Summary report Alberta Phosphorus Watershed Project

2018–2020 supplement

Summary report Alberta Phosphorus Watershed Project 2018–2020 supplement

Author: Alberta Agriculture, Forestry and Rural Economic Development

Published by Alberta Agriculture, Forestry and Rural Economic Development

November 2021

ISBN 978-1-4601-5276-8

Title page photo credit: Cows and Fish

For more information regarding this content visit: https://www.alberta.ca/irrigation-strategy.aspx

Table of Contents

1. Introduction and Background

The movement of excess soil nutrients such as nitrogen (N) and phosphorus (P) from non-point sources to surface-water bodies in runoff is a major environmental concern in North America because nutrient enrichment, especially P enrichment, can degrade water quality (Carpenter et al. 1998). Research has shown that in Alberta, the amount of P in streams increases with agricultural intensity in watersheds (Lorenz et al. 2008). Further, the Nutrient Beneficial Management Practices Evaluation Project (Nutrient BMP Evaluation Project) demonstrated that the use of beneficial management practices (BMPs) successfully improves water quality, particularly by reducing nutrient concentrations, at the edge-of-field scale and recommended that more testing and analysis be done at the watershed scale (Paterson Earth & Water Consulting Ltd. and AARD 2014). The Alberta Phosphorus Watershed Project (APWP) was initiated in 2013 to address this recommendation, and to support the development of a long-term P strategy in Alberta.

During the initial years of the APWP, the Alberta Phosphorus Management Tool (APMT), a risk assessment tool, was developed for producers to identify locations on their operations at highest risk for P loss and to propose BMPs that could be adopted to minimize those risks. The APMT was used during the APWP with participating producers to test its utility, and to evaluate the land within the study watersheds to determine the risk of P loss. The results of the APMT assessments suggested several BMPs, some of which were implemented in the study watersheds. Water quality and flow were monitored in order to assess the cumulative effects of BMPs on reducing P loss at the watershed scale. The objectives of the APWP were to:

1. Develop the Alberta Phosphorus Management Tool (APMT).
2. Use the APMT to identify risk and implement BMPs on a watershed-wide scale.
3. Evaluate the cumulative effects of the BMPs on reducing P loss.
4. Evaluate the economic costs of implementing the recommended BMPs.

A paired watershed design was chosen, with two treatment watersheds (Tindastoll, Acme) and two control watersheds (Threehills, Lonepine) (Figure 1). The intent was to assess as much of the land within the watersheds as possible, and implement as many BMPs as possible in as short a time as possible, in accordance to results of the APMT land assessments. The first five years (2013 – 2017) of the study were previously reported by Seitz Vermeer et al. (2019). At the end of five years (2017), roughly 20% of the treatment watersheds had been assessed using the APMT, and less than 9% of the watersheds had BMPs implemented. No measurable changes in water quality could be defended as a result of BMP implementation at the time of reporting.

