 54-inch interceptor directly upstream of the Menlo Park Pump Station.



Note: Meters 4, 7, 8 and 9 were relocated for the 2011/12 flow monitoring program. Meters 13 through 16 were added to better delineate Basin 2C (Atherton Avenue).

DRAFT

LEGEND

Flow Monitoring Locations

- ▲ 2011/2012
- ▲ 2009/2010
- Ⓡ Rain Gage

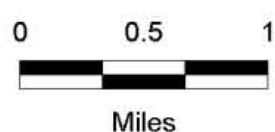
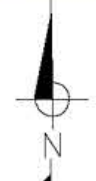


FIGURE 1

**West Bay Sanitary District
Hydraulic Model Recalibration**

Flow Meter Sites and Basins



Figure 2. January 2012 Rainfall @ Gauge MD6575

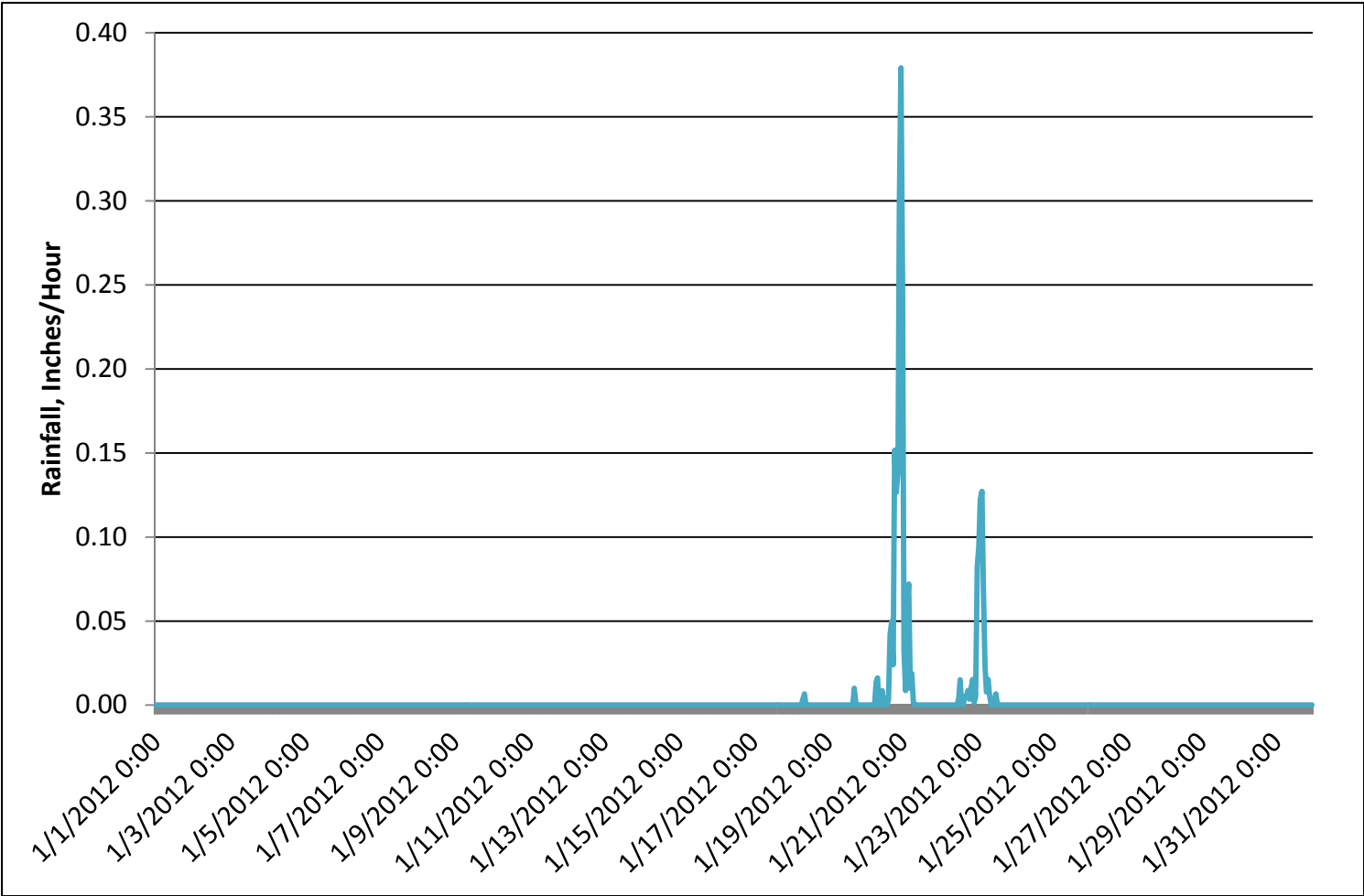


Figure 3. February 2012 Rainfall @ Gauge MD6575

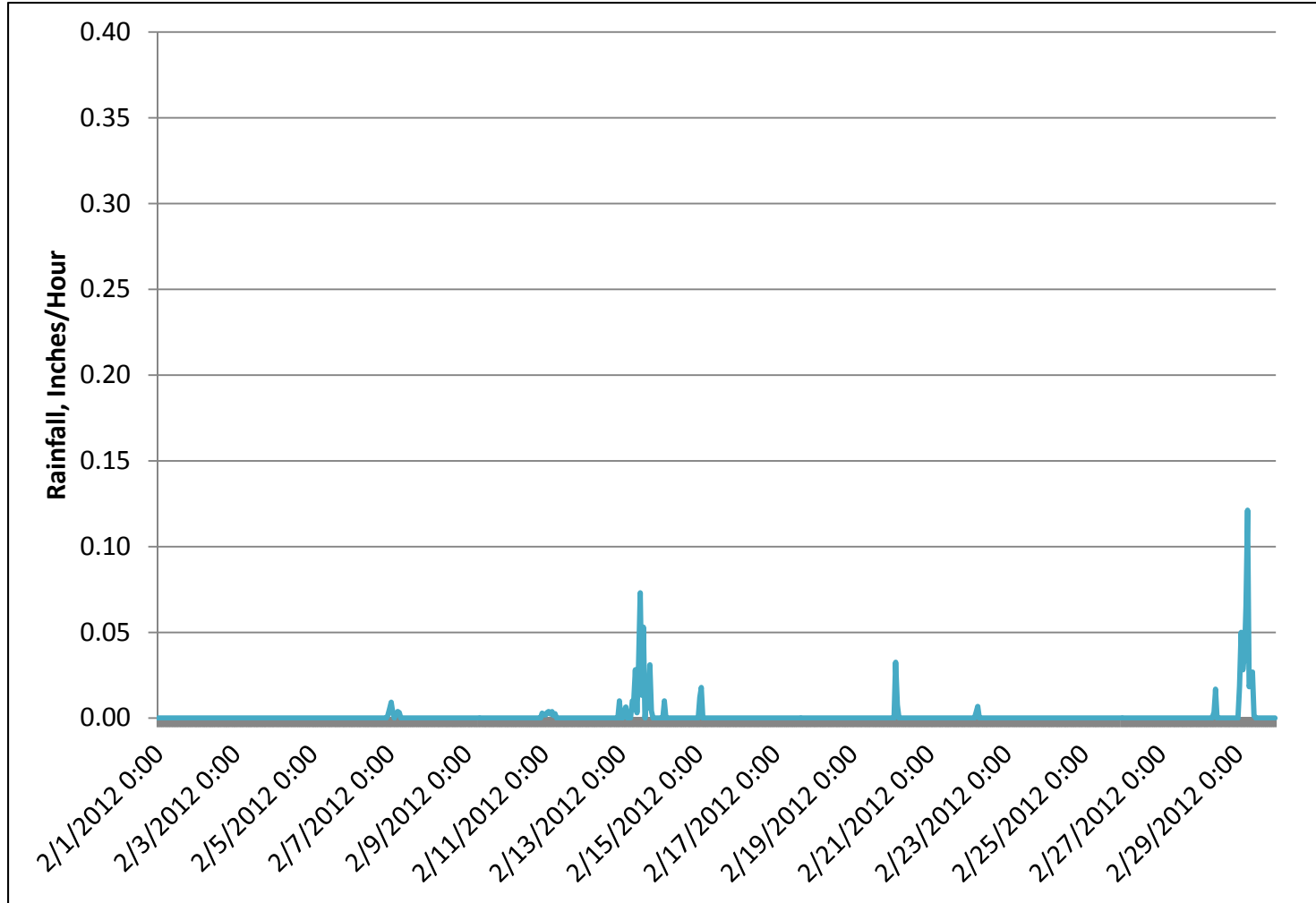


Figure 4. March 2012 Rainfall @ Gauge MD6575

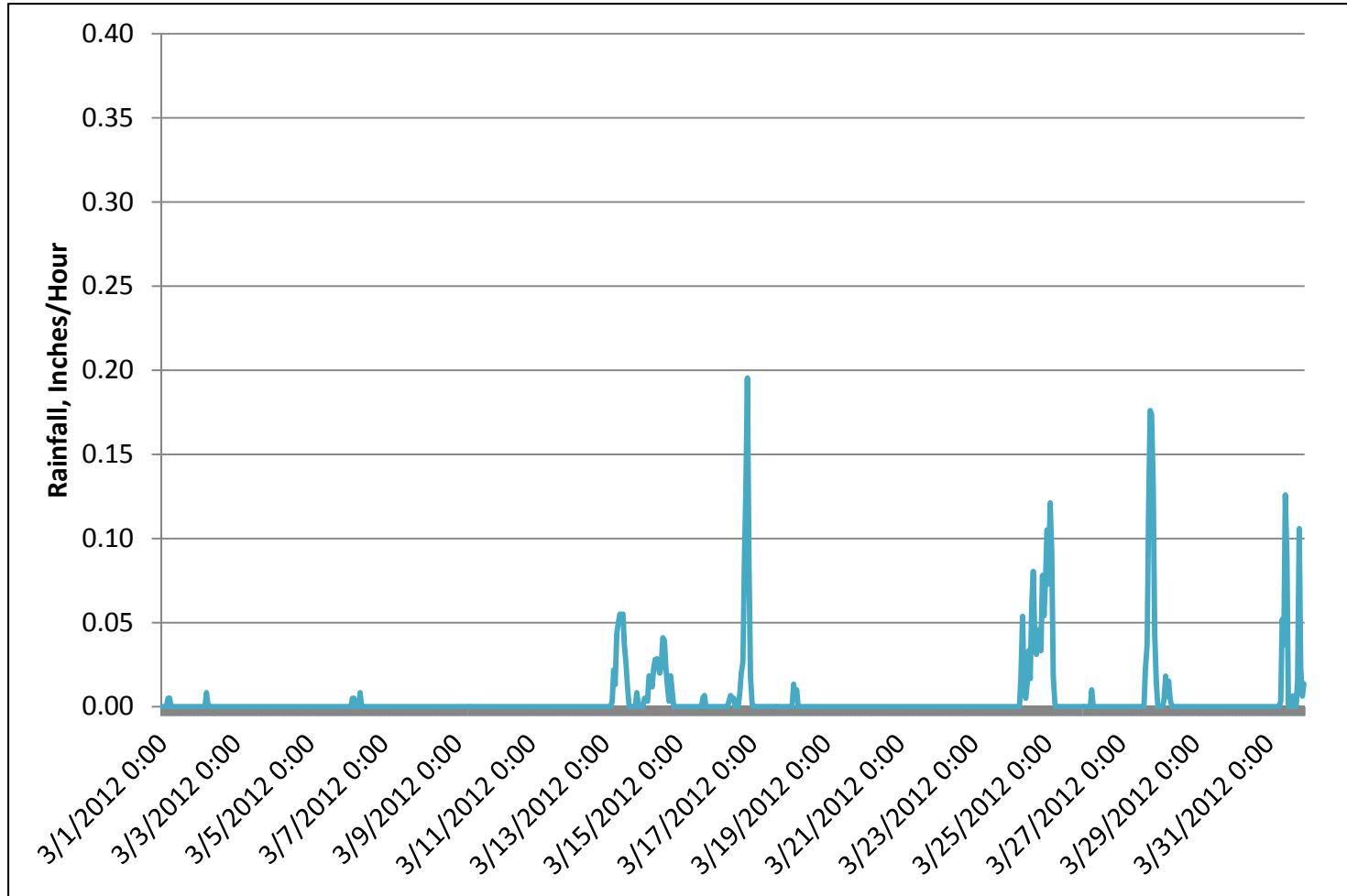


Figure 5. Comparison of Basin 2B (Marsh Road) Flows

