Livingston County Water Quality Monitoring - 2020 Tributary Program

Report Submitted to
The Livingston County Planning Department

By

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Summary

- Eleven streams were sampled for water quality in 2020. Former USDA study tributaries were monitored to continue long term monitoring efforts in the BMP streams and a reference stream. Additional non-BMP streams were added for 2020 monitoring efforts.
- We completed a short-term follow-up to a streambank remediation study that began in 2008 at established sites upstream ("reference") and downstream ("remediated") from restoration activities on North McMillan Creek, North Gully, and Wilkins Creek
- In 2020, we observed greater TSS concentrations downstream of the remediated site at North Gully, indicating erosion may be occurring between the upstream and downstream sites. While this was not observed during baseflow conditions, it was evident during storm events. In 2020, we saw a similar pattern to 2008 in Wilkins Creek, where upstream of the remediation had greater TSS concentrations than the downstream site. In 2020, average baseflow TSS concentrations in North McMillan Creek were slightly greater at the upstream than downstream site. However, this pattern was reversed during high flow conditions following storm events, with greater TSS at the downstream site than upstream site. These patterns and observations from the field sampling crew indicated that the stream bank erosion control is failing near the upstream site, and that significant erosion is occurring on this reach of North McMillan Creek.
- Graywood Gully and Southwest Creek continue to have some of the highest concentrations of phosphorus (dissolved and particulate) of all of the streams monitored.
- Heavily agricultural watersheds continue to show greater nutrient concentrations than the reference stream, North McMillan Creek, and streams that have less agricultural activities occurring in their watersheds (e.g., North Gully and Wilkins Creek).
- Compared to historical concentration data, average loadings of nutrients and sediments were among the highest documented since the early and mid-2000s in several of the USDA BMP tributaries.

Recommendations

- Increased year-round tributary sampling frequency, especially in the spring runoff period, for former USDA tributaries and other major tributaries, as allowed by resources and funding. Selected tributaries could potentially be sampled annually on a rotating basis.
- Storm events should be sampled more frequently, as storm events have the potential to carry much greater concentrations and loads of nutrients into Conesus Lake than baseflow conditions.
- Current information on agricultural practices for the USDA tributaries and other subwatersheds is needed.
- During heavy storm events, North McMillan Creek TSS concentrations are very high, as a result of streambank erosion and potentially changes in land use occurring in the watershed. Given the importance of North McMillan as a major tributary to Conesus Lake, and its historical use as a reference watershed, segment analysis in 2021 is recommended on this stream to determine potential sources of high TSS concentrations observed during storm events in 2020.

Background

USDA Streams

In the early 2000s, several small tributary sub-watersheds of Conesus Lake were selected to evaluate if agricultural BMPs could reduce soil and nutrient runoff to the lake and whether impacts of reduced loadings on the lake ecosystem could be documented (Herendeen and Glazier 2009; Makarewicz et al. 2009). Monitoring began in September 2002 (Makarewicz et al. 2008). BMP implementation was voluntary for farms on selected tributaries (Herendeen and Glazier 2009). Watersheds were selected based on the type of agricultural activities occurring, whether the farmers wanted to voluntarily use BMPs, if there was previous knowledge of sediment and nutrient loss in the watershed, and if macrophytes and algal cover were present in stream mouths in the lake (Herendeen and Glazier 2009). Selected watersheds included Graywood Gully, Cottonwood Gully, Long Point Gully, Sand Point Gully, Sutton Point Gully, and North McMillan Creek. Watershed area, management practices implemented, and agricultural percentage in watersheds for selected tributaries are found in Table 1. Most selected BMP tributaries received a mix of cultural and structural BMPs (e.g., installation of grass filter strips and reduction in winter manure spreading on Graywood Gully) (Table 1). All tributaries were sampled at the base of their watersheds during the entire study (Herendeen and Glazier 2009). A main goal of implementing BMPs was to reduce the abundance and biomass of algal cover and macrophytes in the lake by reducing nutrient loss in watersheds and nutrient input near stream mouths (Makarewicz et al. 2001; Makarewicz et al. 2009). However, it is realized that recovery is not instantaneous and other systems where BMPs were implemented, such as Irondequoit Bay and Lake Erie, took as long as 20-25 years to improve water quality (Makarewicz et al. 2001). Water quality should improve locally near the stream mouths where BMPs were implemented faster than the rest of the lake.

Prior to BMP implementation, high concentrations of nutrients during storm events were measured in Graywood, Hanna's Creek, Sand Point, Long Point Gully, and North Gully (Makarewicz et al. 2001). High nitrate/nitrite concentrations were documented in Long Point Gully, Cottonwood Gully, Sutton Point, Rivulet 5989 (also named Southwest Creek), Graywood Gully, and North Gully (Makarewicz et al. 2001). High concentrations of nutrients were measured during baseflow conditions in Graywood Gully as well, indicating water quality degradation (Makarewicz et al. 2001).

After BMPs were implemented, periodic monitoring continued on study tributaries (Makarewicz et al. 2009). Graywood Gully was found to have the greatest percent reduction in concentrations (55% lower) across the largest suite of analytes (e.g., total phosphorus, orthophosphate (i.e., soluble reactive phosphate, SRP), nitrate/nitrite, and total suspended solids) prior to 2009 (Makarewicz et al. 2009). With implementation of cultural and structural BMPs, major impacts on soil and nutrient losses were documented (Makarewicz et al. 2009). Significant reductions in concentrations of nitrate/nitrite during all flow regimes were observed when fields were planted with vegetative crops or left fallow, while reductions in total nutrients (total plus dissolved) were measured following structural BMP implementation (Makarewicz et al. 2009). While significant reductions of nutrients were observed after implementing BMPs in managed streams, ambient concentrations remained above those measured in pristine streams (Makarewicz et al. 2009). In contrast, after 5 years of monitoring, suspended solids concentrations were not significantly different from the reference watershed (North McMillan) during non-event and event sampling after 5 years of monitoring (Makarewicz et al. 2009). It is possible that the full effect of BMPs on nutrients was still not realized after 5 years of post-monitoring.

In 2015, more than a decade after initial BMP’s were introduced, monitoring of Long Point Gully, Graywood Gully, and Sutton Point Gully was performed after some additional BMPs were implemented (Lewis and Makarewicz 2015). Generally, decreases in total phosphorus (except Graywood Gully), total suspended solids, and nitrate/nitrite were observed with the addition of more BMPs (Lewis and Makarewicz 2015). It is likely that total phosphorus did not improve in Graywood Gully because BMP construction was occurring in the watershed during the study period (Lewis and Makarewicz 2015). However, SRP was elevated in all three watersheds compared to historical data (Lewis and Makarewicz 2015). It is unclear as to why SRP concentrations had increased in streams draining these watersheds; but was recommended that additional BMPs be installed that help reduce soluble nutrient runoff.

In general, the implemented BMPs have demonstrated that water quality can be improved both within tributaries and in-lake near tributary mouths. Bacteria, macrophytes, and algae can be reduced from these practices (Makarewicz et al. 2008; Bosch et al. 2009; Makarewicz and Lewis 2009). Water quality should continue to be monitored in the USDA study streams to evaluate whether water quality conditions are improving in these watersheds and in the lake (Makarewicz et al. 2008; Makarewicz and Lewis 2009). Continued monitoring of these tributaries can also guide future BMP and management efforts designed to improve water quality and ecosystem health of Conesus Lake and its tributaries.

Erosion Control and Streambank Remediation

In March 2008, the Livingston County Planning Department conducted a preliminary study of several high priority impacted streams to collect baseline data on suspended solids prior to streambank restoration. Pre-remediation data on total suspended solids were collected during the summer of 2008 from stream reaches of North McMillan and Wilkins Creeks and North Gully. Results indicated that sediment erosion was more evident (highest to lowest) at North McMillan, Wilkins, and least at North Gully. Subsequently, stream bank remediation projects were constructed on segments of North McMillan, Wilkins, and North Gully.

In summer and fall of 2019, SUNY-Brockport and SUNY-Geneseo began a follow-up study to assess the effectiveness of the 2008 streambank stabilization projects that were implemented as part of the Conesus Lake Watershed Management Plan. Samples were collected monthly from July until October during baseflow and 1 storm event (5 total sampling dates). However, the spring high-water period and storm event periods were not adequately represented during sampling. The 2020 and 2019 data sets, when compared to pre-remediation data, enables managers to determine the effectiveness of these remediation projects. The findings will inform a cost-benefit analysis of streambank stabilization projects by Livingston County.

Methods

Eleven streams were sampled for water quality in 2020. Former USDA study tributaries were monitored to continue long term monitoring efforts in the BMP streams and a reference stream. (Tables 1 and 2; Appendix 1). Some additional non-BMP streams were added for 2020 monitoring efforts (Tables 1 and 2; Appendix 1). We also performed a short-term follow-up to a streambank remediation study that began in 2008 at established sites upstream ("reference") and downstream ("remediated") on North McMillan Creek, North Gully, and Wilkins Creek (Tables 1 and 2; Appendix 1). Pre-remediation sampling was conducted on stream in 2008 to provide a baseline for comparison. The 2008 sampling design was replicated in spring 2020 to compare nutrient and sediment loss under comparable streamflow conditions. All tributary sites were monitored bi-weekly from April 13^{th} 2020 to May 29^{th} 2020, except erosion study tributaries which were sampled bi-weekly from April 13^{th} 2020 to May 14^{th} 2020. All tributary sites (except upstream "reference" sites in erosion control study) were then sampled monthly from June 2020 to December 2020. A total of 12 sampling events were captured for selected tributaries. Sampling dates were classified as baseflow or hydrometeorological event (>0.5 inches of precipitation in a 24h period, based on information from the Conesus Lake Association weather station at the north end of the lake and the National Weather Service) (Table 4).

Each sampling event consisted of 1) collecting water samples for laboratory analyses, including total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN), nitrate/nitrite (NOx), and orthophosphate (i.e., soluble reactive phosphorus, SRP); (2) stream discharge measurements; (3) *in-situ* water chemistry measurements, including temperature, dissolved oxygen, pH, conductivity, and turbidity; and (4) field observations (Table 3). Water chemistry samples were collected from flowing water using a grab sampler and plastic bucket that was rinsed with deionized water and respective stream water at each site prior to sample collection. Water was not collected from streams that contained stagnant water or were dry. Samples were appropriately processed and placed into pre-cleaned and labeled bottles according to standard methods and stored on ice while in the field (Table 3). SRP and nitrate/nitrite were immediately filtered on site with 0.45-µm syringe filters. One field duplicate and field blank were collected during each sampling event. All water chemistry samples were analyzed by the SUNY-Brockport Limnology Laboratory (ELAP ID #12116) within standard hold times. *In-situ* measurements were obtained by using a calibrated YSI multimeter probe. Stream discharge was estimated on select days, when possible, unless stream depth was too shallow. Stream staff gauges were used at each tributary site, and rating curves were developed (see appendix 3). Established rating curves were used to estimate discharge during selected sampling trips.

Results and Discussion

Erosion Control and Streambank Remediation

TSS is a measure of the amount of sediment, soil and other organic and inorganic matter being transported in the water and is an indicator of erosion. In 2019-2020, samples were collected during the summer and early fall (2019) and spring runoff period (2020). In 2008, samples were collected during late spring and summer. The spring sampling period is critical in determining the overall success of prior stream bank restoration projects, particularly in North McMillan Creek, where most TSS samples were below detection (LOD = 4 mg/L, Life Sciences Laboratory, ELAP ID #2048) in summer and fall 2019. For TSS data analysis, samples below the 2019 limit of detection (4 mg/L) were replaced with a value of LOD/2 for statistical testing. In 2020, we saw a considerable increase in average TSS concentrations compared to 2008 and 2019, particularly in North Gully and North McMillan Creeks (Figure 1 A and E). These overall increases were likely due to greater flow and greater connectivity of the watershed to the streams from spring runoff.

<u>North Gully (Figure 1 a and b)</u>

In North Gully, data from 2008 showed that average TSS concentrations were slightly greater upstream of the remediated stream bank site than downstream. This pattern was also observed in average 2019 TSS concentrations. In 2020, we saw greater TSS concentrations downstream of the remediated site, indicating erosion may be occurring between the upstream and downstream sites. While this was not seen during baseflow conditions, it was evident during storm events. Observations and photographs from sampling personnel indicated possible erosion occurring at the remediated zone (Appendix 4)

<u>Wilkins Creek (Figure 1 c and d)</u>

At Wilkins Creek, 2008 average TSS data indicated that the upstream site had considerably higher TSS concentrations than the downstream sites. In 2019, the opposite pattern was observed; TSS concentrations were greater downstream than upstream of the remediated zone. However, road and bridge replacement were occurring at our downstream site, which may have influenced greater TSS concentrations. In 2020, we saw a similar pattern to 2008 data, where upstream of the remediation had greater TSS concentrations than the downstream site. This pattern was consistent during baseflow and storm event sampling. These results may indicate that erosion and sediment loss between sites is less in magnitude on this stream. Alternatively, observed patterns may be the result of longer stream distance between sampling locations on Wilkins Creek (versus North Gully and North McMillan), with the potential for eroded sediment to settle to the stream bed before reaching the downstream site.

<u>North McMillan Creek (Figure 1 e and f)</u>

In North McMillan Creek, 2020 average TSS concentrations were comparable between the upstream and downstream sites. 2008 showed a much greater sediment concentration downstream than upstream, evidence that stream bank erosion was occurring between the sites. In 2020, average baseflow TSS concentrations were slightly higher at the upstream site than downstream site. In contrast, TSS concentrations were greater at the downstream site than upstream site during storm events. This indicates that stream bank erosion is still occurring. Observations from the sampling crew along with these data provide evidence that prior stream bank restoration efforts may be failing near the upstream site, and that significant erosion is occurring close to the downstream site (Appendix 4).

USDA BMP streams and other non-BMP stream monitoring activities

The former "USDA streams" were monitored biweekly from April 2020 to end of May 2020 and monthly from June 2020 until December 2020 to assess if nutrients and TSS concentrations and loads from watersheds were improving, declining, or stable, relative to the historical data (Makarewicz and Lewis 2010). Concentration and loading data from 2020 were compared to past data collected by Makarewicz and Lewis (2010) in 2003-2010 from May through August. In 2020, TKN was calculated by subtracting NOx concentration from TN concentration. It is important to note that sample frequency changed in 2020; samples were collected weekly from 2003 to 2010, but biweekly in May 2020 and monthly from June to August 2020. Historical concentration and loading data from May through August are presented as averages by year on bar graphs with standard error of the mean bars to compare the data. Loading data were also compared using ANOVA and Tukey's post-hoc tests to determine if significant differences existed between 2020 and historical data. 2020 sampling concentration and loading data were also compared across sampling dates to examine water quality differences and if any temporal patterns exist on USDA tributaries and the additional 2020 study tributaries.

Graywood Gully (Tables 1 and 5, Figures 2 a-j and 10 a-f, appendix 2 and 3):

In Graywood Gully, numerous BMPs were implemented in the watershed as part of the USDA study including reducing fertilizer, ceasing winter manure spreading, utilizing cover crops, and removing cattle from the stream (Table 1). Compared to historical data, total phosphorus (TP), SRP, and TSS concentrations were higher in 2020 than in all prior sampling years (i.e., 2003-2010 in May through August) (Table 5, Figure 2 a, c, e, g, and i). Furthermore, 2020 TP, SRP, and TSS loadings were higher than every year except 2010 and 2004 (Figure 2 b, d, f, h, and j). 2020 nitrate/nitrite and TKN were greater than loadings observed from 2006 to 2009 (Figure 2 b, d, f, h, and j). Loadings for 2020 TP, SRP, TSS, nitrate/nitrite, and TKN were significantly greater than 2008 and 2009 ($p<0.05$). 2020 TSS loading was also significantly greater than 2007 loading.

In 2020, we observed the highest TP, SRP, and TSS concentrations and loadings during the spring period, before the stream was dry from July through October. The greatest nitrate/nitrite and TKN concentrations were observed in December; however, the greatest loadings occurred in the spring period (Figure 10 a-f).

Sand Point Gully (Tables 1 and 5, Figures 3 a-j and 16 a-f, appendix 2 and 3):

Numerous BMPs were implemented in the Sand Point Gully watershed as a part of the USDA study, including rotational grazing, cattle fenced off from the stream, and crop rotation (Table 1). In 2020, we observed relatively similar concentrations of TP, SRP, and TSS to concentrations from 2003 to 2009 (monitoring did not occur in 2010) (Table 5, Figure 3 a, c, and i). In contrast, nitrate/nitrite concentrations were the highest of any other year in 2020, while TKN was the lowest of any other year in 2020 (Table 5, Figure 3 e and g). In 2020, TP, TKN, and TSS loadings were the highest observed since 2004, while SRP and nitrate/nitrite loadings were the highest since 2005 (Figure 3 b, d, f, h, and j). However, the 2020 loadings were not significantly different than loadings observed in 2003 through 2009 for all analytes measured, except nitrate/nitrite.

In 2020, we saw the greatest SRP concentrations during the summer and fall sampling periods. However, loading was lowest during the summer and fall, and was greatest in the spring (Figure 16 a and b). TP concentrations were also high during the summer and fall periods, but loading was lowest during this period and greatest during the spring (Figure 16 a and b). We saw the lowest nitrate/nitrite concentrations during the early spring before increasing in the late spring and summer (Figure 16 c). Nitrate/nitrite concentrations were greatest during the late summer and early fall period. Nitrate/nitrite loading was the lowest during the late summer and fall, and highest during the spring (Figure 16 d). TKN concentrations were relatively stable throughout the sampling period and the greatest loading occurred during the spring (Figure 16 c and d). TSS concentrations varied throughout the sampling period (Figure 16 e). The greatest TSS loading occurred during the spring and lowest loading occurred during the fall (Figure 16 f).

Long Point Gully (Tables 1 and 5, Figures 4 a-j and 12 a-f, appendix 2 and 3):

In Long Point Gully, BMPs were implemented in the watershed during the USDA study, and included a reduction in cropland, ceasing winter manure spreading, and injection of manure instead of spreading (Table 1). Compared to historical data, the greatest TP and TSS concentrations since 2004 were observed in 2020 (Table 5, Figure 4 a and i). 2020 SRP, Nitrate/nitrite, and TKN concentrations were similar to historical data (Table 5, Figure 4 c, e, and g). 2020 TP, SRP, TSS, and TKN loadings were the greatest since 2005 (Figure 4 b, d, h, and j). Nitrate/nitrite loading was less than 2010 loading, but greater than loading observed from 2006-2009 (Figure 4 f). However, loadings for all analytes in 2020 were not significantly greater than historical loading. This may indicate that BMPs are being maintained in the watershed, however Long Point Gully was dry during sampling from June through October due to prolonged dry weather.