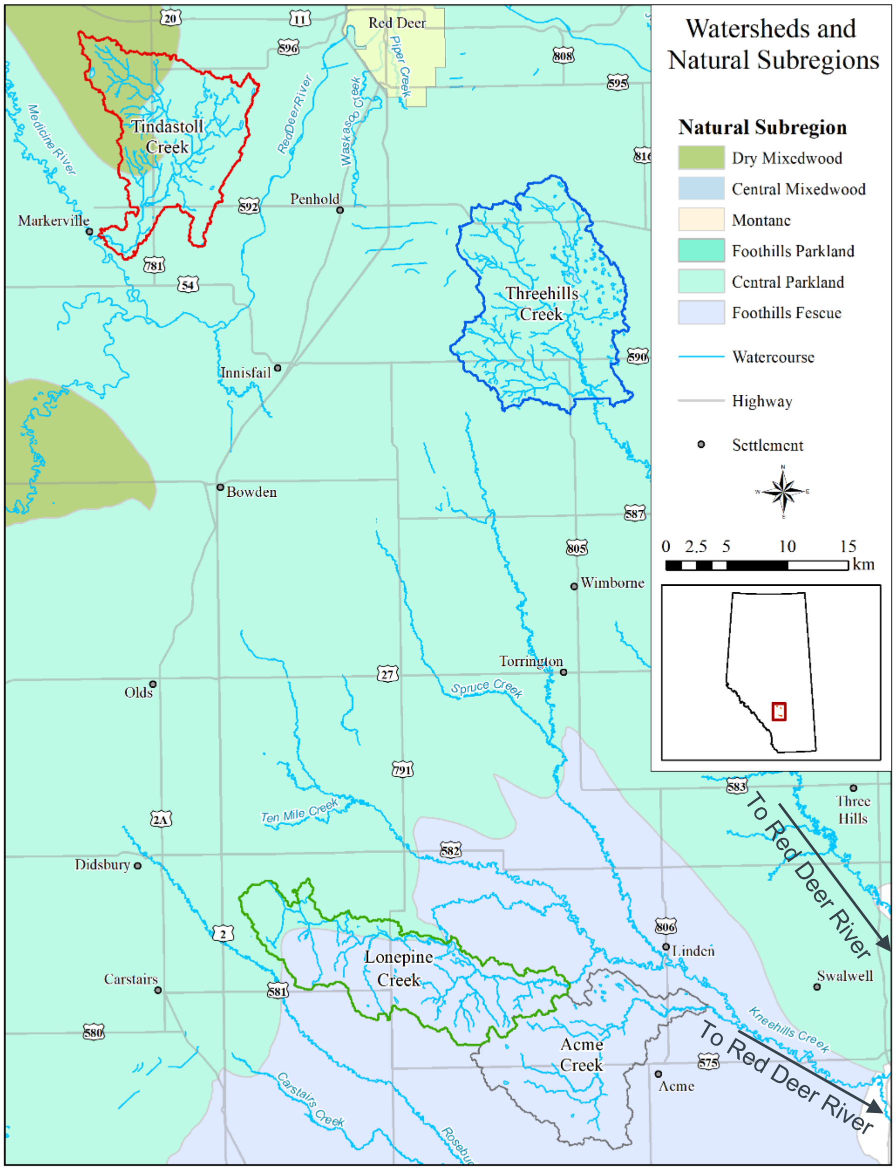

Figure 1. Location of treatment watersheds (Tindastoll Creek and Acme Creek) and control watersheds (Threehills Creek and Lonepine Creek) relative to natural sub-regions and major water systems. The red box in the inset shows the locations of the watersheds within Alberta.

In the first five years of the project, several challenges were encountered:

- Not all producers contacted were interested in participating, and several did not return phone calls, emails or other contact efforts.

- It took a long time to develop a relationship with producers and gain their trust. Thus, BMP implementation took longer than expected.
- Engagement with some counties and producer groups lost momentum.
- There was no project funding to implement BMPs and project staff relied on external funding programs to offset the costs of BMP implementation. This became a challenge in later years as there were fewer producer engagement specialists involved in the project.
- Beaver dams were a problem in the Tindastoll watershed, which affected water quality and flow monitoring efforts.

In 2017, the project team renewed efforts to continue to engage with new and participating producers, to assess land with the APMT, and implement BMPs for two more years (2018–2019). Outlets would also continue to be monitored for six more years (2018–2023).These changes were intended to allow for more BMPs to be implemented, resulting in a 10-year record of water quality data for robust statistical trend analyses. At the end of 2018, some progress had been made in assessing more land with the APMT in the treatment watersheds, however, no progress had been made with BMP implementation.

In 2019, a newly proposed Phase II of the project was adopted in which monitoring and producer engagement in the Acme (ACME) and Lonepine (LPT) watersheds were discontinued in favour of focusing efforts in the Tindastoll (TIN) and Threehills (THC) Watersheds (Figure 2). This was done for several reasons. First, producer engagement was especially challenging in the ACME Watershed. As well, the TIN Watershed is within Red Deer County (RDC) and APWP staff developed a good working relationship with the RDC conservation coordinator during the initial years of the project, and it was thought that this relationship would aid in recruiting more producers to join the project. Further, RDC is one of the counties in Alberta that delivers the Alternative Land Use Services (ALUS) program— a national program that works with local municipalities throughout Canada to implement environmentally friendly land-use projects (ALUS Canada 2020). Through ALUS, farmers and ranchers are provided financial support to implement BMPs, especially for livestock management (i.e., off-stream watering), which, in turn, produce ecological services, such as clean water, flood mitigation, and species at risk habitat. By working with RDC, there were potential benefits to the project as RDC's involvement in the ALUS program would provide another means of funding, in addition to that available from the Canadian Agricultural Partnership (CAP), for implementing BMPs in the TIN watershed. Refer to Section 2.1.

During Phase II, efforts in producer engagement and water quality and flow monitoring were completely focused in the TIN and THC watersheds, and were proposed to continue until 2023. The objectives of Phase II were to:

- Continue to assess the risk of P loss using the APMT and aim to assess at least 90% of the treatment watershed.
- Continue to implement BMPs based on APMT recommendations and available resources.
- Monitor water quality to determine the cumulative effect of BMPs on water quality at the watershed scale.

Despite these renewed efforts, the APWP was discontinued in 2020 due to continued challenges with producer engagement and BMP implementation.