In 2020, the greatest TP and SRP concentrations were observed in the spring during storm events (Figure 12 a). TP and SRP loadings were also the greatest during the spring (Figure 12 b). The greatest nitrate/nitrite concentrations were observed during fall sampling while the greatest TKN concentrations were observed during the spring (Figure 12 c). Nitrate/nitrite loading was greatest during the fall and during spring storm events, and TKN loading was greatest in the spring (Figure 12 c). TSS concentration and loading was greatest during the spring Figure 12 e and f).

Sutton Point Gully (Tables 1 and 5, Figures 5 a-j and 18 a-f, appendix 2 and 3):

Sutton Point Gully had gully plugs installed and a 60% cropland conversion to alfalfa during the USDA study (Table 1). Compared to historical data, the greatest TP and TSS concentrations since 2004 were seen in 2020 (Table 5, Figure 5 a and i). The greatest SRP and nitrate/nitrite concentrations were also observed in 2020 (Table 5, Figure 5 c and e). TKN concentrations were lower in 2020 than most years in the historical dataset (Table 5, Figure 5 g). However, 2020 loading data shows that TP, SRP, TKN, and TSS were among the lowest observed in the historical data, but were not significantly lower (Figure 5 b, d, h, and j).

Nitrate/nitrite loading was the greatest in 2020 for all years except 2004, but was not significantly greater than historical loading (Figure 5 f).

In 2020, the greatest TP and SRP concentrations occurred during the late spring through the fall (Figure 18 a). Loading was relatively consistent during all sampling trips, but was greatest during September (Figure 18 b). Nitrate/nitrite concentrations were the greatest during the spring and fall, and lowest during the summer (Figure 18 c). TKN concentrations were relatively consistent throughout the sampling period (Figure 18 c). The greatest nitrate/nitrite loading occurred during the spring and late fall while TKN loading remained relatively consistent through the sampling period (Figure 18 d). TSS concentrations were greatest during the late summer period (Figure 18 e). TSS loading was relatively consistent during the sampling period, except for the September sampling date, where loading was high (Figure 18 f). Possible disturbance upstream may have influenced the high TSS and TP concentrations and loading during our September sampling date and is likely not indicative of land use.

Cottonwood Gully (Tables 1 and 5, Figures 6 a-j and 9 a-f, appendix 2 and 3):

Numerous BMPs were implemented in the Cottonwood Gully watershed during the USDA study including cover crops, reducing cropland area, installing gully plugs and ceasing fall tillage activities (Table 1). Compared to historical data, SRP concentrations were the highest in 2020 (Table 5, Figure 6 c). TP and TSS concentrations were the greatest since 2004/2005 in 2020 (Table 5, Figure 6 a and i). TKN and nitrate/nitrite concentrations were lower in 2020 than some past years (Table 5, Figure 6 e and g). 2020 TP loading was relatively consistent to historic loading, and 2020 SRP loading was the lowest since 2007 but not significantly lower than 2008-2010 loading (Figure 6 b and d). Nitrate/nitrite and TKN loading in 2020 were significantly lower than loadings observed in 2010 (Figure 6 f and h). TSS loading in 2020 was the greatest since 2005, but was not significantly greater (Figure 6 j).

In 2020, TP and SRP concentrations were generally the greatest during the late spring and summer sampling periods, but loading was generally lowest during the summer period (Figure 9 a and b). Nitrate concentration was the lowest during the summer and highest during the spring and late fall (Figure 9 c). Nitrate loading showed a similar pattern, and was lowest during the summer (Figure 9 c). Nitrate/nitrite loading was the greatest during the May 1st 2020 storm event (Figure 9 d). TKN concentration was relatively consistent through the sampling period and lowest loading occurred during the summer (Figure 9 c and d). The greatest 2020 TSS concentrations were observed in September and October after gradually increasing throughout the summer (Figure 9 e). TSS loading was greatest during the May 1st storm event and in September (Figure 9 f).

Southwest Creek (Tables 1 and 5, Figures 7 a-j and 17 a-f, appendix 2 and 3)

The Southwest Creek watershed had a manure pit installed as part of the USDA BMP study (Table 1). Compared to 2003-2009 historical data (no data collected in 2010), 2020 had the greatest TP and SRP concentrations recorded (Table 5, Figure 7 a and c). TP and SRP loading in 2020 was also the highest recorded in all years except 2009, but was not significantly greater (Figure 7 b and d). Nitrate/nitrite and TKN concentrations were relatively consistent to concentrations observed in 2004-2009 (Table 5, Figure 7 e and g). Nitrate/nitrite and TKN loading in 2020 was lower than loading observed in 2009, but greater than 2004-2008 for nitrate/nitrite and greater than 2005-2008 for TKN (Figure 7 f and h). TKN loading in 2020 was significantly lower than loading observed in 2009. TSS concentrations in 2020 were consistent with concentrations observed in the historical dataset, except for 2004, which was much greater than 2020 (Table 5, Figure 7 i). TSS loading in 2020 was also relatively consistent to past years, except in 2004 (Figure 7 j).

In 2020, TP and SRP concentrations remained consistently high through the sample period (Figure 17 a). The greatest loading of TP and SRP occurred in the spring and was lower in the summer and fall (Figure 17 b). The greatest nitrate/nitrite and TKN concentrations occurred in the spring and decreased in the summer (Figure 17 c). Nitrate/nitrite and TKN loading were the greatest during the spring period in 2020 (Figure 17 d). TSS concentrations were greatest during the May 1st storm event and during the late spring and summer (Figure 17 e). Loading of TSS was greatest during the May 1st storm event but relatively consistent during other sample dates (Figure 17 f). We observed a significant growth of algae in Southwest Creek during the late spring and early summer with the high nutrient availability in the stream water (appendix 4).

<u>North McMillan Creek (Tables 1 and 5, Figures 8 a-j and 15 a-f, appendix 2 and 3)</u>

North McMillan Creek was the reference watershed during the USDA study due to its low agricultural land use and did not have any BMPs installed in the watershed during the BMP study (Table 1). In 2020, TP and SRP concentrations were relatively similar to historical concentrations, except SRP in 2010 which was much greater than all monitoring years (Table 5, Figure 8 a and c). Loading of TP and SRP in 2020 was also consistent with other historical loading data, except 2004 which was much higher than all other monitoring years (Figure 8 b and d). Nitrate/nitrite concentrations and loading remained relatively stable in 2020 (Table 5, Figure 8 e and f). TKN concentrations were the lowest in 2020 compared to all other years in the historical dataset, and 2020 loading was consistent with most years (Table 5, Figure 8 g and h). TSS concentrations continued to remain low (Table 5, Figure 8 i). TSS loading in 2020 was greater than all years except 2004 and 2009, but was not significantly greater (Figure 8 j).

In 2020, TP concentrations were greatest during the spring, and greatest loading occurred during the spring storm events (Figure 15 a and b). SRP concentrations were relatively stable throughout the sampling period (Figure 15 a). TP and SRP loading were lowest during the summer and fall months (Figure 15 b). Nitrate/nitrite and TKN concentrations remained relatively stable throughout the sampling period and the greatest loading occurred during the spring storm events (Figure 15 c and d). TSS concentrations were greatest during the spring, and lowest during the summer and fall, except during August and October (Figure 15 e). TSS loading was greatest in the spring, especially during storm events and very low in the summer and fall (Figure 15 f).

<u>Hanna's Creek (Table 1, Figure 11 a-f, appendix 3):</u>

Hanna's Creek was not included in the USDA BMP study, but monitored in 2020 for water quality (Table 1). In 2020, we observed high total phosphorus concentrations in the spring and summer (Figure 11 a). SRP concentrations were the greatest during the late spring and summer (Figure 11 a). Loading for TP and SRP was greatest during the spring (Figure 11 b). No loading data is calculated during the April 13th sampling date because discharge was not measured and the staff gauge was not installed yet. Hanna's Creek was dry in September and October. Nitrate/nitrite concentration was greatest in November and December and during the spring (Figure 11 c). Nitrate/nitrite loading was greatest during the spring and fall (Figure 11 d). TKN concentrations were relatively consistent during the sampling period and greatest loading occurred during the spring and fall sampling periods (Figure 11 c and d). The greatest TSS concentrations and loading occurred during the spring period (Figure 11 e and f). Compared to BMP tributaries, Hanna's Creek had greater TP and SRP concentrations than Cottonwood, Long Point, Sand Point, and Sutton Point, and was considerably greater than the reference stream, North McMillan Creek. Hanna's Creek also has greater nitrate/nitrite and TKN concentrations than North McMillan Creek and greater TSS concentrations than Cottonwood, Long Point, Sand Point, Southwest Creek and North McMillan Creek. Loading for nutrients is also greater than numerous BMP tributaries as Hanna's Creek generally had greater discharge.

No Name Creek (Table 1, Figure 13 a-f, appendix 3):

No Name Creek was not included in the USDA BMP study, but monitored in 2020 for water quality (Table 1). No Name Creek was dry from June through October. TP and SRP concentrations were the greatest during the May 1st storm event, and were relatively high during other sampling dates (Figure 13 a). The greatest loading of TP and SRP occurred during the May 1st storm event, and was much lower during the other sampling dates (Figure 13 b). Nitrate/nitrite concentrations were greatest during November and December sampling and were relatively consistent in the spring time (Figure 13 c). Nitrate/nitrite loading was greatest during the May 1st storm event and during the fall (Figure 13 d). TKN concentrations and loading were the greatest during the spring (Figure 13 c and d). TSS concentrations were the greatest during the spring, and greatest loading occurred during the spring storm events (Figure 13 e and f). Significant stream bank erosion is occurring at this sampling site (Appendix 4). Compared to BMP tributaries, No Name Creek has greater TP and SRP concentrations than Long Point, Sand Point, Sutton Point, and the reference stream, North McMillan Creek. No Name Creek also has greater nitrate/nitrite and TKN concentrations than Cottonwood, Sand Point, Southwest Creek and North McMillan Creek. Loading is also greater than numerous BMP tributaries that had less stream discharge.

North Gully (Tables 1 and 5, Figure 14 a-f, appendix 3):

North Gully was not included in the USDA BMP study, but monitored in 2020 for water quality (Table 1). In 2020, we saw the greatest TP concentrations in the spring and during the late summer (Figure 14 a). SRP concentrations were greatest during the summer and early fall (Figure 14 a). Loading for TP and SRP was the greatest during the spring (Figure 14 b). Nitrate/nitrite concentrations varied throughout the sampling period and greatest nitrate/nitrite loadings occurred during the spring and late fall (Figure 14 c and d). TKN concentrations were mainly stable during the study period with the greatest loading also occurring during the spring and late fall months (Figure 14 c and d). Highest TSS concentrations and loadings occurred during the spring (Figure 14 e and f). Compared to BMP tributaries, North Gully had greater TSS concentrations than Long Point, especially in the spring. North Gully also had greater TSS, TP, SRP, nitrate/nitrite and TKN than North McMillan Creek. While concentrations of most analytes were lower than BMP tributaries, loading from North Gully was greater than numerous BMP tributaries due to greater stream discharge into Conesus Lake.

Wilkins Creek (Table 1, Figure 19 a-f, appendix 3):

Wilkins Creek was monitored in 2020 for water quality and was not included in the USDA BMP study (Table 1). In 2020, TP and SRP concentrations were the greatest during the summer and early fall (Figure 19 a). However, TP and SRP loadings were greatest during the spring and late fall in conjunction with lower stream discharge (Figure 19 b). Nitrate/nitrite and TKN concentrations were greatest during the spring and early summer (Figure 19 c). Nitrate/nitrite and TKN loadings were greatest during the spring and late fall with greater discharge (Figure 19 d). TSS concentrations in Wilkins Creek were highest from the spring until July (Figure 19 e). TSS loading was the greatest during the early spring (Figure 19 f). Compared to BMP tributaries, Wilkins Creek generally had lower concentrations of the analytes measured in 2020. Wilkins Creek had greater concentrations of the analytes than North McMillan Creek. Loading of some analytes were greater than some BMP tributaries likely due to greater stream discharge in Wilkins Creek.

Graywood Gully and Southwest Creek continue to have some of the highest concentrations of phosphorus (dissolved and particulate) of all of the streams monitored. Changes in land use activities may be occurring in these watersheds. Heavy agricultural watersheds continue to show greater nutrient concentrations than the reference stream, North McMillan Creek, and streams that have less agricultural activities occurring in their watersheds, such as North Gully and Wilkins Creek. It is important to note that sampling frequency in 2020 is much less than sampling frequency of 2003-2010, where samples were taken weekly. 2020 also had a very dry summer, which caused numerous streams to dry up, including Hanna's Creek, Graywood Gully, Long Point Gully, and No Name Creek. An increased sampling frequency in 2020 may have shown different results, and different results may have been seen if 2020 had a wetter summer. Storm events should also be sampled more frequently in future years (as allowable), as storm events have the potential to carry much greater concentrations and loads of nutrients into Conesus Lake than baseflow conditions.

Brockport graduate student, Dan Beers, thesis focuses on the same streams analyzed in this report, but with a greater attention to storm event response sampling. The work has shown that storm events in 2020 transport very high concentrations of nutrients and sediment into Conesus Lake (Appendix 5). While these data were not analyzed with the data included in this report, it is still important to show the massive amounts of nutrients and sediment being transported into Conesus Lake. Southwest Creek and Graywood Gully have been observed to have very high total phosphorus and SRP concentrations during these storm events. During several summer and fall storm event samples, the smell of chicken manure was present in the stream water in Southwest Creek. North McMillan Creek is also showing very high TSS concentrations during heavy storm events, possibly indicative of erosion occurring along the stream banks or due to changes in land use occurring in the watershed. Segment analysis is recommended on this stream in the future to determine where the source of high TSS concentrations within the North McMillan subwatershed. Long Point Gully also shows very high TP and TSS concentrations during heavy storm events. Climate change in the Finger Lakes and Great Lakes region is expected to increase the intensity and frequency of storm events into the future (USGCRP 2017), and it is important to document the outcome of greater frequency storm events on Conesus Lake tributary water quality and the water quality of the lake.

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Tables:

Table 1. Selected subwatersheds of Conesus Lake from past studies. Watershed area, percentage of agriculture in watershed and implemented management plans are listed (Herendeen and Glazier 2009; Makarewicz *et al.* 2009; Bida *et al.* 2015).

Tributary	Watershed area (ha)	Agricultural activity (% of watershed)	Implemented Management Practices
Graywood Gully	38.1	74	Winter manure spreading ceased, fertilizer reduced, drain tiles, grass filter strips, contour tillage, cover crops, cattle removed from stream
Cottonwood Gully	98.8	75	Cover crops, fall tillage ceased, 28% reduction in cropland, and gully plugs
Long Point Gully	587.9	86	37% reduction in cropland, cow removal, winter manure spreading ceased, inject manure instead of spreading
Sand Point Gully	188.0	83	9.5% area transformed to rotational grazing, cattle fenced from stream, crop rotation, soybean plants increased by 50%, gully plugs and tile drains
Sutton Point Gully	67.5	76	Gully plugs, and 60% of cropland to alfalfa
Southwest Creek	176.4	72	Manure pit installed
North McMillan Creek	1778.2	12	Reference watershed
Hanna’s Creek	760	68	Agricultural non-BMP
Wilkins Creek	630	50	Agricultural non-BMP
North Gully	700	48	Agricultural non-BMP
No Name Creek	355	68.2	Agricultural non-BMP

Table 2. Sampling Locations, Justifications, and Data Collection

Site Code	Sampling Location	GPS Coordinates		Sample Justification	Field Measurements[1]	Water Chemistry[2]
		North	West			
SAND	Sand Point Gully	42.786988	-77.722795	Prior implementation of BMPs, including: 9.5% area transformed to rotational grazing, cattle fenced from stream, crop rotation, soybean plants increased by 50%, gully plugs and tile drains	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
SUTT	Sutton Point Gully	42.741986	-77.727513	Prior implementation of BMPs, including: Gully plugs, and 60% of cropland to alfalfa	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
LONG	Long Point Gully	42.780157	-77.722837	Prior implementation of BMPs, including: 37% reduction in cropland, cow removal, winter manure spreading ceased, inject manure instead of spreading	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
COTT	Cottonwood Gully	42.757887	-77.727248	Prior implementation of BMPs, including: Cover crops, fall tillage ceased, 28% reduction in cropland, and gully plugs	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
GRAY	Graywood Gully	42.810421	-77.716416	Prior implementation of BMPs, including: Winter manure spreading ceased, fertilizer reduced, drain tiles, grass filter strips, contour tillage, cover crops, cattle removed from stream	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
SWCK	Southwest Creek	42.73532	-77.72480	Prior implementation of BMPs, including: Manure pit installed	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
HANN	Hanna's Creek	42.833364	-77.707621	Agricultural non-BMP	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total

						suspended sediments
NNAM	No Name Creek	42.748912	-77.727358	Agricultural non-BMP	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
WCUP	Upstream-Wilkins Cr.	42.724889	-77.706583	Agricultural non-BMP, and Reference site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
WCDN	Downstream-Wilkins Creek	42.725611	-77.707056	Remediated site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
NGUP	Upstream-North Gully	42.778361	-77.708806	Agricultural non-BMP, and Reference site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
NGDN	Downstream-North Gully	42.7785	-77.71025	Remediated site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
NMUP	Upstream-North McMillan	42.823139	-77.680556	Reference watershed for agricultural land use, and Reference site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments
NMDN	Downstream-North McMillan	42.823167	-77.686028	Remediated site for Erosion Control and Streambank Remediation Study	Multiprobe	Total phosphorus, total nitrogen, orthophosphate, nitrate + nitrite (NO_x), total suspended sediments

[1]Water temperature (°C), specific conductivity (µS/cm), pH, dissolved oxygen (LDO - %, mg/L), turbidity (NTUs), Discharge (ft^3/s, cfs).
[2]Total phosphorus (µg/L), total nitrogen (mg/L), orthophosphate (µg/L), nitrate + nitrite (NO_x) (mg/L), and total suspended solids (TSS) (mg/L).

Table 3: Parameters, analytical specifications, QA/QC requirements, and laboratories processing samples.

Lab Measurements Analyte	Method	Minimum Volume/ Container	Preservative	QC Sample	Frequency	QC Acceptance Limits	Corrective Action	Holding Time	Method Detection Limit	Report Limit
Nitrate + Nitrite	EPA 353.2, Rev. 2.0 (1993)	125 ml plastic	filter 0.45µm, cool 4°C	Method Blank	10%	< 0.003 mg/L	Reanalyze or Qualify data	2 days	0.003 mg/l	0.010 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Orthophosphate	SM 4500-P G-2011	125 ml plastic	filter 0.45µm, cool 4°C	Method Blank	10%	< 0.0006 mg P/L	Reanalyze or Qualify data	2 days	0.0006 mg/l	0.001 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Total nitrogen	SM 4500-N C-2011	125 ml plastic	Cool; -20°C	Method Blank	10%	< 0.002 mg P/L	Reanalyze or Qualify data	28 days	0.024 mg/l	0.100 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Total phosphorus	SM 4500-P H-2011	125 ml plastic	H2SO4 to pH<2, cool 4°C	Method Blank	10%	< 0.002 mg P/L	Reanalyze or Qualify data	28 days	0.002 mg/l	0.003 mg/l
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%	Reanalyze or Qualify data			
				Matrix spike duplicate set	10%	Between 90% to 110%	Qualify data Reanalyze or Qualify data			
Total suspended solids	SM 2540 D-2011	1000 ml plastic	Cool 4°C	Method Blank	10%	< 0.4 mg/L	Reanalyze or Qualify data	7 days	*0.4 mg/L *For 1000 mL sample	*0.4 mg/L *For 1000 mL sample
				ICC/LCS	10%	% Recovery between 90% to 110%	Reanalyze or Qualify data			
				Lab Duplicate	10%	RPD within ± 10%, ±50% for values < 5 mg/L	Reanalyze or Qualify data			
				Matrix spike duplicate set	NA	NA	NA			

Field Measurements Parameter	Method	Calibration/ Verification	Precision	Range
Temperature	YSI, *in situ*	Factory set annual check with NIST-reference thermometer	±0.20 C	-5 to 70°C
Luminescent Dissolved oxygen	YSI, *in situ*	Daily	±0.1 mg/L or 1%	0 to 50 mg/L
pH	YSI, *in situ*	Daily	±0.2	0 to 14
Specific Conductivity	YSI, *in situ*	Daily	±0.001 mS/cm or 0.5%	0 to 200 mS/cm
Turbidity	YSI, *in situ*	Daily	±0.3 FNU or 2%	0-4000 FNU
Velocity (wadable)	Marsh McMirney Flo-Mate Model 2000 Portable Flowmeter, *in situ*	Factory set, annual self-test diagnostics	±2% + 0.05 ft/sec	-0.5-19.99 Ft/s

Table 4: Tributary sampling dates, previous 24-hour weather conditions, and event classification

Date	Previous 24-hour Weather:	Event?
4/13/2020	Light Rain	No ~0.15 inches
4/27/2020	Rain	Yes ~0.60 inches
5/1/2020	Rain	Yes ~0.76 inches
5/14/2020	Sunny	No
5/29/2020	Rain/Thunder	No 0.38 inches (Hanna's, Graywood), ~0.25 inches rest of tributaries
6/10/2020	Sunny	No
7/1/2020	Sunny	No
8/4/2020	Light Rain	No <0.15 inches
9/5/2020	Sunny	No
10/4/2020	Drizzle	No <0.10 inches
11/1/2020	Drizzle and Sun	No
12/3/2020	Light Snow and Sun	No

Table 5: Average summer stream nutrient and TSS concentration (May through August) for Graywood, Sand Point, Long Point, Sutton Point, Cottonwood, Southwest Creek, North McMillan and North Gully. Data from 2003 to 2010 are adapted from Makarewicz and Lewis (2010).

		TP (µg/L)		Nitrate/Nitrite (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
	Year	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
Graywood	2003	247.9	71.5	8.09	1.21	8.8	1.4	539	42	116.6	15.4
	2004	241.9	25.2	8.14	1.2	14.8	2.7	558	35	120.8	13.1
	2005	163.3	10.6	3.63	0.4	9.1	2.4	555	54	104.7	8.9
	2006	173.8	19.7	1.87	0.19	7.1	1.5	384	52	105.5	13.5
	2007	96.3	21.1	2.22	0.31	5.3	1.2	376	77	59.2	13.3
	2008	123.8	19.9	1.21	0.31	5.4	1	303	44	99.1	16.2
	2009	236.9	43.1	3.79	1.26	19.4	4.6	768	135	171.5	36
	2010	205.6	33	4.52	1.17	18.4	6.8	546	64	159.5	27
	2020	456.39	101.1	5.22	0.46	99.62	36.22	675	222	270.11	36.23
Sand Point	2003	59.6	4.2	2	0.5	5.5	1.3	569	75	39.2	5
	2004	111.4	44.4	0.97	0.13	46.8	41.1	719	217	37	9.1
	2005	75.5	8.7	1.65	0.36	5	1.6	466	76	50.3	6.8
	2006	86.8	13.5	1.17	0.14	3.8	0.6	539	104	43.5	4.5
	2007	70.4	8.4	1.57	0.66	2.5	0.3	477	59	48.5	8
	2008	79.6	3.6	0.66	0.04	4.5	1.1	505	40	54.3	4
	2009	80.4	8.4	2.44	0.8	15.8	90.9	654	90	50.3	4.3
	2010	NO DATA									
	2020	75.48	15.04	2.55	0.62	9.46	4.05	379.1	76.56	49.44	13.76
Long Point	2003	102.3	22.6	4.99	0.97	10.6	4.4	775	116	39.7	7.1
	2004	219.4	129.3	4.41	1.11	132.6	124	832	199	40.4	7.7
	2005	69.8	17.8	2.58	0.58	8.7	4.2	568	54	34.4	8.5
	2006	60.7	14.9	2.23	0.55	8.1	3.8	552	95	29.5	7.7
	2007	41	15.3	2.4	0.96	3.4	0.7	515	90	14.8	8.3
	2008	75.7	15.5	1.97	0.31	16.5	13.1	771	265	44.8	7.9
	2009	50.3	10.3	3.85	0.98	4.8	3.5	489	78	33.2	5.6
	2010	59.4	4.2	5.09	1.32	3.5	0.9	544	50	43.1	4.9
	2020	97.6	77.76	2.36	0.89	18.77	17.22	676.7	266.8	34.09	24.88

Table 5 Continued	Year	TP (µg/L)		Nitrate/Nitrite (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
		Mean	**Standard Error of Mean**	**Mean**	**Standard Error of Mean**	**Mean**	**Standard Error of Mean**	**Mean**	**Standard Error of Mean**	**Mean**	**Standard Error of Mean**
Sutton Point	2003	45.5	4.7	1.93	0.36	11.6	3.2	415	50	28.4	2.6
	2004	216.6	160.6	1.15	0.1	13.7	7.3	413	56	26.5	3.7
	2005	46.6	5	1.28	0.26	4.2	0.7	318	38	30.9	3.9
	2006	48.6	2.9	0.98	0.09	2.8	0.9	352	86	28.9	2.9
	2007	38	3.2	1.57	0.21	1	0.1	305	83	25	4.1
	2008	46.6	2.1	1.32	0.28	3.7	1.1	221	36	31.2	3
	2009	47.4	3.2	1.09	0.1	5.3	2.1	483	85	35.9	2.2
	2010	NO DATA									
	2020	67.88	16.16	3.29	1.29	16.36	8	251.83	32.95	42.17	8.89
Cottonwood	2003	68	6	2.83	0.48	3.6	1.1	468	65	51.1	5.7
	2004	143.2	66	2.35	0.6	69.4	58.3	568	86	53	6.6
	2005	97.3	23.3	2.3	0.44	10.5	4.5	424	38	57.5	6
	2006	68.8	6.4	1.64	0.17	1	0.3	393	37	43.4	3.9
	2007	63.8	3.5	1.48	0.13	2.5	0.8	433	76	45.8	3.7
	2008	84.7	9.9	1.12	0.13	2.6	0.8	381	46	57.7	3.9
	2009	72.5	3.7	2.79	0.28	3.9	1.2	518	82	58.8	3.2
	2010	73.6	6.2	3.86	0.72	6.6	2.2	559	66	59.7	1.9
	2020	116.75	12.34	1.62	0.58	9.86	4.34	421.17	95.23	80.82	13.51
Southwest	2003	83.2	5	3.54	0.74	5.7	1.5	1054	527	63.1	7.2
	2004	179.1	47.9	1.63	0.24	46.2	34.6	796	204	78.1	10.2
	2005	124.2	7.7	1.28	0.39	10.8	3.5	486	61	69.1	7.7
	2006	97.9	6.4	1.03	0.17	4.6	1.7	456	63	61.8	4.9
	2007	116.1	10.3	1.09	0.11	7.1	3.6	469	100	76.4	5
	2008	100.4	3.6	1.17	0.14	3	0.8	297	33	69.5	5.3
	2009	127.6	8.5	1.17	0.1	8.9	4.3	633	76	100.5	7.5
	2010	NO DATA									
	2020	232.19	34.64	1.58	0.5	6.43	2.45	562.83	204.72	192.54	19.43

Table 5 Continued	Year	TP (µg/L)		Nitrate/Nitrite (mg/L)		TSS (mg/L)		TKN (µg/L)		SRP (µg/L)	
		Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
North McMillan	2003	10.9	2.3	0.26	0.05	2.7	1.3	265	41	4.4	0.6
	2004	39.6	26.6	0.14	0.02	33.3	30	365	85	5.1	1.4
	2005	11.4	2	0.24	0.03	3.5	0.8	276	39	4.8	0.6
	2006	10.5	1.5	0.13	0.03	1.7	0.5	229	30	3.7	0.9
	2007	7.6	0.9	0.14	0.02	2	0.5	246	64	2.5	0.3
	2008	13.8	7	0.11	0.02	2.3	0.4	220	34	2.9	0.5
	2009	27.4	8.8	0.13	0.01	70.3	67.1	455	96	9.1	4.3
	2010	14.4	3.8	0.19	0.04	1.8	0.2	559	66	59.7	1.9
	2020	17.08	3.03	0.15	0.03	3.7	1.85	156.5	19.57	5.25	0.84
North Gully	2003	NO DATA									
	2004	33	16.6	0.41	0.15	5.1	6.3	413	203	15.7	14.3
	2005	34.9	25.7	0.71	0.9	4.8	5.2	312	212	17	14.7
	2006	28.3	18	0.31	0.17	5	15.7	366	153	13.5	9.5
	2007	28.7	15.2	0.2	0.15	5.7	7.44	273	171	15.2	8.7
	2008	NO DATA									
	2009	39.7	10.5	0.33	0.07	15.1	6.5	370	54	18.2	4.4
	2010	NO DATA									
	2020	34.07	12.25	0.61	0.12	12.62	8.94	272.83	37.01	13.87	3.52

Figures:

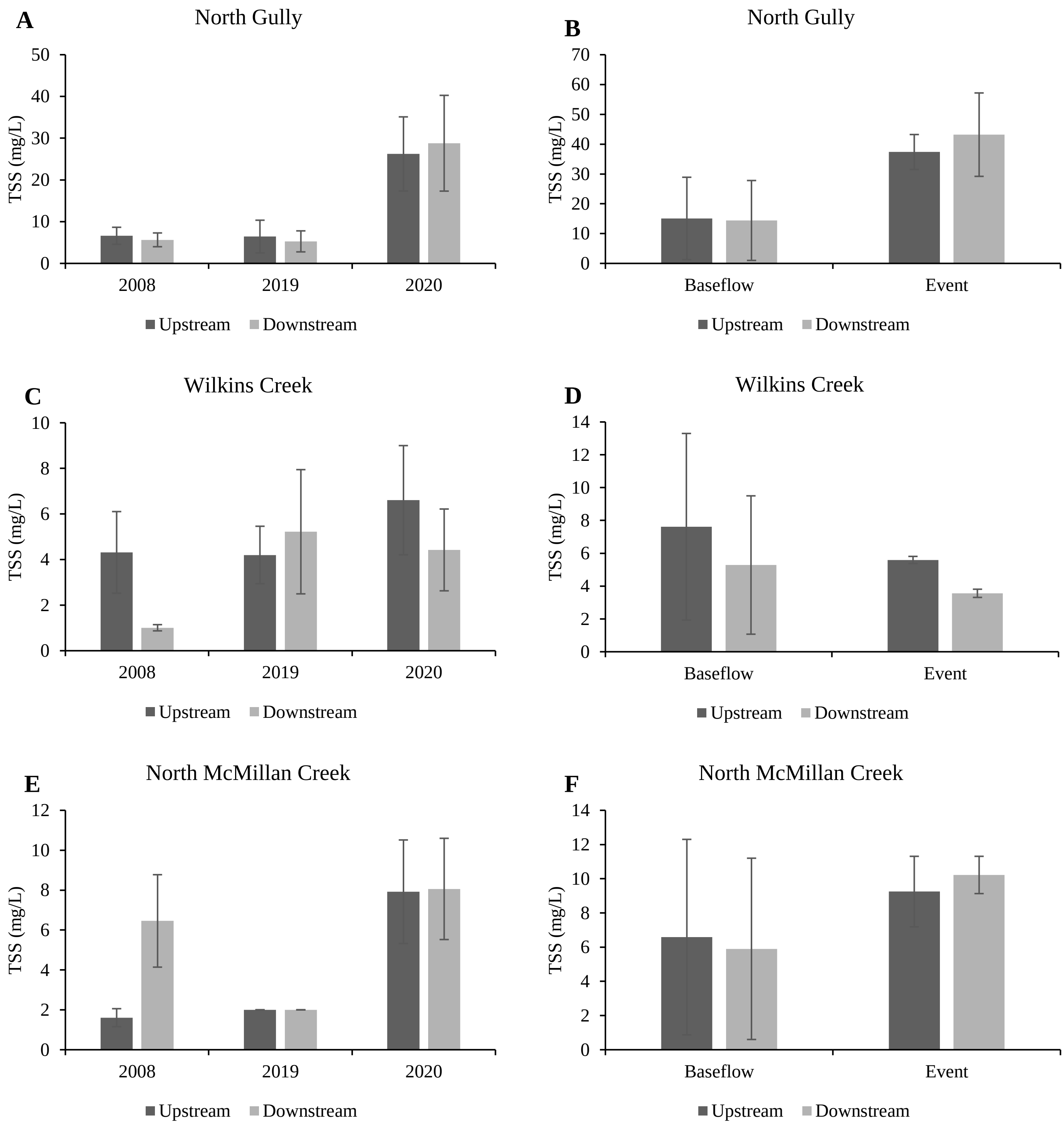


Figure 1: Average (+/- SE) total suspended solids (TSS) concentrations in (A) North Gully, (C) Wilkins Creek, and (E) North McMillan Creek from 2008, 2019, and 2020, and for 2020 baseflow and event concentrations (B, D, and F). S.E.=standard error.

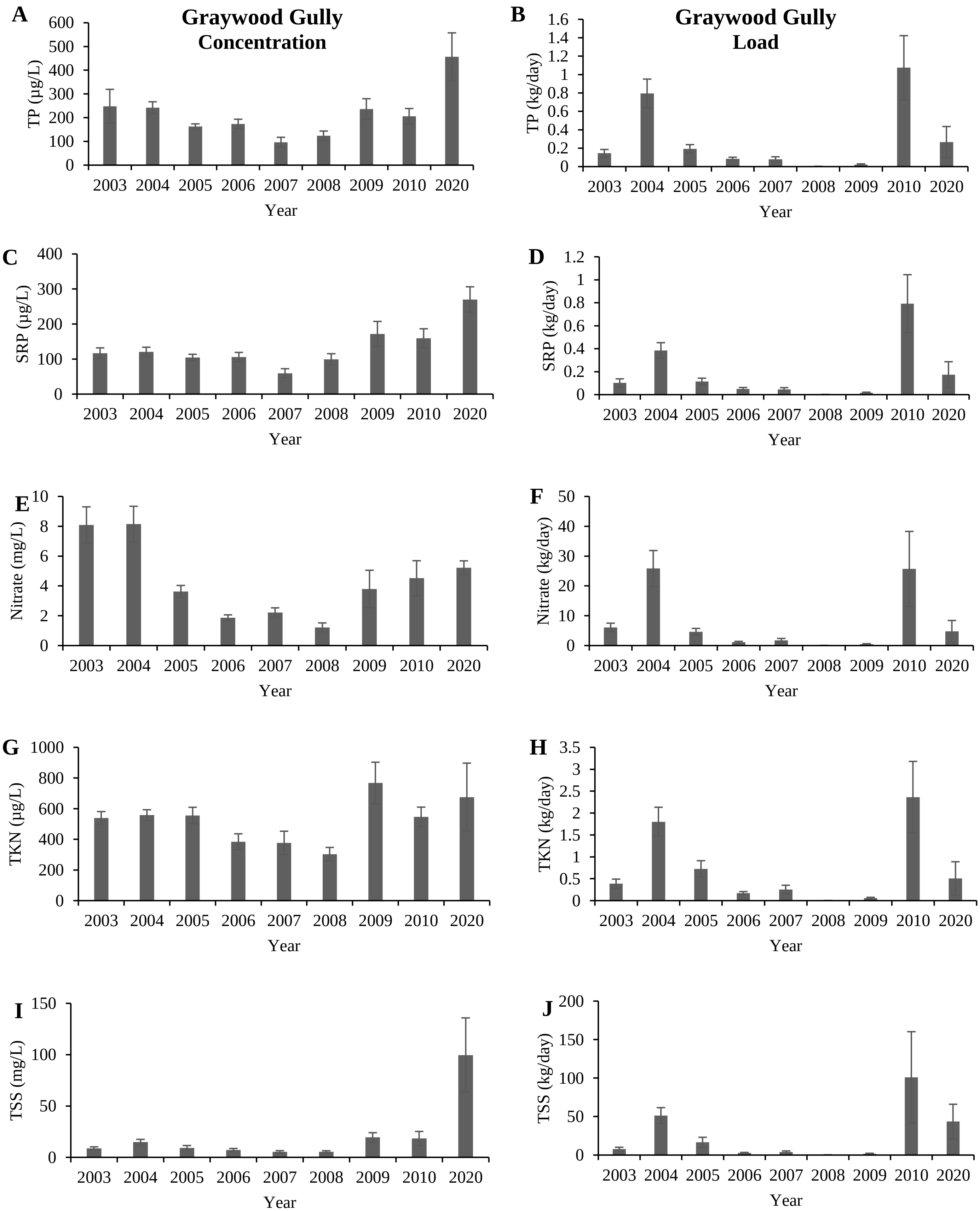


Figure 2: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Graywood Gully from 2003 to 2010. and 2020. S.E.=standard error.