1.1 Purpose

As 2020 was the last year of the APWP, this report is meant to supplement the 2013–2017 progress report by summarizing the progress made in the APWP from 2018–2020. This final project summary report is the final deliverable of the project.

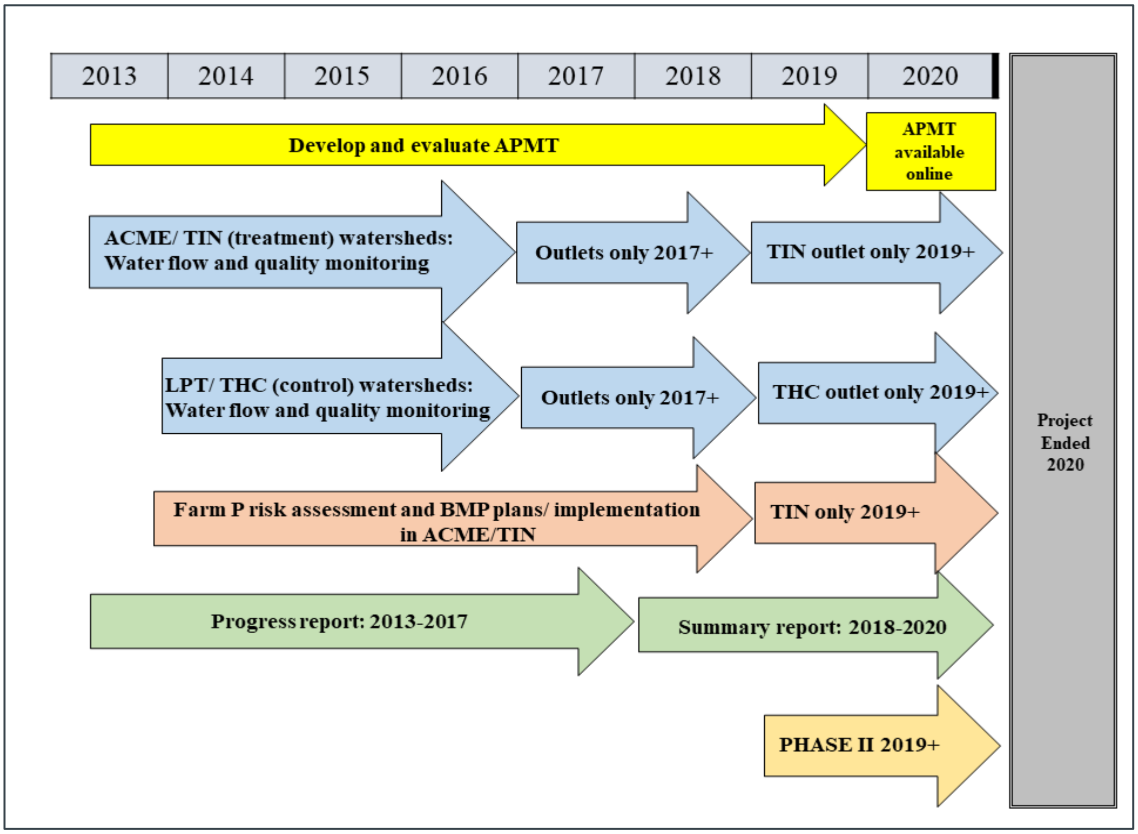

Figure 2. Project Timeline and major phases.

2. Alberta Phosphorus Management Tool, Watershed Assessment and Beneficial Management Practices Progress

2.1 Introduction

The Alberta Phosphorus Management Tool (APMT) was developed during this project. It is a risk assessment tool to help producers minimize their risk of environmental impacts associated with the loss of P from their agricultural operations, and maximize the benefits of applied manure and fertilizer. It also serves as an educational tool, explaining the effects a given BMP can have on P loss. In 2020, the APMT was made available online for producers to use[1] (AAF 2020). Although water quality and flow monitoring began in 2013 in the treatment watersheds, producer recruitment and APMT assessments did not begin until 2014.

Ideally, the APMT would be filled out by project staff in the presence of the participating producer to train producers on its use and to build a rapport with the producer, as was done in 2014–2017. Efforts were focused on land within the watershed boundaries, particularly along the creek and tributaries, however, if a producer also managed land outside of the watershed, that land was assessed with the APMT as a courtesy to the producer. In 2018–2020, project staff found that it was equally efficient to complete the assessments over telephone and e-mail, where producers could answer questions at their convenience. In-person assessments often required follow-up conversations to answer questions that could not be answered or provide details that were not available in the few hours set aside for the visit. In 2020, assessments were done exclusively using telephone and e-mail due to restrictions put in place in response to the COVID-19 pandemic.

2.2 Discussion

In the TIN Watershed, from 2014–2017, 70 quarter sections (4,550 ha) were assessed using the APMT, of which 61 were within or on the watershed boundary, representing 22% of the watershed area (Table 1). From 2018–2020, 103 quarter sections (6695 ha) were assessed with the APMT, of which 71 were within or on the watershed boundary (Figure 3). This brought the total number of assessed quarter sections within the watershed to 132, or 47% of the watershed

[1] Available at: https://www.alberta.ca/phosphorus-management-tool.aspx

area, representing a 25% increase in the assessed watershed area. However, this falls 43% short of the goal of assessing 90% of the watershed. Notably, in terms of using the APMT to assess land, more progress was made in the last three years of the project (25% assessed) than in 2014–2017 (22% assessed). Of the 71 quarter sections assessed from 2018–2020, 40 (or 56%) were assessed as being high risk for P loss. This changed the total proportion of the assessed watershed area that was rated as high risk for P loss to 49% (Table 1).

Table 1. Project participation and watershed assessment progress in each treatment watershed from 2014–2017 and 2018–2020.

	2014–2017		2018–2020	
	TIN	ACME	TIN	ACME
Producers	9	7	18	9
Watershed Area Assessed	22%	17%	47%	31%
Proportion of assessed area designated as high risk	41%	64%	49%	60%
Proportion of watershed area with BMPs[z]	5%	8%	7%	8%

[z] Includes all BMPs (i.e., soil testing, additional land to spread manure).

A total of 18 producers in the TIN watershed had their land assessed by the APMT, with nine producers participating from 2014–2017 and nine participating from 2018–2020.

In the ACME watershed, seven producers participated in the project from 2014–2017. All but one of those producers had their land assessed by the APMT. That particular producer had some land that was either not assessed, or partially assessed, with the APMT, but had implemented BMPs on the unassessed land on their own initiative from 2014–2017. From 2018–2019, that producer, and two additional producers who joined the project after 2017, had their land assessed by the APMT (Figure 4). As was done in the TIN watershed, if a producer managed land outside of the ACME watershed, that land was also assessed with the APMT.

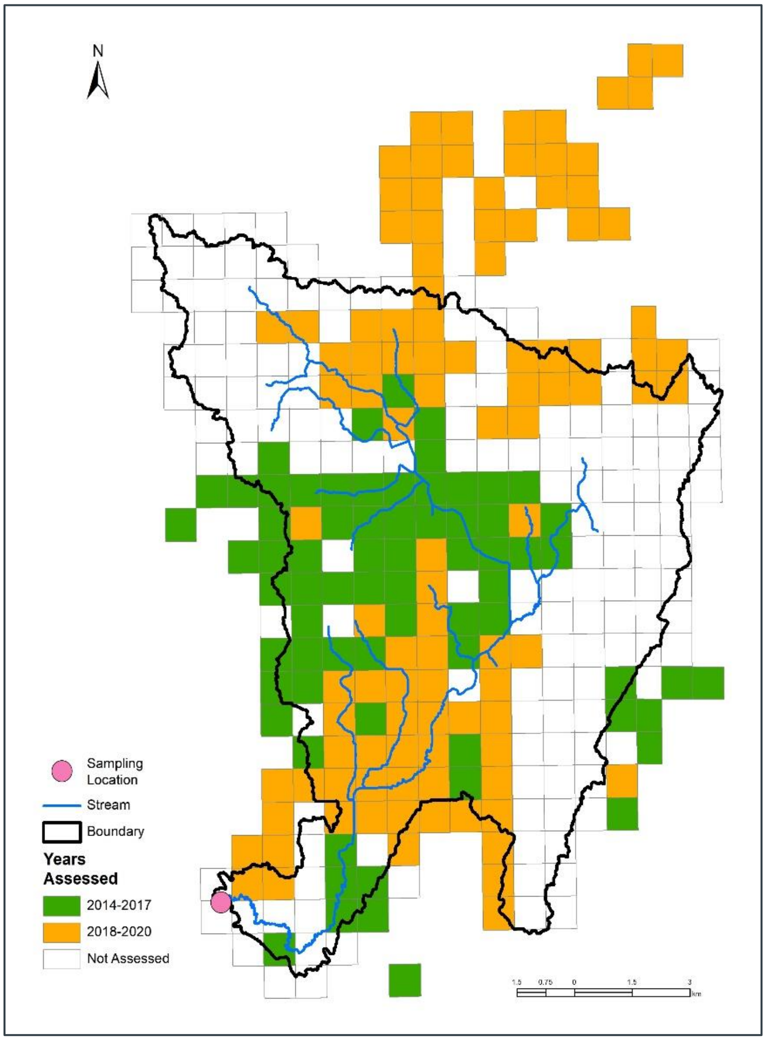

Figure 3. Land assessed using the APMT in the TIN Watershed from 2014–2017 and 2018–2020.