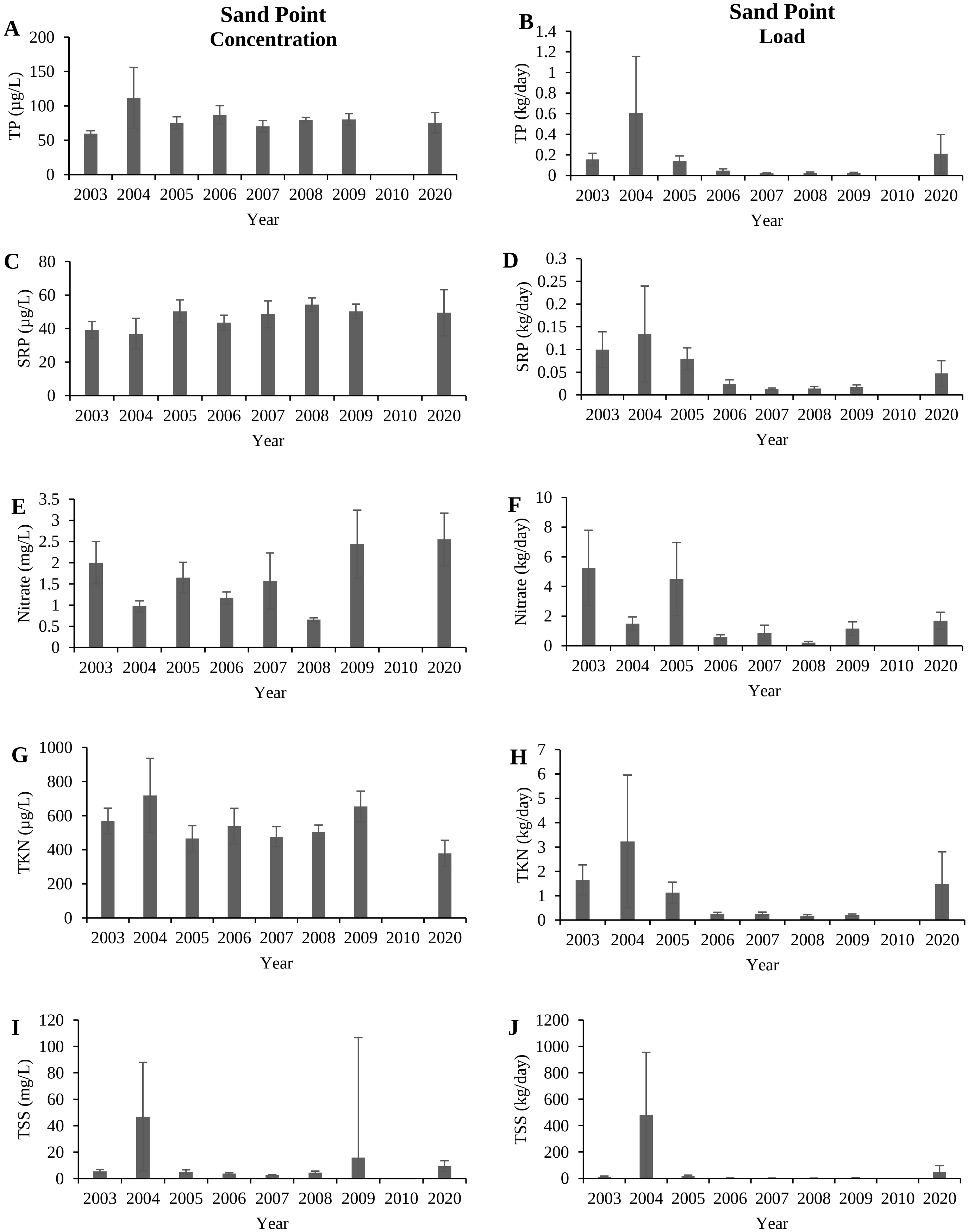


Figure 3: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Sand Point Gully from 2003 to 2010, and 2020. S.E.=standard error.

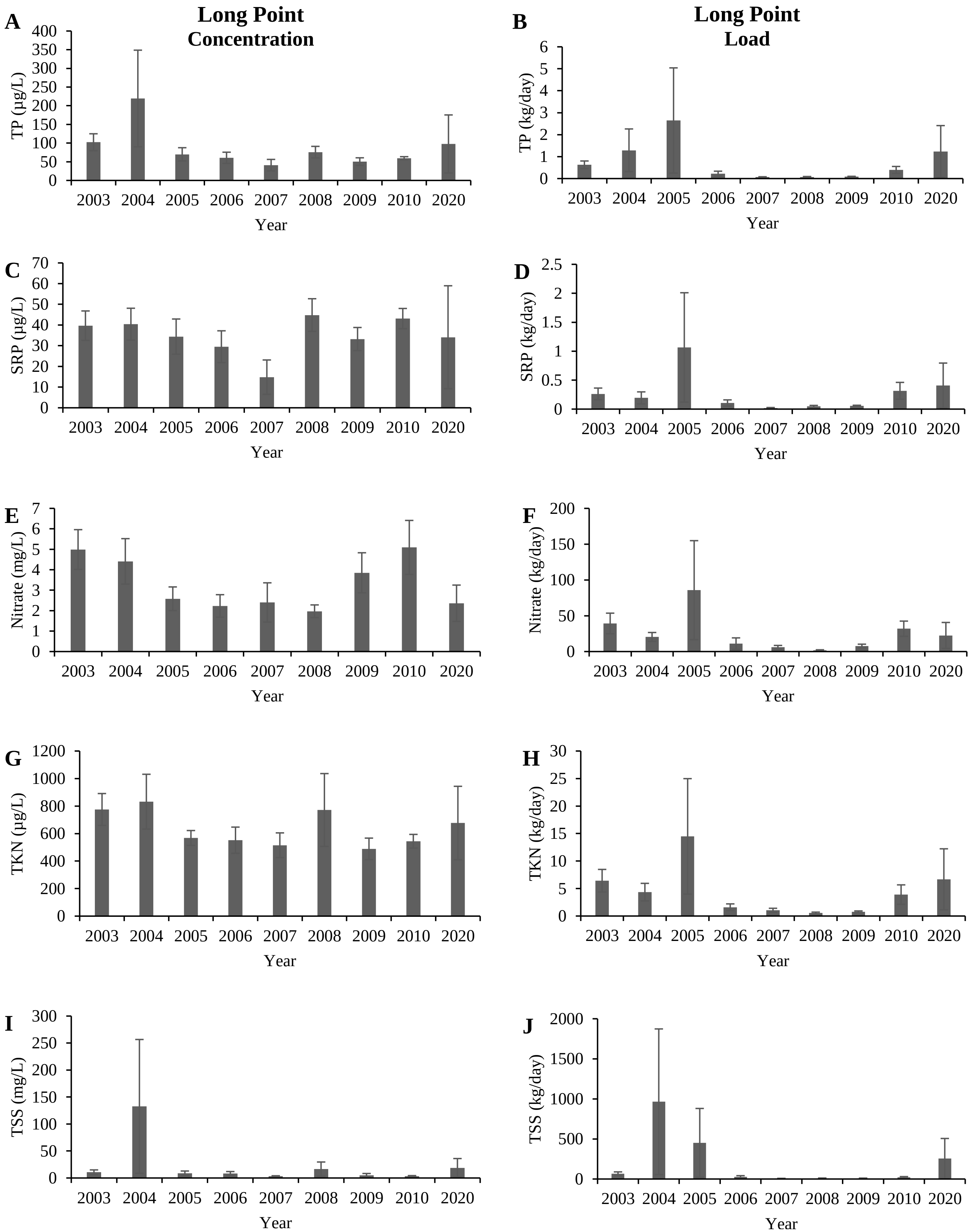


Figure 4: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Long Point Gully from 2003 to 2010, and 2020. S.E.=standard error.

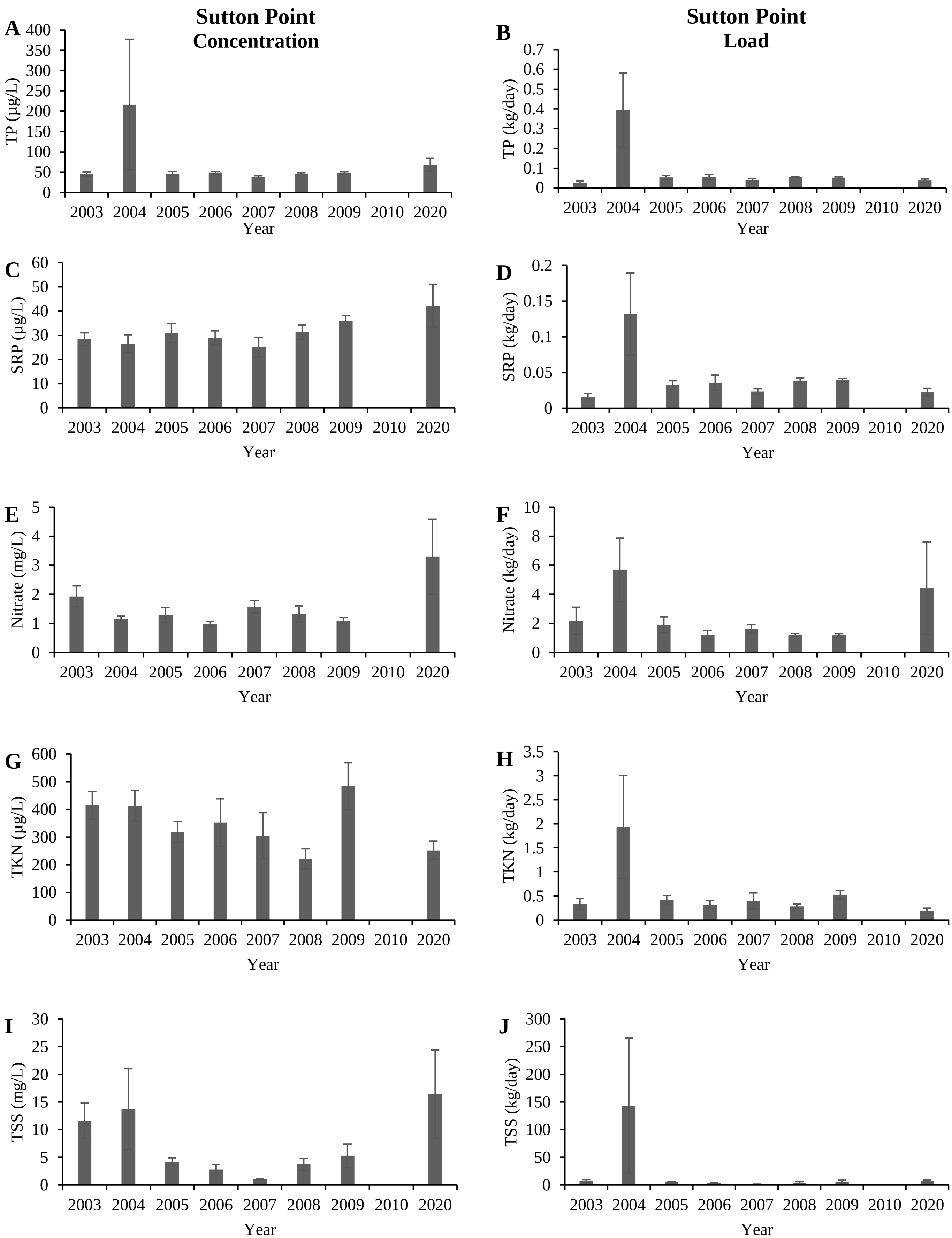


Figure 5: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Sutton Point Gully from 2003 to 2010, and 2020. S.E.=standard error.

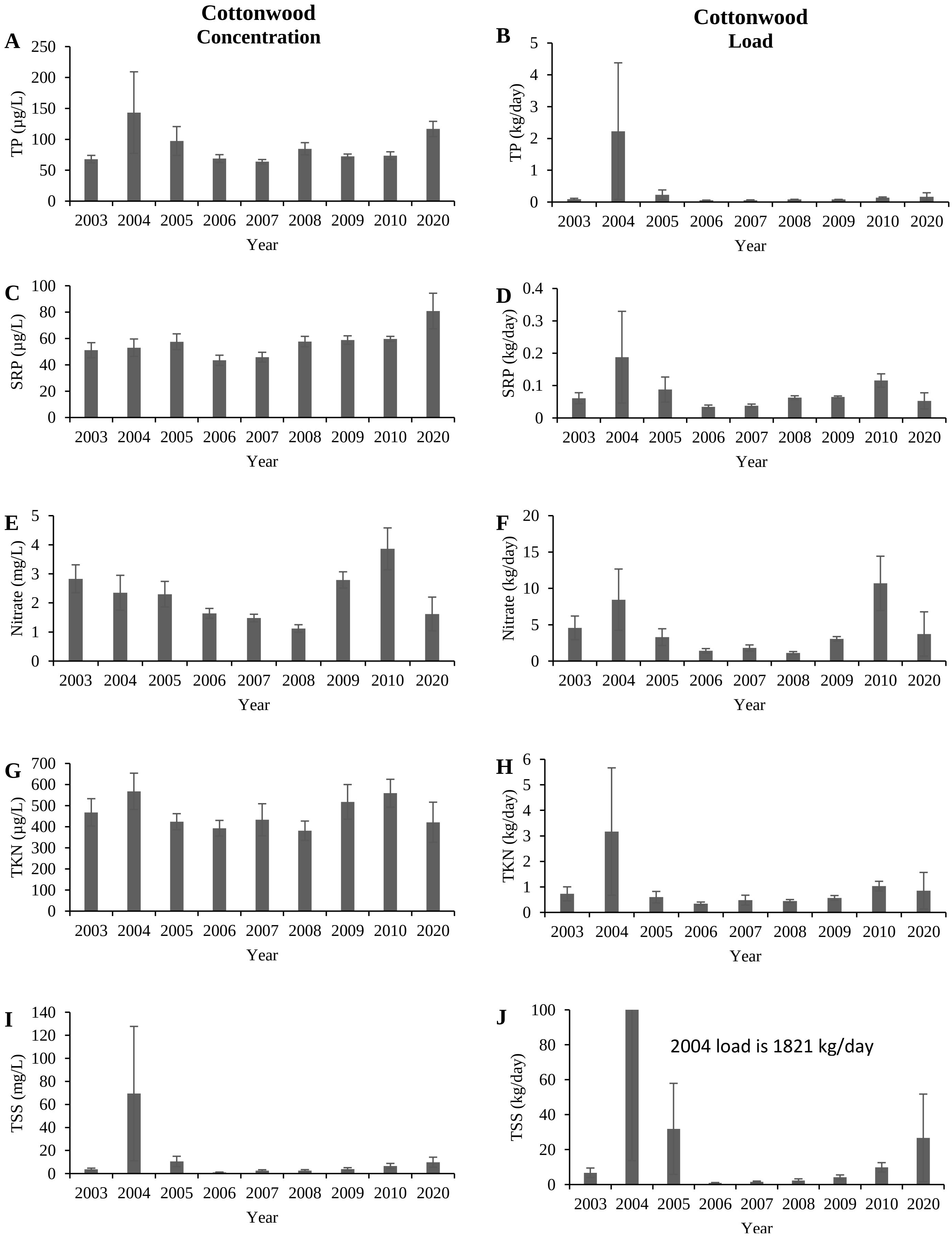


Figure 6: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Cottonwood Gully from 2003 to 2010. and 2020. S.E.=standard error.

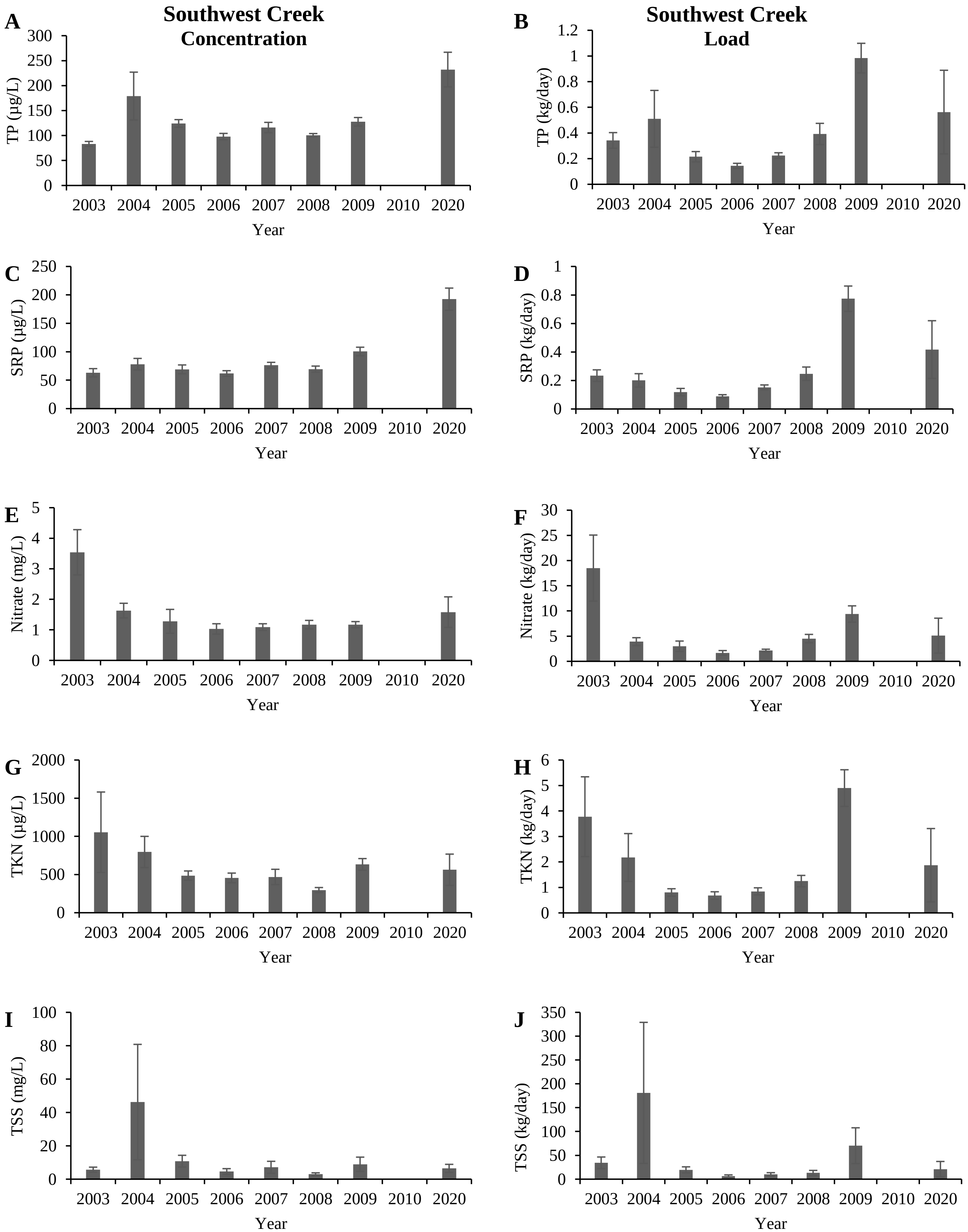


Figure 7: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in Southwest Creek from 2003 to 2010, and 2020. S.E.=standard error.

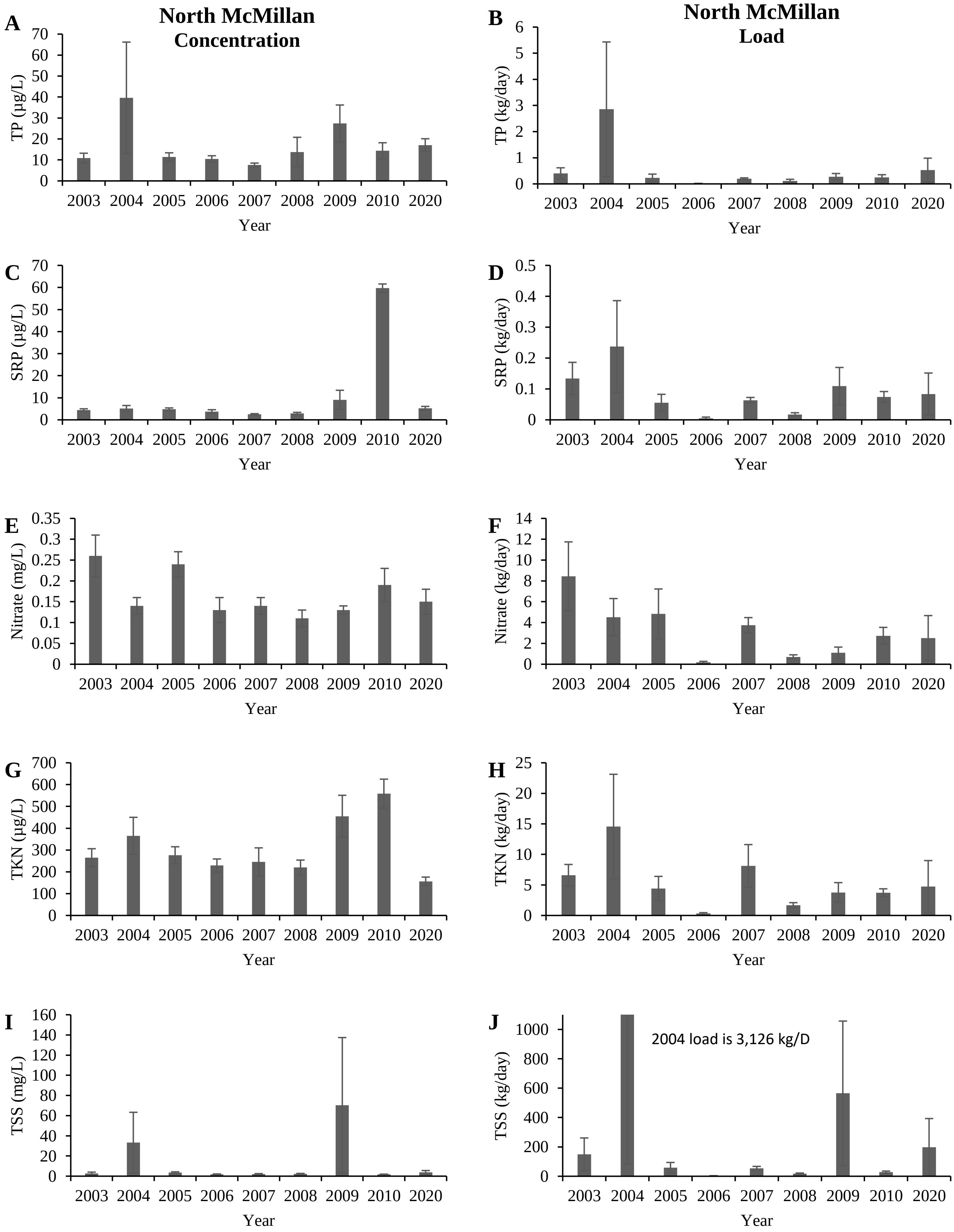


Figure 8: Average (+/- SE) concentrations and average nutrient load (May through August) of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (C and D), nitrate/nitrite (E and F), total Kjeldahl nitrogen (TKN) (G and H), and total suspended solids (TSS) (I and J) in North McMillan Creek from 2003 to 2010, and 2020. S.E.=standard error.

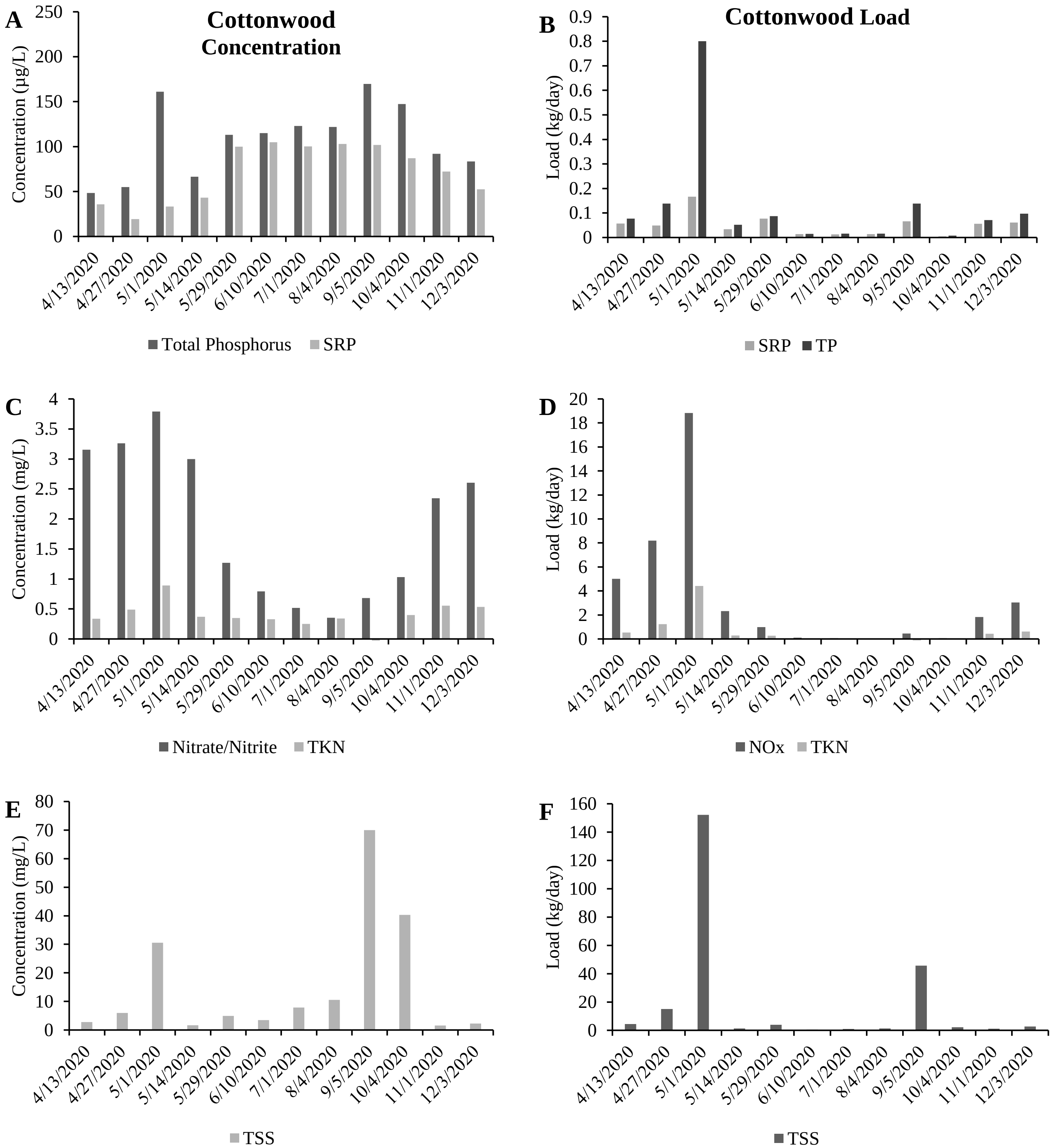


Figure 9: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Cottonwood Gully from 2020 sampling dates.

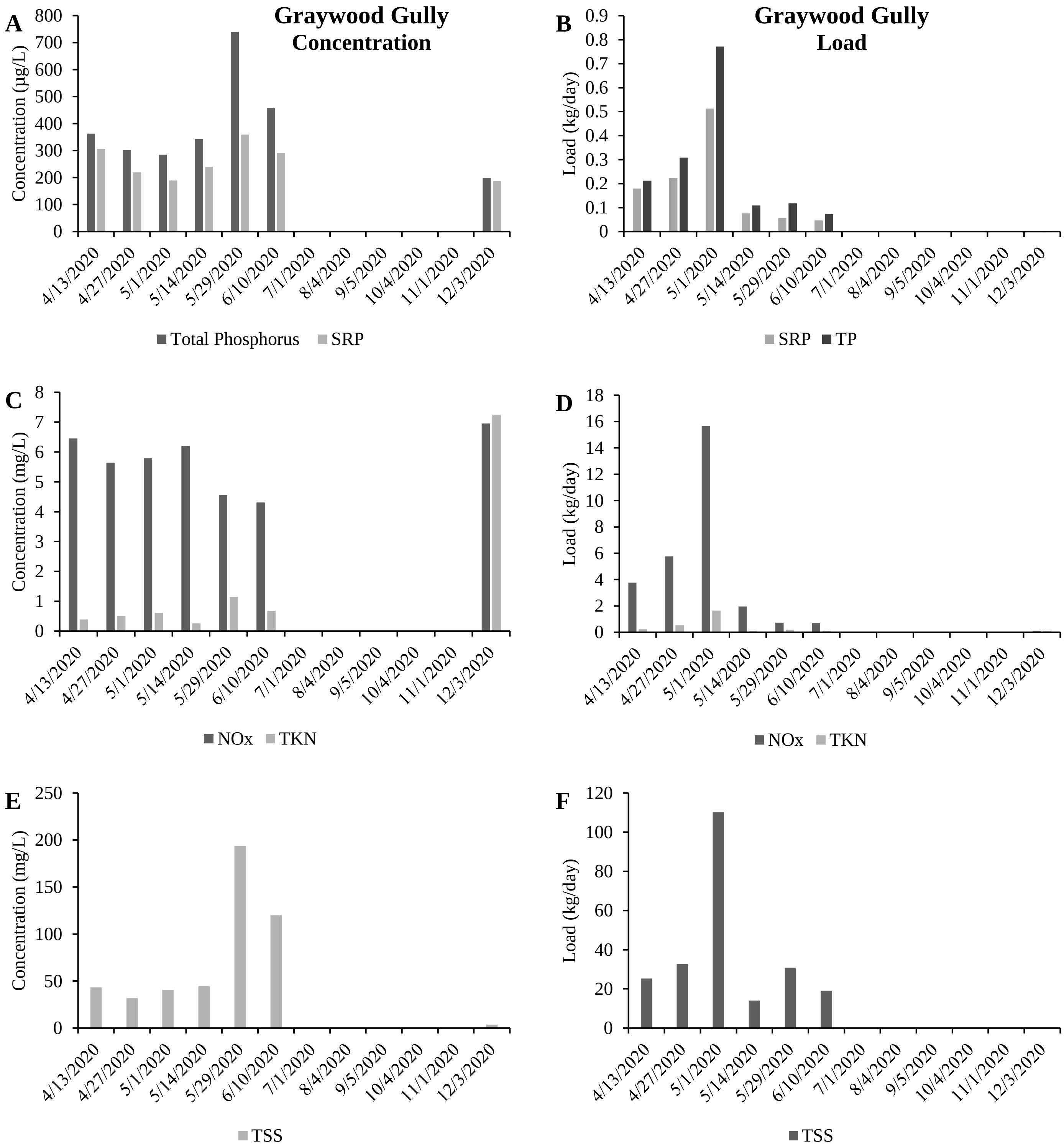


Figure 10: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Graywood Gully from 2020 sampling dates.

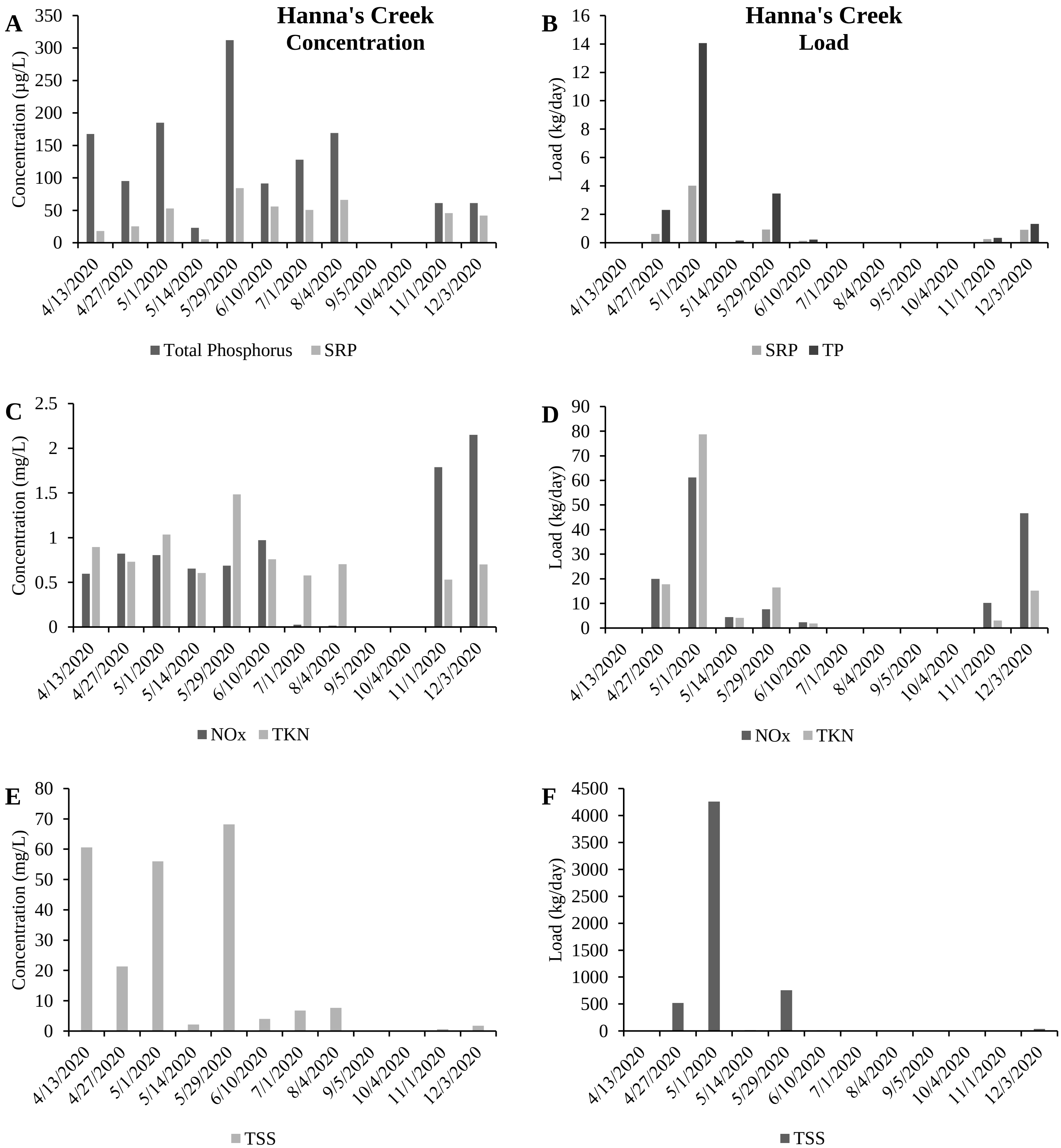


Figure 11: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Hanna's Creek from 2020 sampling dates.