From 2014–2017, 57 quarter sections (3705 ha) were assessed using the APMT, of which 47 were within or on the ACME watershed boundary. From 2018–2019, 43 quarter sections (2795 ha) were assessed with the APMT, of which 37 were within the ACME Watershed boundary. This brought the total number of assessed quarter sections within the watershed to 84, or 31% of the watershed area, an increase of 14% over the total area assessed from 2014–2017. Further, of the 37 quarter sections assessed from 2018–2019, 20 were assessed as high risk for P loss, representing 54% of those assessed in 2018 and 2019. This changed the total proportion of the assessed watershed area that was rated as high risk for P loss to 60% (Table 1).

No additional BMPs were implemented through the APWP in the treatment watersheds from 2018–2020. However, some landowners in the TIN Watershed implemented seven additional BMPs through RDC's ALUS program from 2018–2020. One of the original landowners installed a livestock management BMP in 2018, three livestock management BMPs in 2020, and two erosion and flooding BMPs in 2020 and one of the landowners that joined APWP after 2017 also installed a livestock management BMP in 2018 (Ken Lewis, RDC, personal communication). Five of these BMPs were implemented on quarter sections that did not already have BMPs implemented. This brought the total proportion of the TIN Watershed with BMPs implemented to 7% (Table 1).

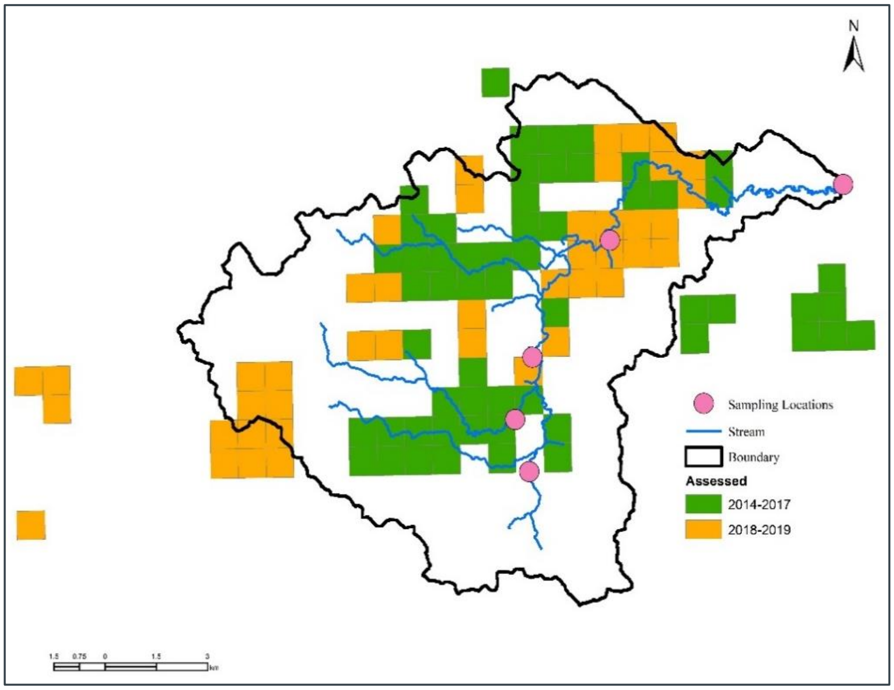

Figure 4. Land assessed using the APMT in the ACME watershed from 2014–2017 and 2018–2019.

A common outcome of the APMT assessments was that some of the quarter sections were assessed as being low risk for P loss, and therefore BMPs were not suggested by the P tool. For example, in 2018–2020, just under half (49%) of the land that was assessed in the TIN watershed (47% of the total watershed) was rated as being high risk for P loss. By 2019, 60% of the land that was assessed in the ACME watershed (31% of the total watershed) was rated as high risk (Table 1). This indicates that about 50% of the land assessed in the TIN watershed and 40% of the land assessed in the ACME watershed were rated as being low risk for P loss.

From 2018–2020, funding for BMPs was sought through CAP, which replaced the Growing Forward 2 (GF2) program in April 2018. Under the CAP program, there were additional requirements for producers applying for grants, including completing an Environmental Farm Plan and, in some instances, developing a Long-term Water Management Plan. For producers participating in the APWP, these requirements were in addition to completing the APMT assessment. These changes ensured a robust environmental sustainability plan for agricultural operations, but did require more time to complete.