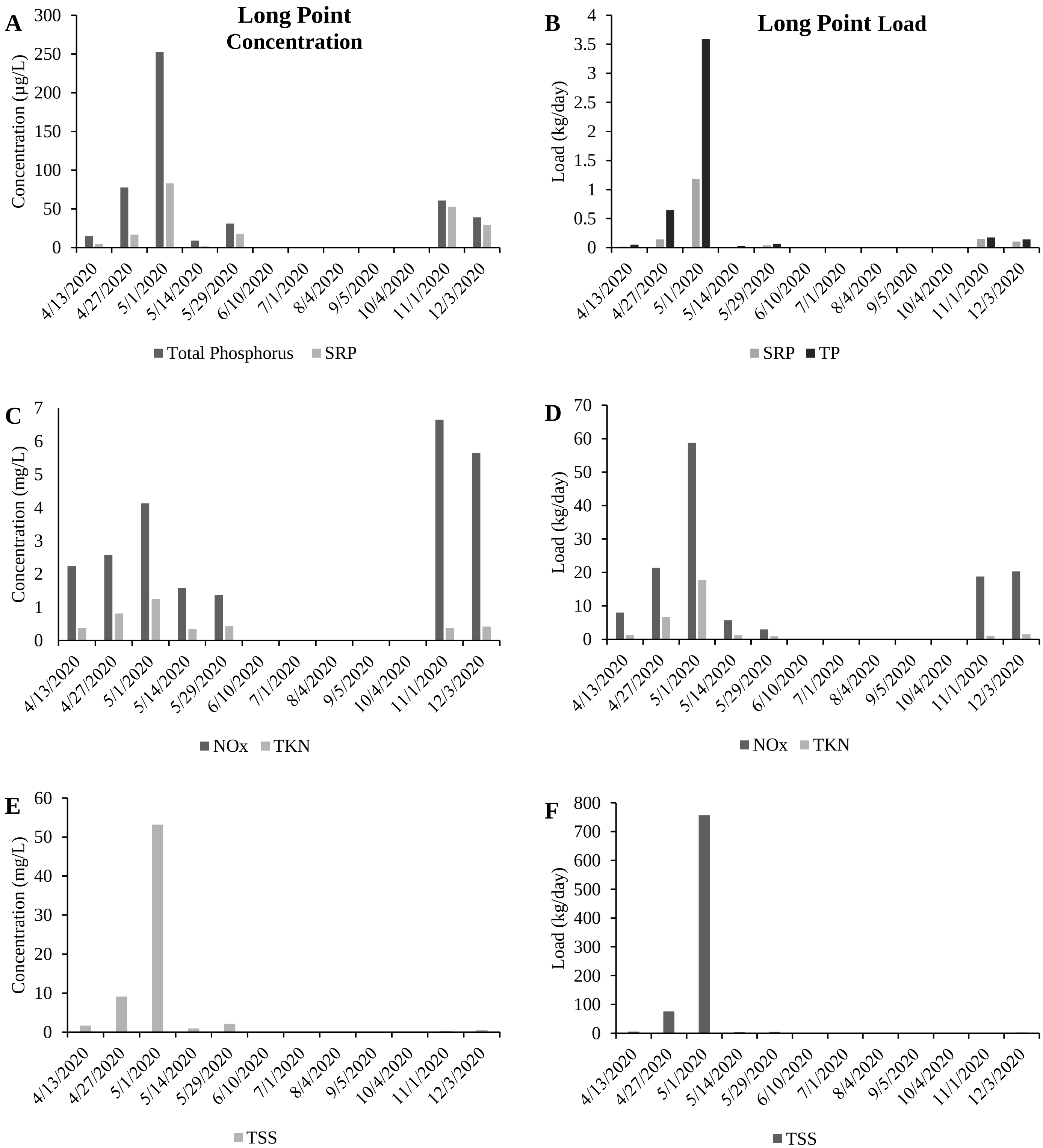


Figure 12: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Long Point Gully from 2020 sampling dates.

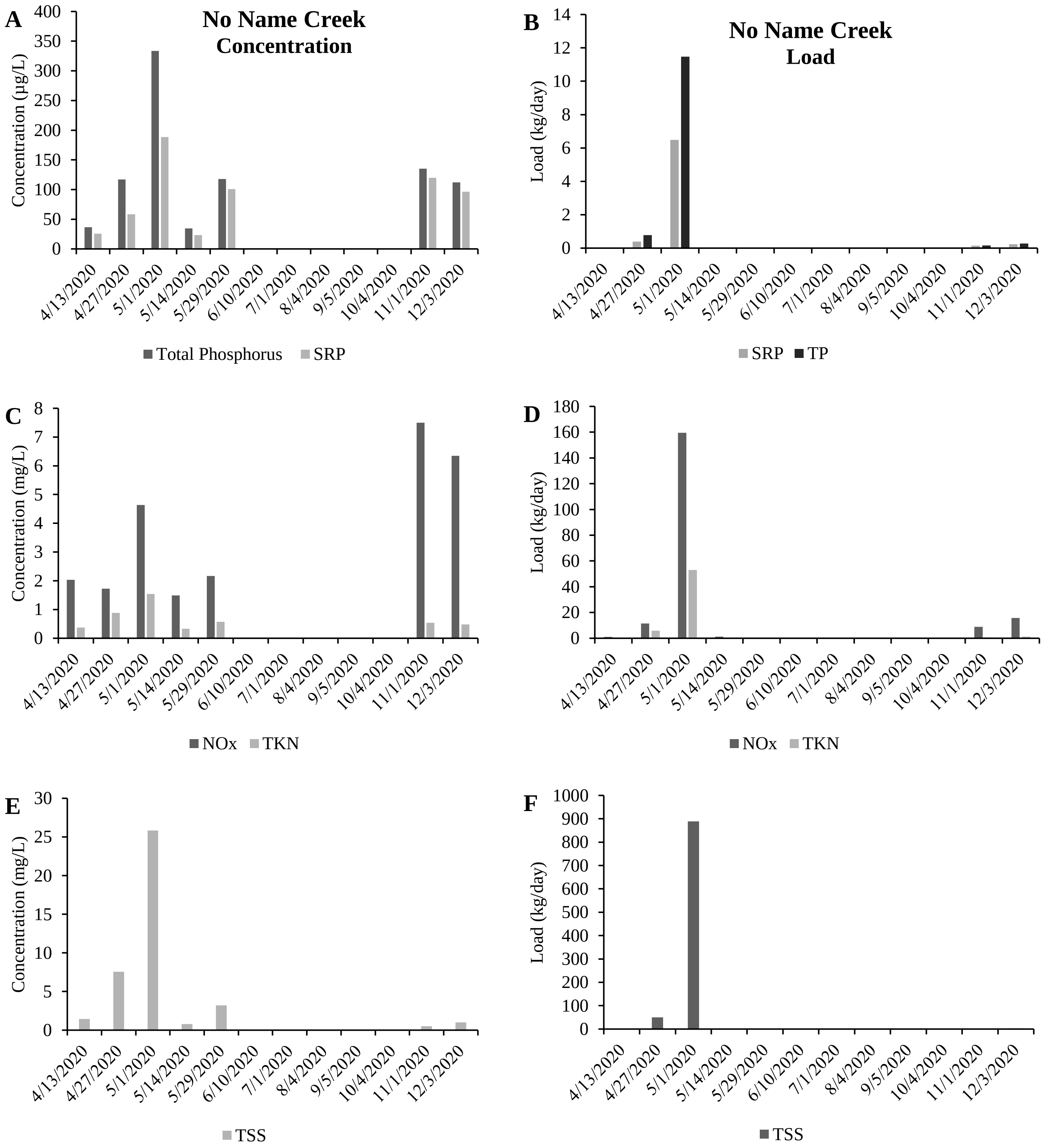


Figure 13: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in No Name Creek from 2020 sampling dates.

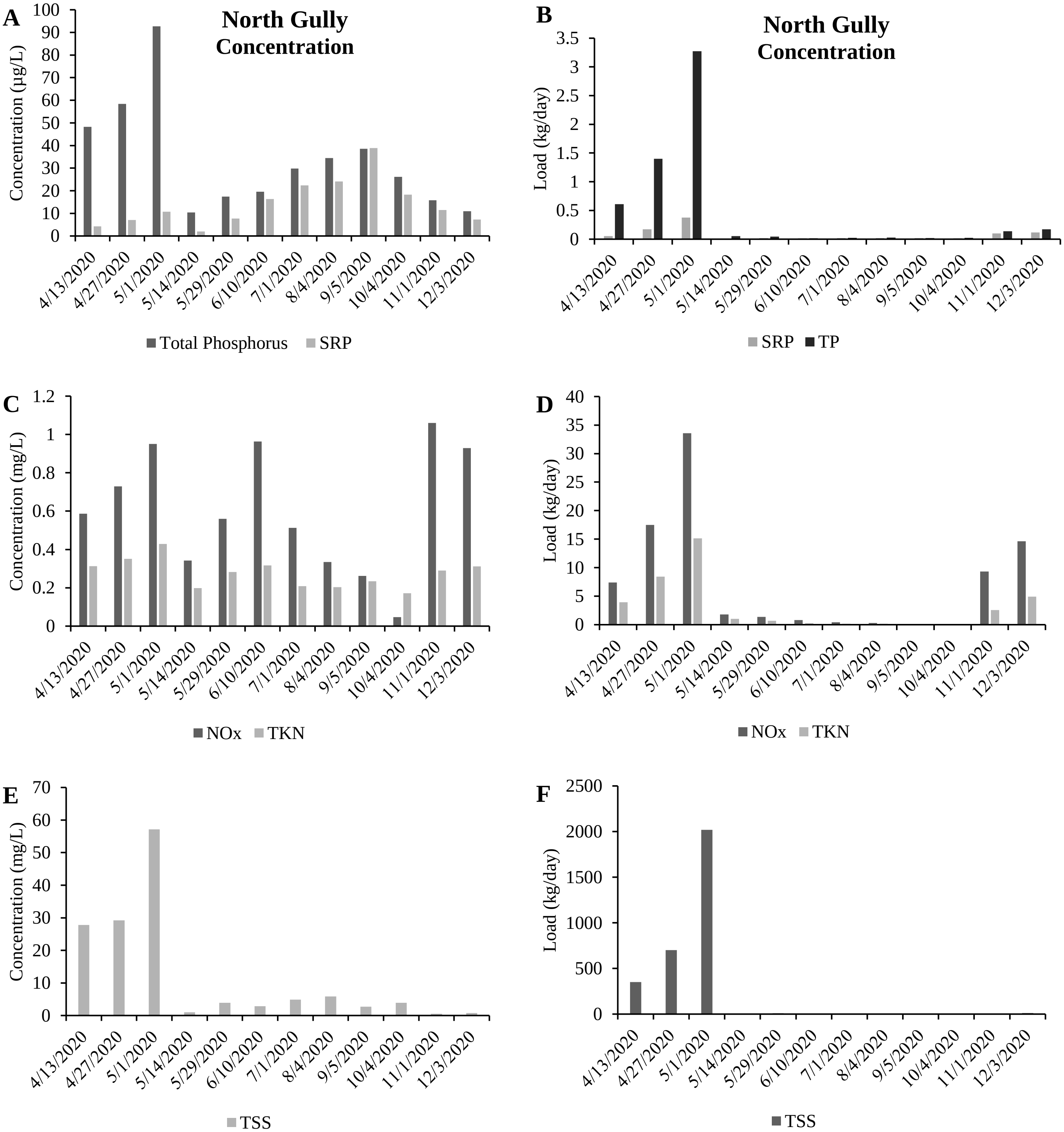


Figure 14: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in North Gully from 2020 sampling dates.

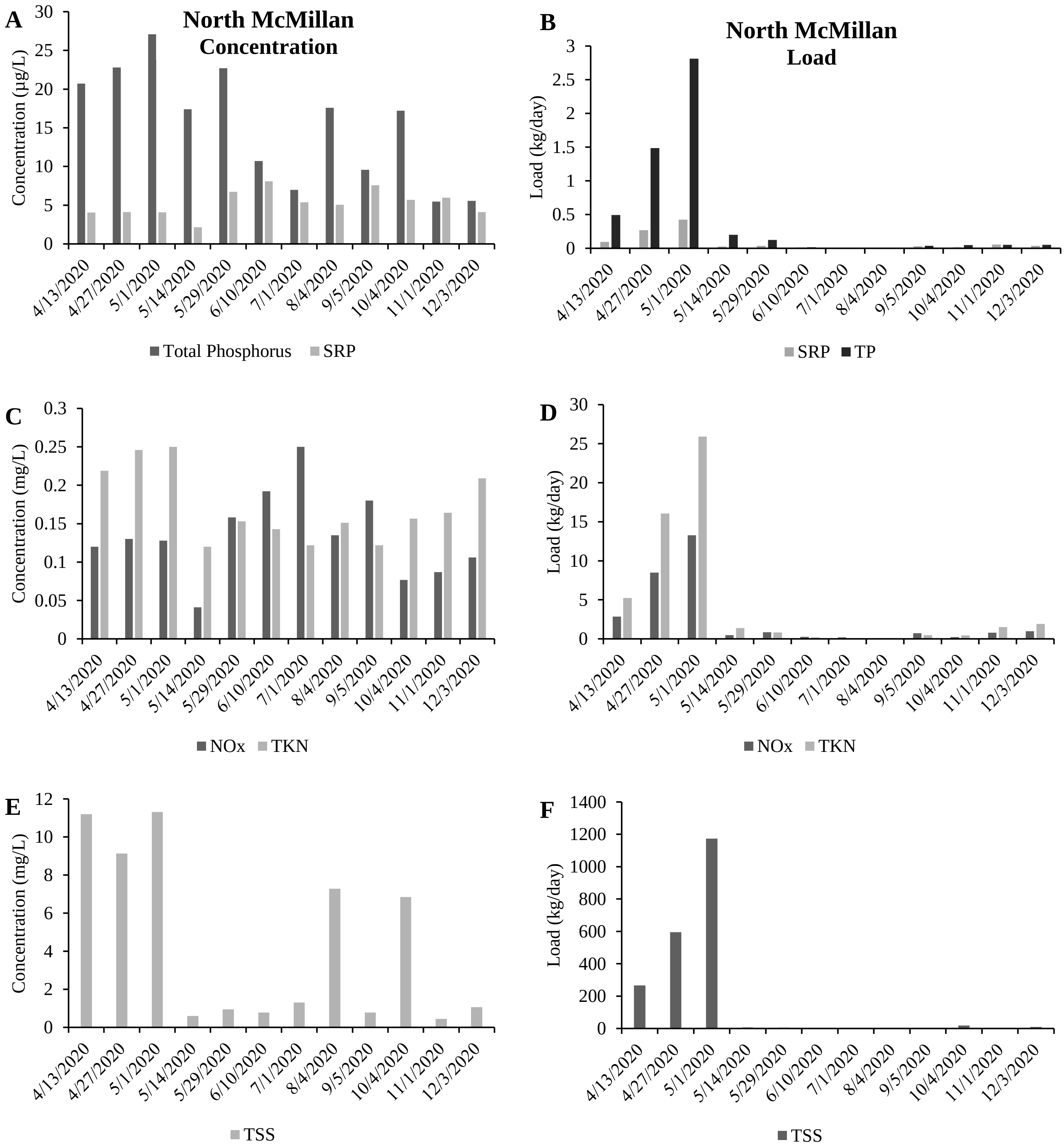


Figure 15: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in North McMillan Creek from 2020 sampling dates.

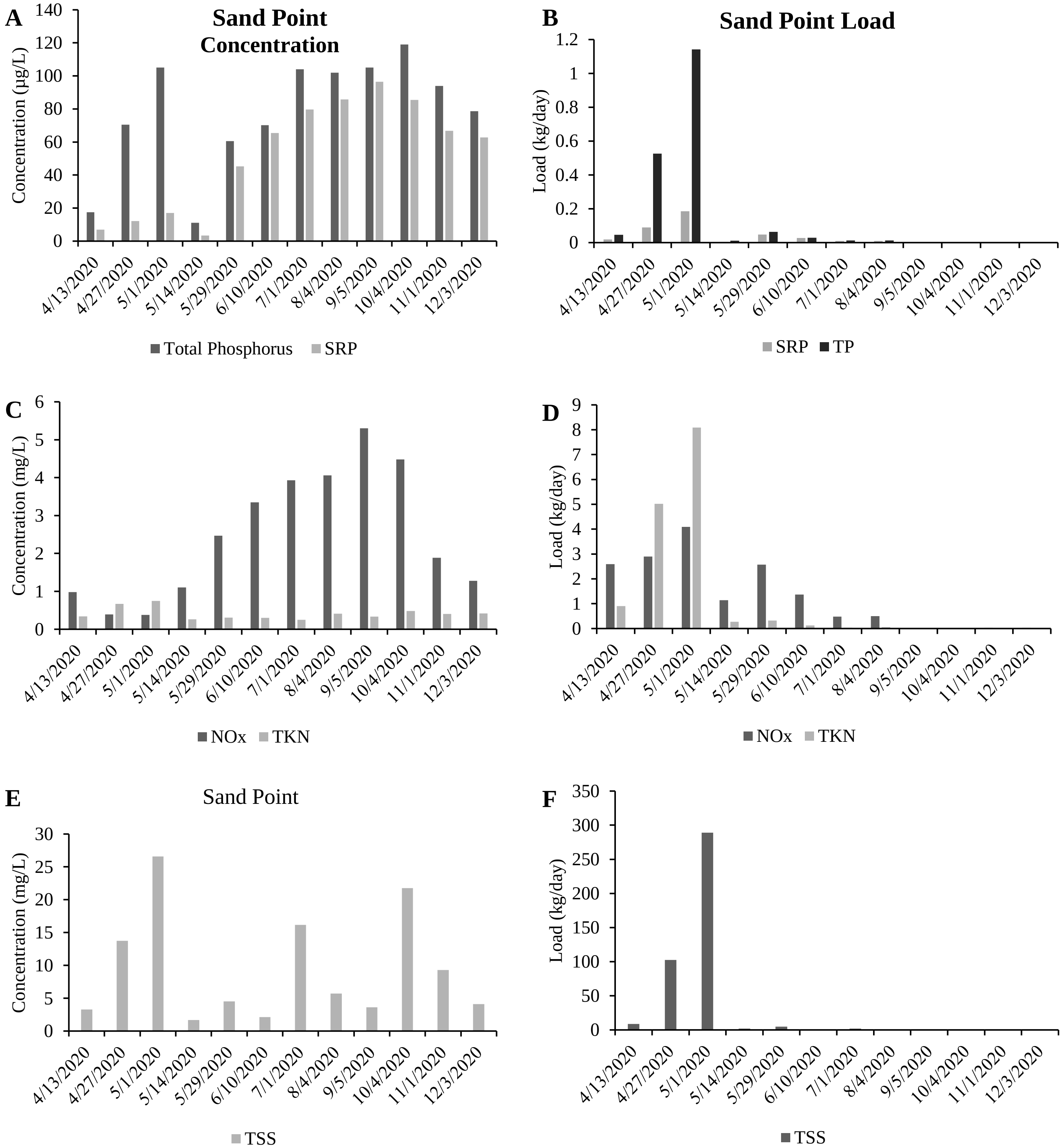


Figure 16: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Sand Point Gully from 2020 sampling dates.