3. Monitoring of Environmental Parameters

3.1 Introduction

Water monitoring stations were established throughout the stream networks, including the outlet, at all four watersheds during the initial years of the study to evaluate the cumulative effects of BMPs on reducing P loss at the watershed scale in the treatment watersheds. Water quality and flow monitoring were performed at each of the monitoring stations. Water quality sampling used the grab-sample method, and was performed twice a week during spring snowmelt, once a week as snowmelt flows subsided, and once every two weeks during base flow periods throughout the remainder of the growing season. When possible, rainfall runoff events were sampled twice a week.

Water samples were analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), orthophosphate (PO_4-P), total nitrogen (TN), nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonia-nitrogen (NH_3-N), total suspended solids (TSS), pH, electrical conductivity (EC), chloride (Cl), and *Escherichia coli* (*E. coli*). Values of dissolved inorganic nitrogen (DIN = NO_3-N + NO_2-N + NH_3-N), organic nitrogen (ON = TN – DIN), and particulate phosphorus (PP = TP – TDP) were also calculated. This report summarizes the results of N, P, and TSS.

Because the study aimed to assess the cumulative effects of BMPs at the watershed scale, monitoring at the upstream stations was discontinued in 2018. Further, due to ponding by a beaver dam at TIN-1, an additional station (TIN-8) was added downstream in 2016. The TIN-1 station was discontinued after 2017 in favour of the TIN-8 station. Only the watershed outlets were instrumented with equipment for collecting continuous flow measurements. Flow monitoring including stage and flow measurements during the open-water season, and spanned from 2014 to 2020 for the TIN and THC watersheds and from 2014 to 2018 for the ACME and LPT Watersheds (Figure 2). Flow data for the THC sub-watershed outlet were retrieved from an Environment and Climate Change Canada (ECCC) flow gauging station (station 05CE018; ECCC 2020). At the time of this report, the 2020 data was preliminary and had not yet been validated by ECCC.

Refer to Seitz Vermeer et al. (2019) for further details on the water monitoring methods used in the APWP.

3.2 Results and Discussion

Water quality patterns observed in the study watersheds from 2018–2020 were similar to patterns observed from 2014–2017. Specifically, the overall concentration of TN was slightly higher in the treatment watersheds than in the control watersheds. Further, the proportion of ON made up more than half of the average TN concentrations compared to DIN in all watersheds in all years, but the fraction of ON compared to DIN was higher yet in the control watersheds than the treatment watersheds for all years (Figure 5a,b; Figure 6a,b). Concentrations of TN were relatively stable in all watersheds, though there were notable increases in 2017 in TIN and in 2018 in ACME.

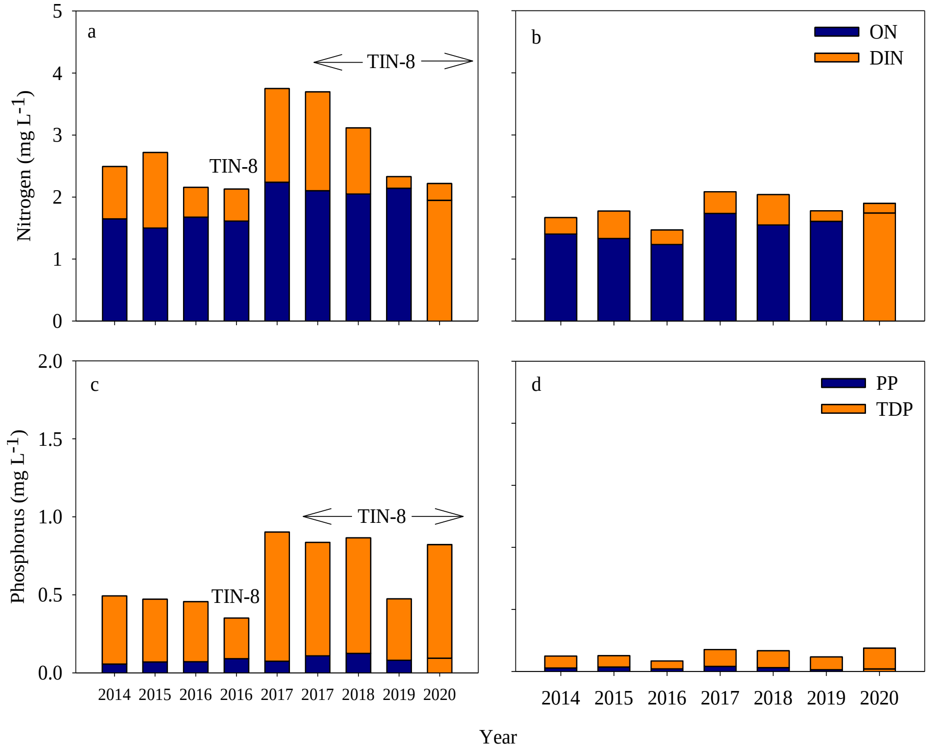

Figure 5. Average concentrations of ON and DIN from 2014 to 2020 for (a) TIN and (b) THC watersheds; and average concentrations of PP and TDP from 2014 to 2020 for (c) TIN and (d) THC watersheds. The stacked bars represent total N (ON plus DIN) and total P (PP plus TDP). The unlabelled bars in Figure 5a,c are for the TIN-1 site, which was discontinued after 2017.