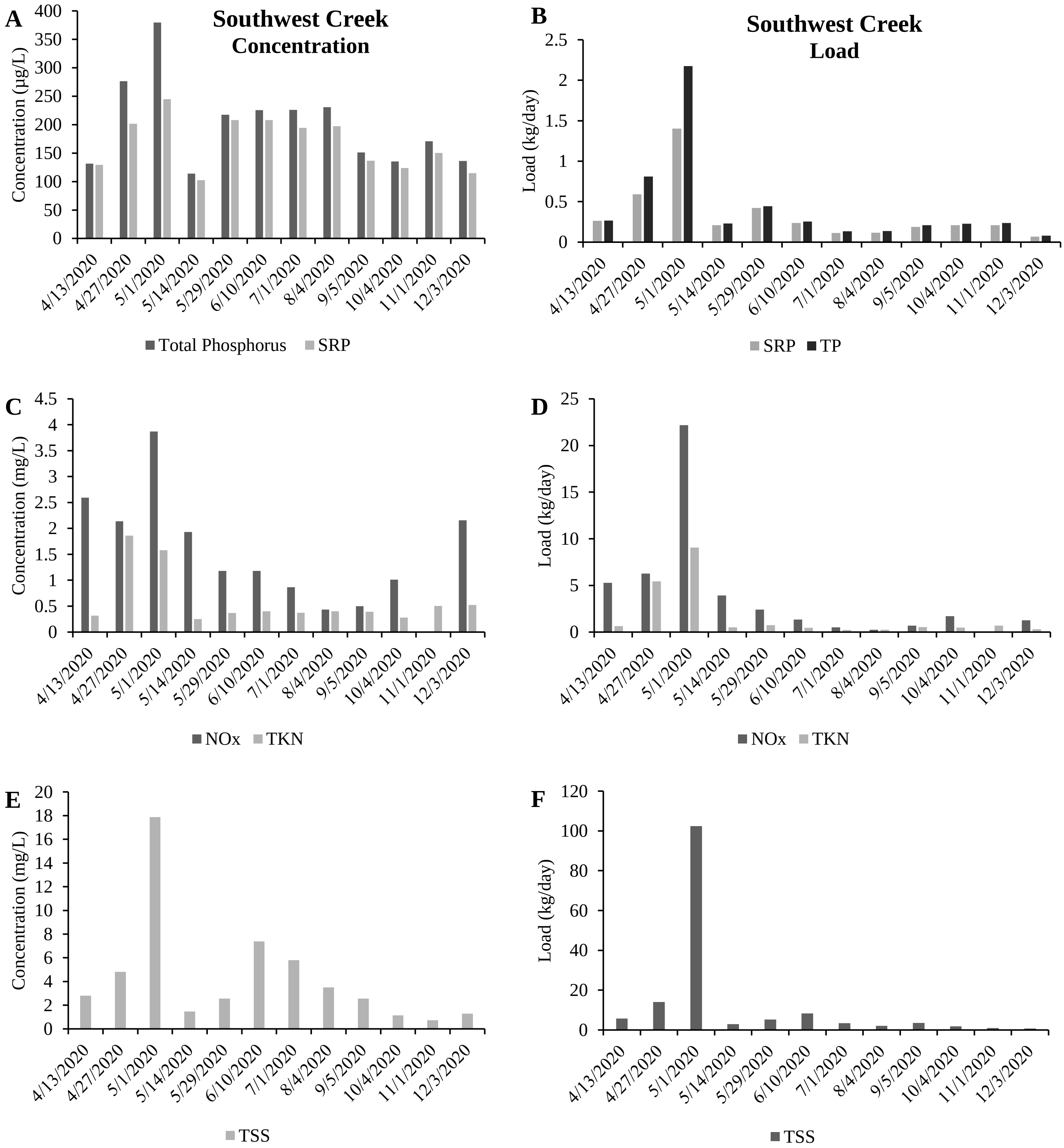


Figure 17: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Southwest Creek from 2020 sampling dates.

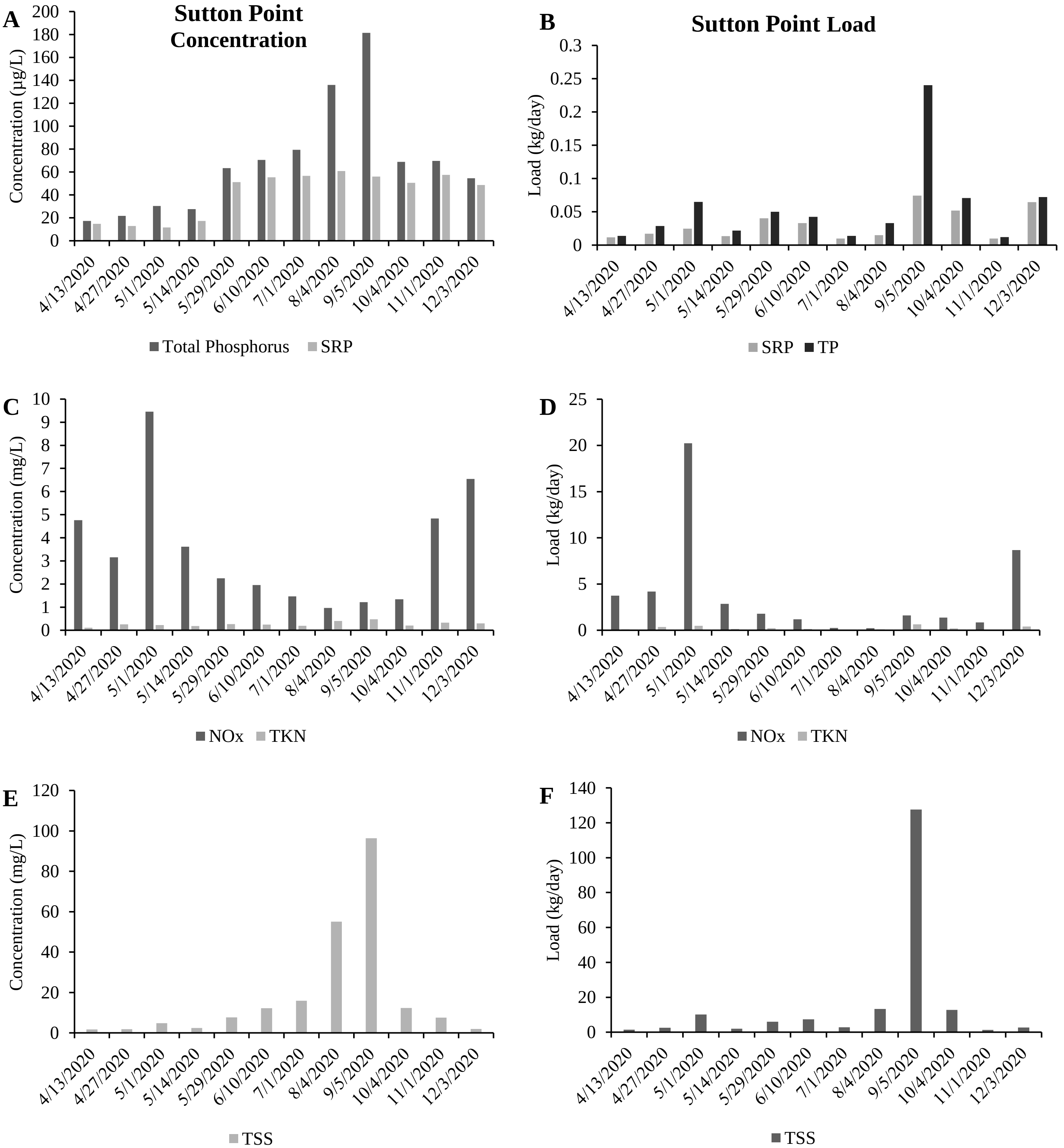


Figure 18: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Sutton point Gully from 2020 sampling dates.

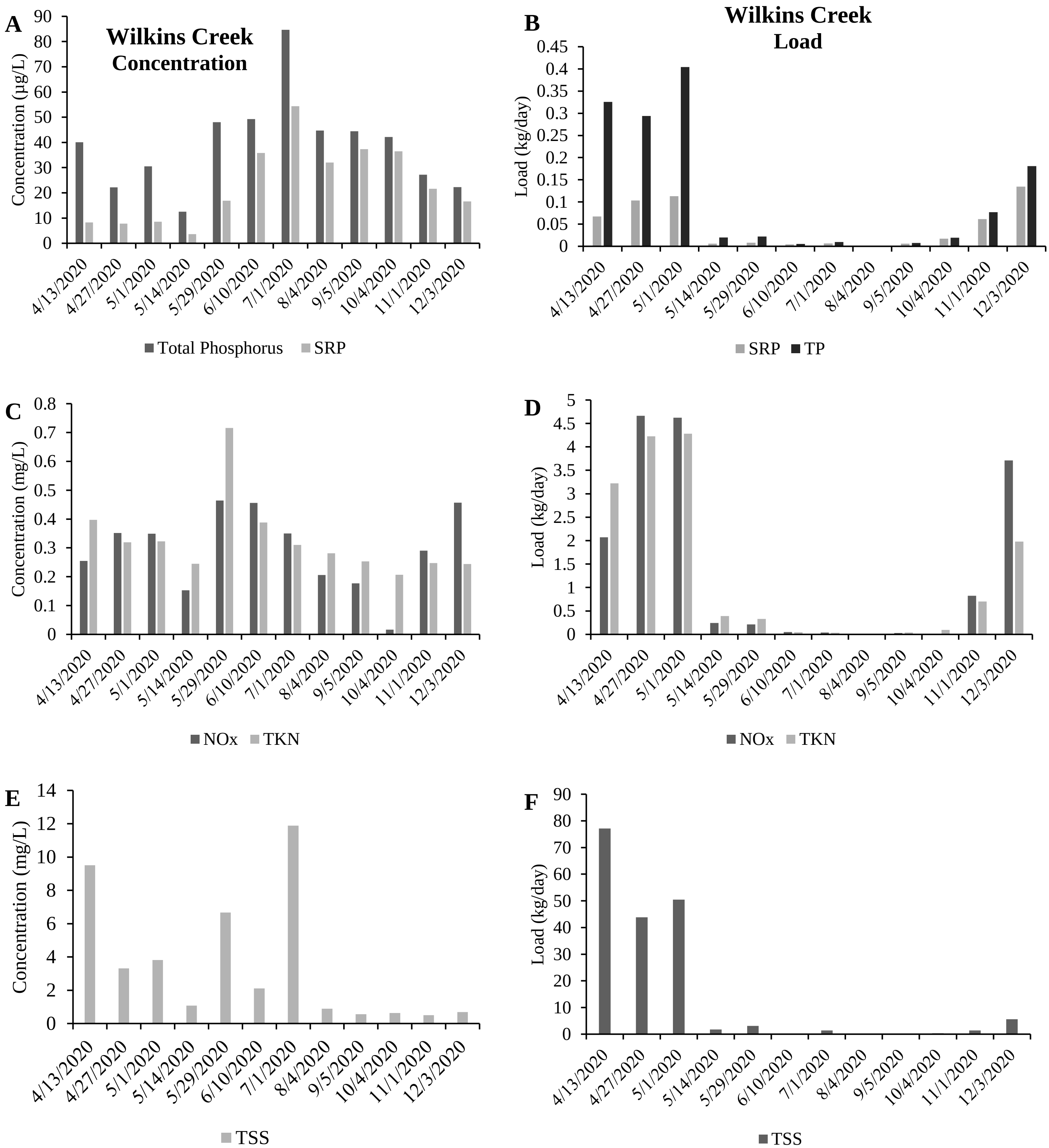
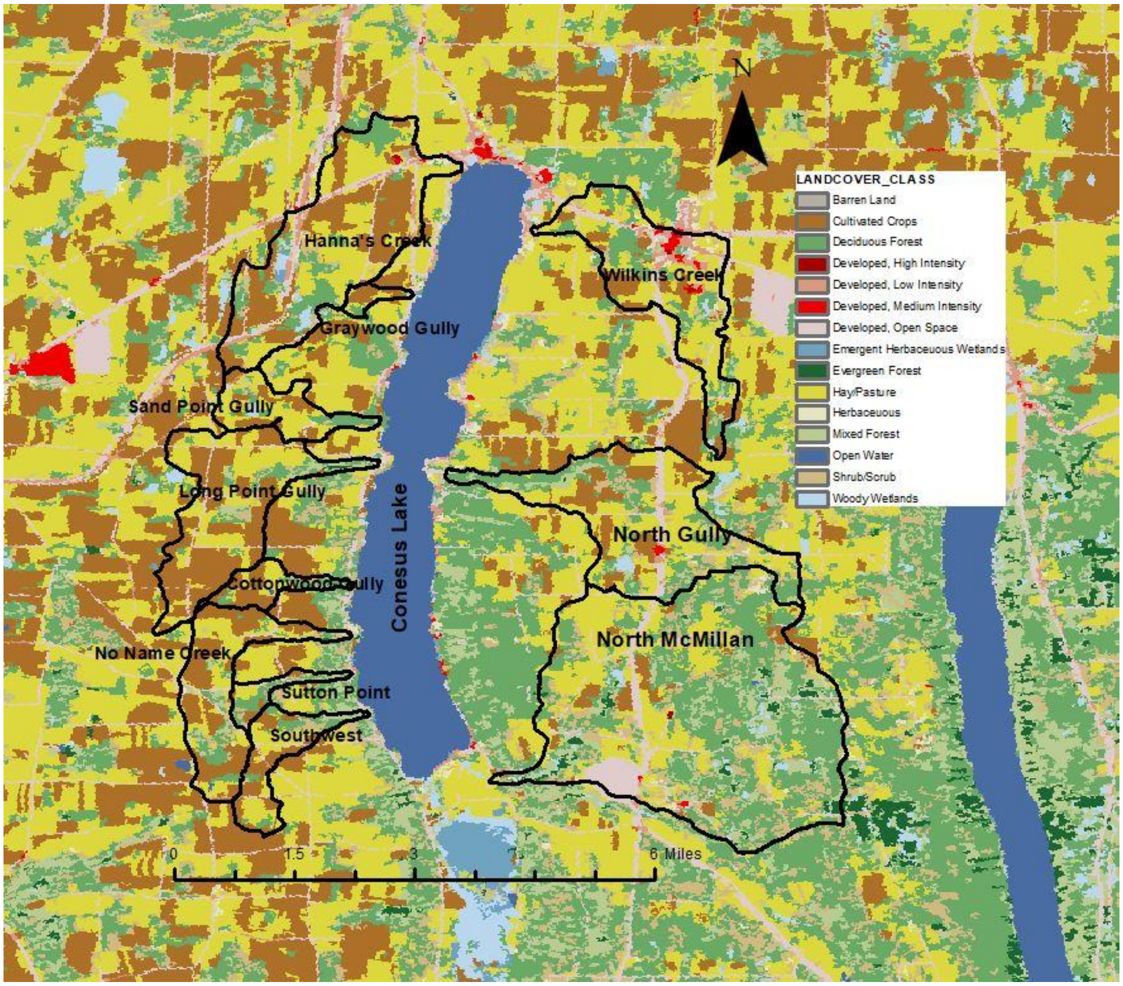
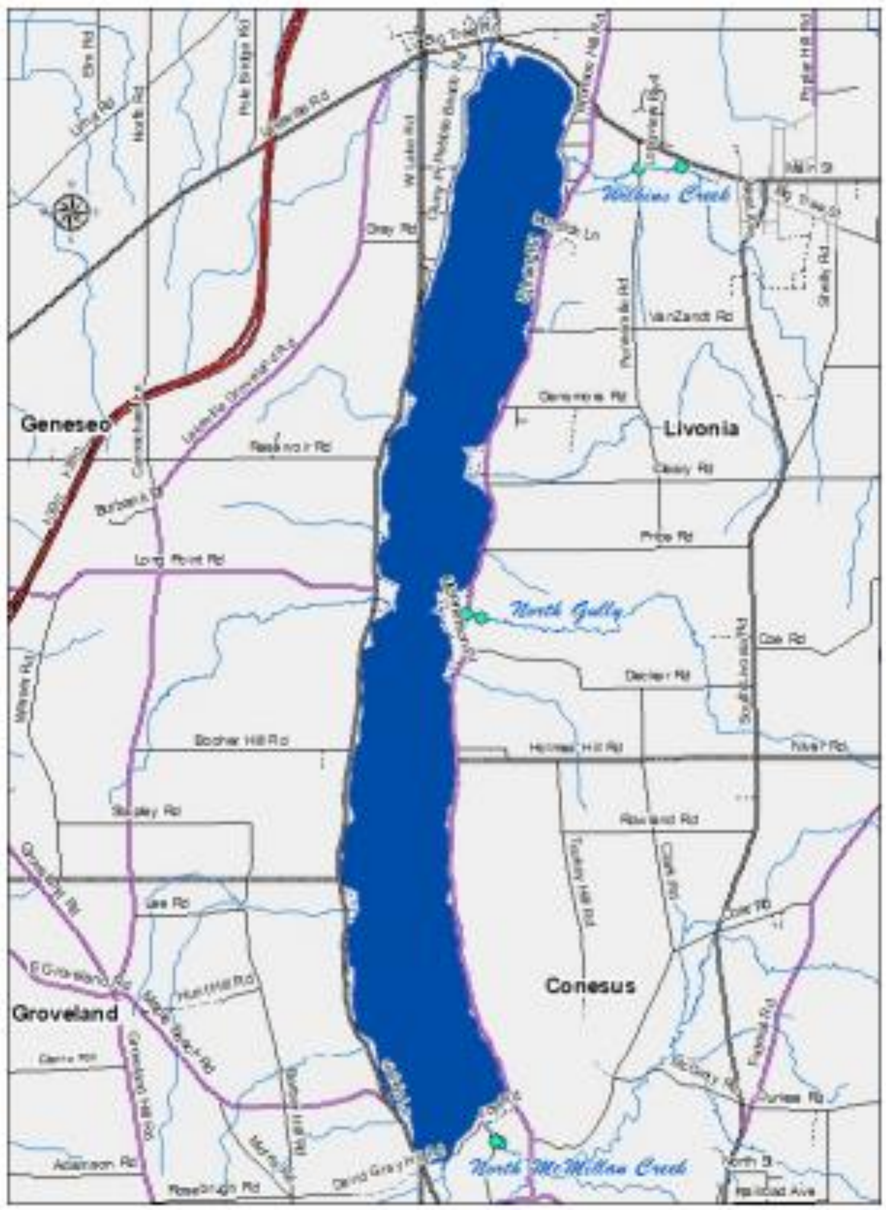


Figure 19: Concentrations and nutrient loads of total phosphorus (TP) (A and B), soluble reactive phosphorus (SRP) (A and B), nitrate/nitrite (C and D), total Kjeldahl nitrogen (TKN) (C and D), and total suspended solids (TSS) (E and F) in Wilkins Creek from 2020 sampling dates.