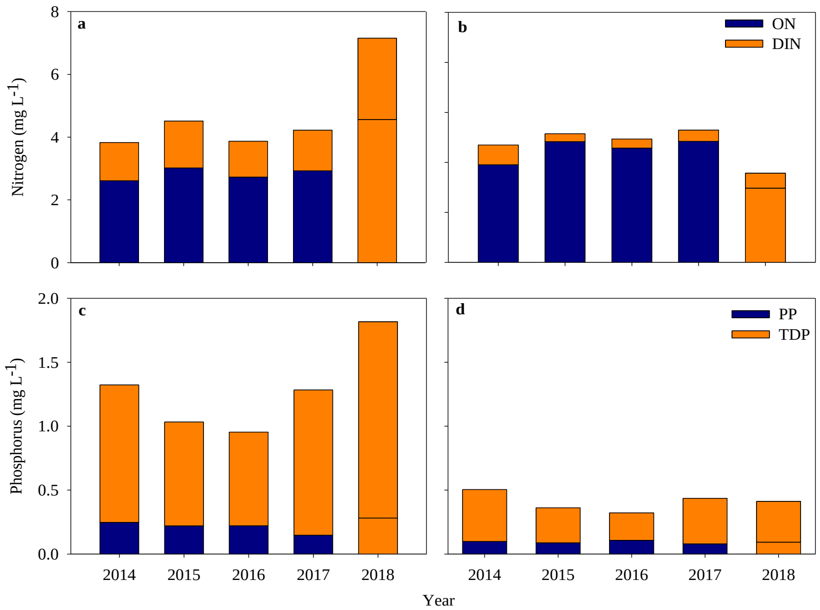

Figure 6. Average concentrations of ON and DIN from 2014 to 2018 for (a) Acme and (b) LPT watersheds; and average concentrations of PP and TDP from 2014 to 2018 for (c) Acme and (d) LPT watersheds. The stacked bars represent total N (ON plus DIN) and total P (PP plus TDP).

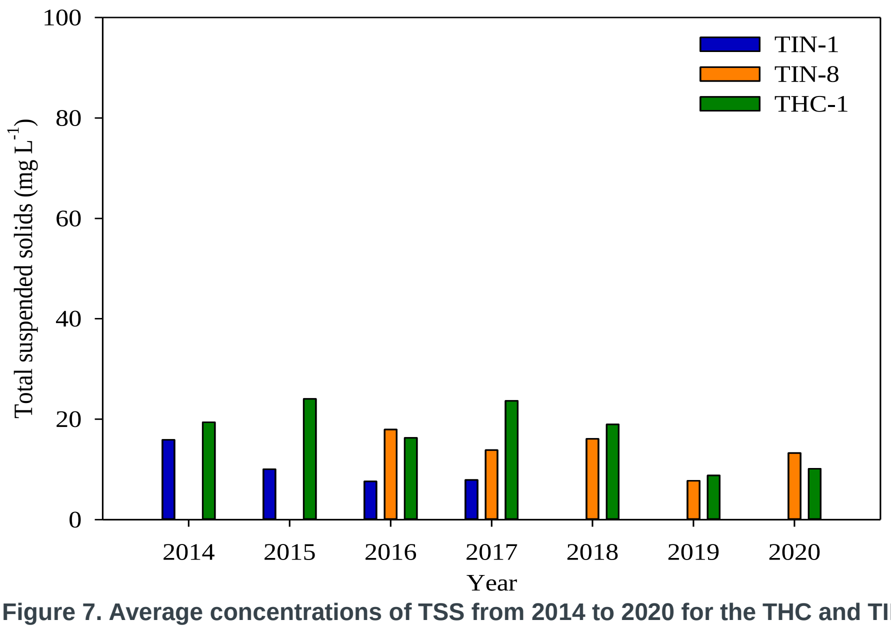

Figure 7. Average concentrations of TSS from 2014 to 2020 for the THC and TIN watersheds, with the TIN-8 site included from 2016–2020. The high value for the y-axis allows for comparison to TSS concentrations in the ACME and LPT watersheds shown in Figure 8.