Appendix 1: Map of site locations

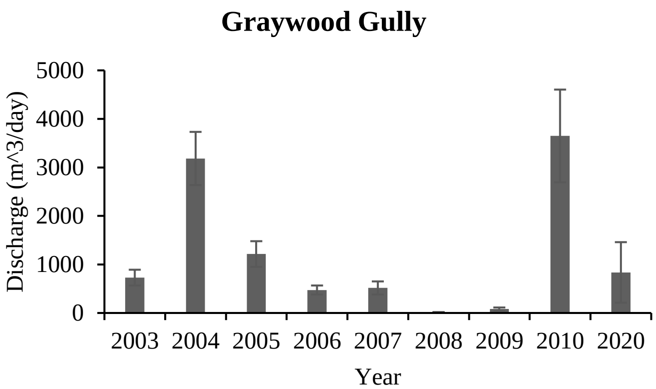


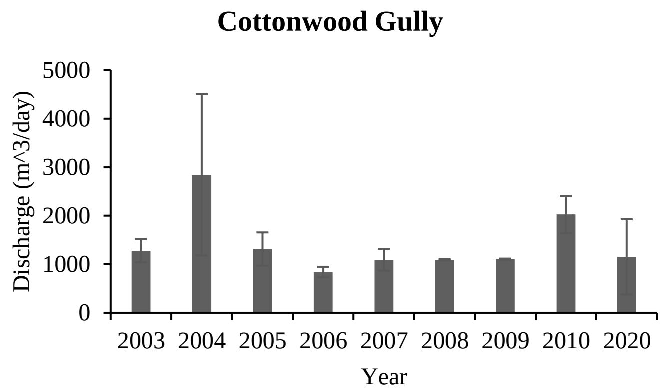
Map of 2020 streams and associated watershed boundaries and land use.

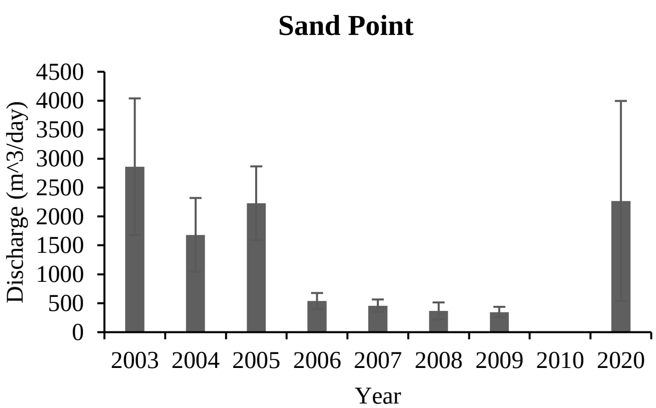


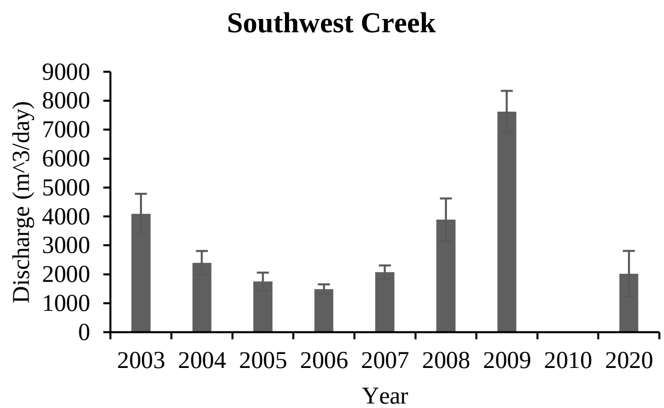
Map of erosion control project tributaries and sites.

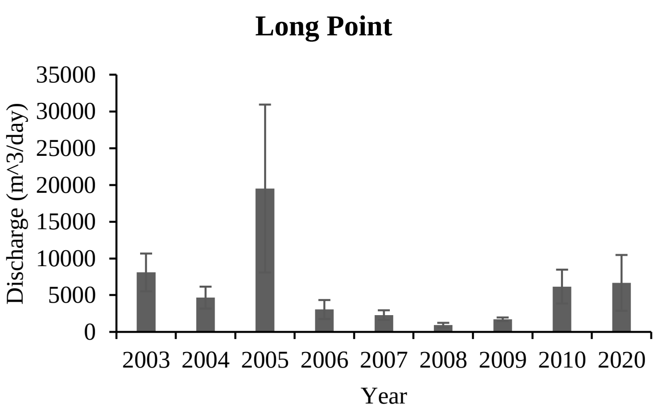
Appendix 2: Average discharge 2003 to 2010, and 2020 from May through August for former USDA study streams**.**

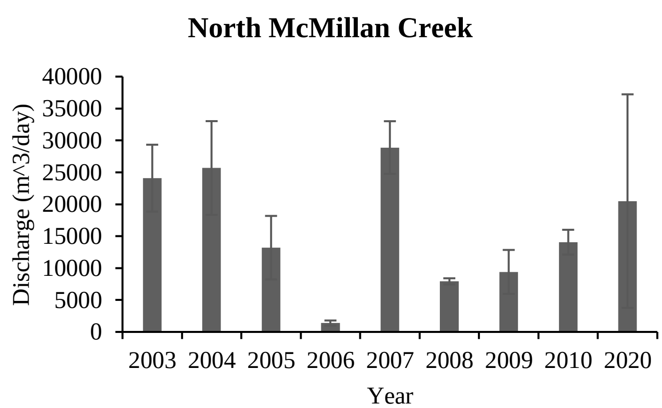


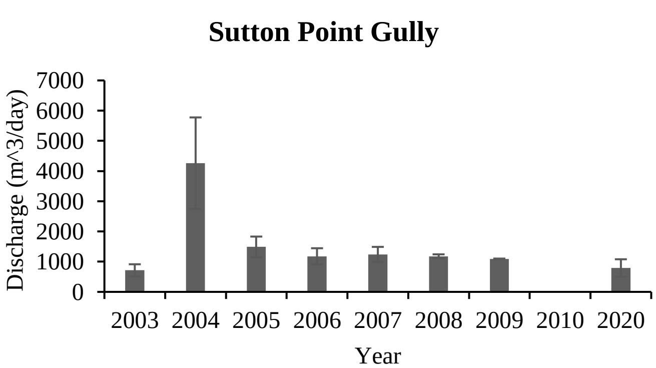




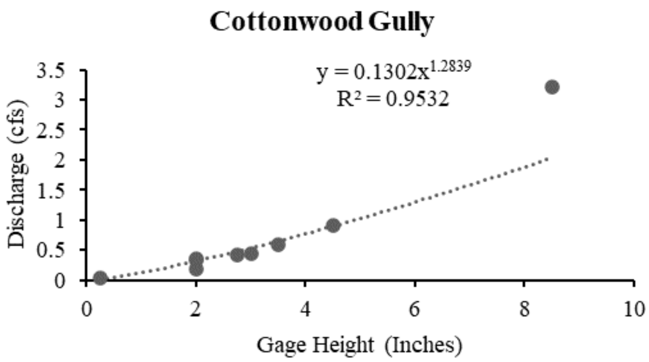


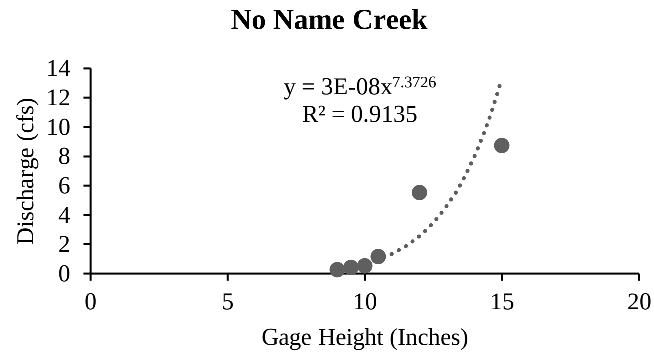


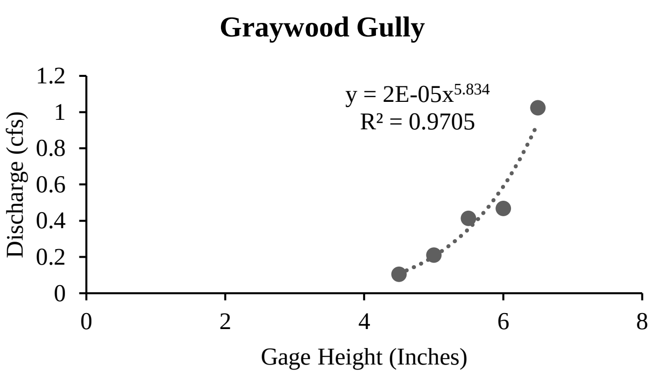


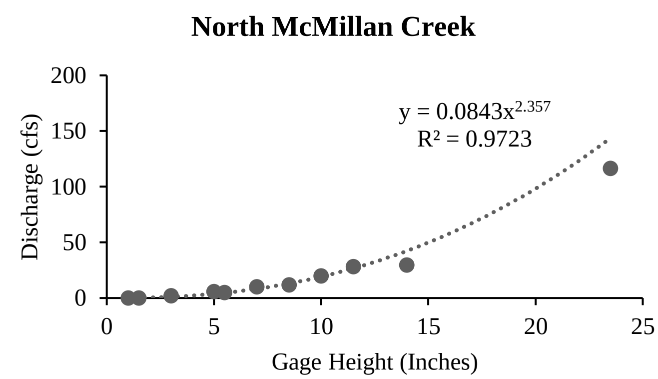


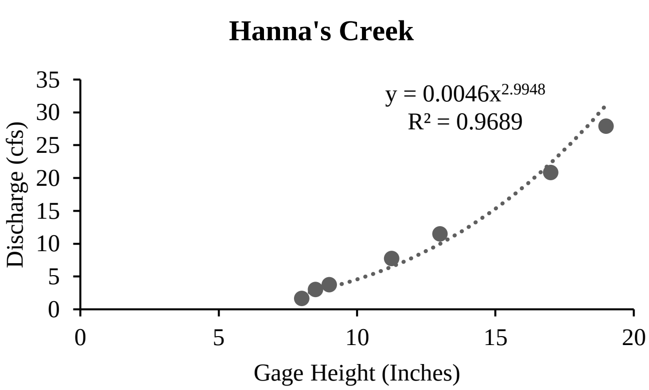
Appendix 3: Rating curves for 2020 study tributaries. Developed spring, summer, and fall 2020.

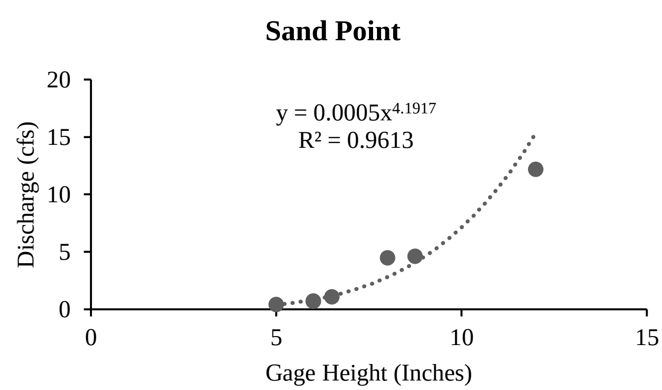


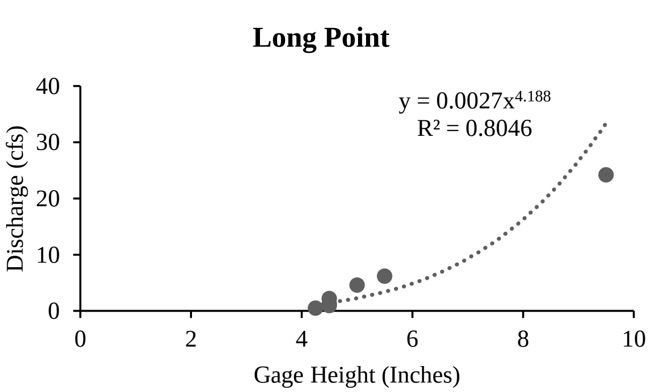


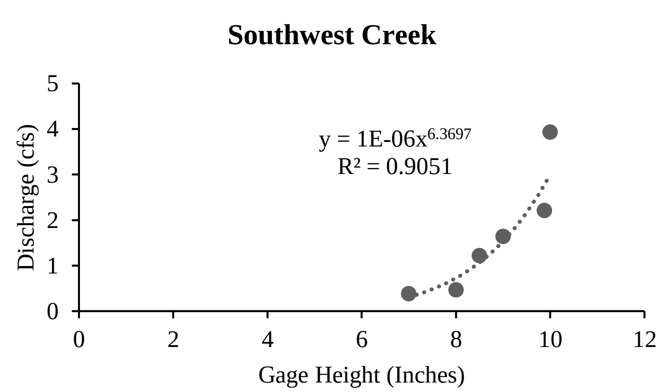


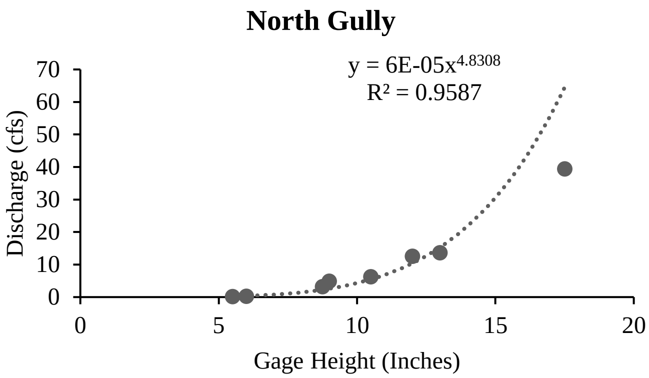


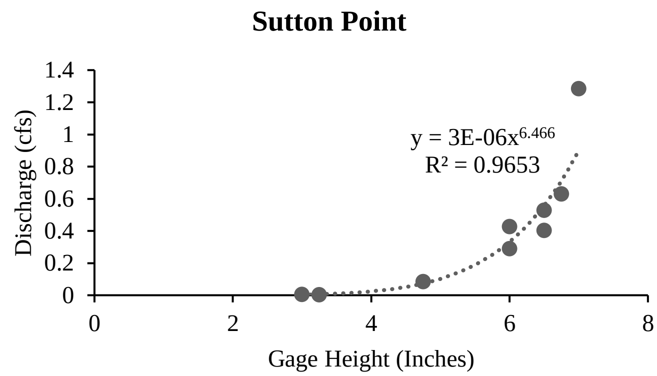


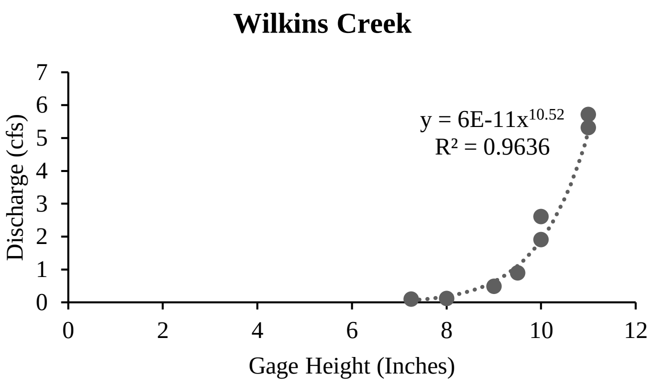







North Gully
y = 6E-05x^4.8308
R² = 0.9587
Discharge (cfs)
Gage Height (Inches)
0
10
20
30
40
50
60
70
0
5
10
15
20


Sutton Point
y = 3E-06x^6.466
R² = 0.9653
Discharge (cfs)
Gage Height (Inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
2
4
6
8


Wilkins Creek
y = 6E-11x^10.52
R² = 0.9636
Discharge (cfs)
Gage Height (Inches)
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12

Appendix 4: Site Pictures

North Gully near upstream sample site, showing erosion occurring above original stream bank stabilization project.

North McMillan Creek near downstream sampling site showing undercutting of stream banks and storm event runoff.

Significant erosion of stream bank on No Name Creek (Pictures taken near NYS RT 256 Bridge looking upstream).

Significant algal growth on substrate in Southwest Creek (left) and storm event runoff (right).

Appendix 5: Additional graduate student thesis storm event TSS and phosphorus concentrations.

Site	Date	Turbidity (NTU's)	TSS (mg/L)	TP (µg/L)	SRP (µg/L)
Eagle Point	5/15/2020	407.1	700	1117	30.7
Eagle Point	10/21/2020	220.51	127.55	650	229
Graywood Gully	3/29/2020	79	128	825	396.5
Graywood Gully	5/15/2020	209	281.1	1114	354.6
Graywood Gully	7/8/2020	58.5	168	650	359
Graywood Gully	7/11/2020	255	385.71	1050	368
Graywood Gully	10/21/2020	91.35	103	1310	824
Hanna's Creek	5/15/2020	197	296.5	559	23.2
Hanna's Creek	7/11/2020	304.3	416.33	1210	226
Hanna's Creek	10/21/2020	156.38	214.29	985	383
Long Point Gully	3/29/2020	355	539.09	1206	147.7
Long Point Gully	5/15/2020	296	467.65	1114	147.15
Long Point Gully	7/8/2020	325.6	429	1040	245.5
Long Point Gully	10/21/2020	275.25	415	990	226.5
North McMillan	5/15/2020	320	593.27	650	10.1
North McMillan	7/11/2020	236.9	314.08	525	28.2
North McMillan	10/21/2020	83.89	128.42	265	41.6
Sand Point Gully	10/21/2020	79.75	108.52	750	468
Southwest Creek	3/29/2020	51	46	930	609.7
Southwest Creek	7/11/2020	433	653	2262	503
Southwest Creek	10/21/2020	69.32	69.41	955	608