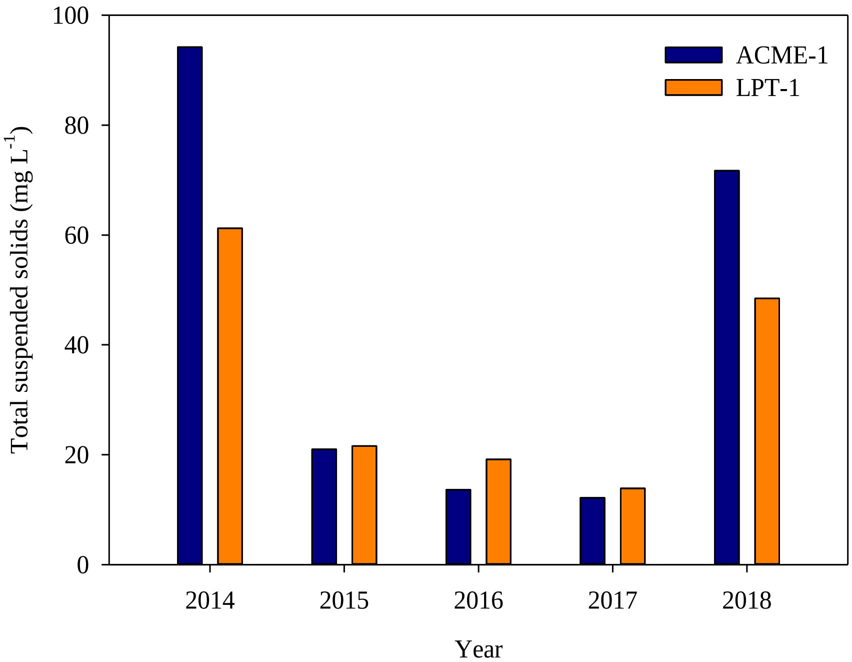

Figure 8. Average concentrations of TSS from 2014 to 2018 for the LPT and ACME watersheds.

Similarly, TP concentrations were markedly higher in the treatment watersheds than the control watersheds, whereas the proportion of TDP made up the majority of TP concentrations in all watersheds in all years (Figure 5c,d; Figure 6c,d).

Concentrations of TSS in the TIN and THC watersheds were low, and showed little variation from 2014–2020. Concentrations were generally only slightly higher in the THC sub-watershed than in the TIN watershed, except for 2016 and 2020 when TSS was slightly higher at TIN-8 than THC-1 (Figure 7). However, flows were nearly three times higher in Threehills creek than Tindastoll Creek in 2016 (Seitz Vermeer et al. 2019) and 2020 (Table 2; Figure 9). There are several reasons why TSS concentrations were higher and flow was lower at TIN-8 compared to THC in these two years. First, in 2016 there was a large beaver dam upstream of TIN-8 which may have prohibited streamflow at the outlet. There was also a large storm event in August 2016 that resulted in increased TSS concentrations at both outlets, but concentrations at TIN-8 were three times higher than at THC-1 following the event, suggesting that the TIN watershed is more responsive to runoff events especially during dry years like 2016. Not surprisingly, snowmelt and rainfall events drive runoff in these two watersheds, and there was likely more TSS transported in TIN than THC in 2016 and 2020, despite lower flows. Suspended algae may also have influenced TSS concentrations.

Concentrations of TSS in the ACME and LPT watersheds were nearly three times higher in 2014 and 2018 than from 2015–2017 (Figure 8). Further, the concentrations of TSS were higher at ACME-1 than LPT-1 in 2014 and 2018, while the reverse was true for 2015–2017. The hydrographs for ACME and LPT show higher flows during spring runoff in 2014 and 2018, and this helps explain the higher TSS concentrations, though LPT had higher flows than ACME in those years (Figure 10). Total annual flow was high for both watersheds in 2018 (Table 2).

Table 2. Annual flow and distribution of flow during snowmelt and rainfall periods at the watershed outlets from 2018–2020. Acme and LPT were not sampled after 2018.

Watershed	Total precipitation (mm)	Annual flow (m^3 yr^{-1})	Snowmelt (%)	Rainfall (%)
		2018		
Tindastoll	343.0	4,377,092	98	2
Threehills	324.8	8,798,252	91	9
Acme	308.0	3,056,137	99	1
Lonepine	345.6	4,232,725	99	1
Average	330.4	5,116,051	97	3
		2019		
Tindastoll	348.8	2,720,494	68	32
Threehills	349.4	3,345,624	85	15
Average	349.1	3,033,059	77	24
		2020		
Tindastoll	471.6[z]	3,202,558	77	23
Threehills	474.6[z]	9,177,335[y]	65	35
Average	473.1	6,189,947	71	29

[z] Data were quality controlled up to Nov 19, 2020 at the time of this report.
[y] Data are preliminary at the time of this report.

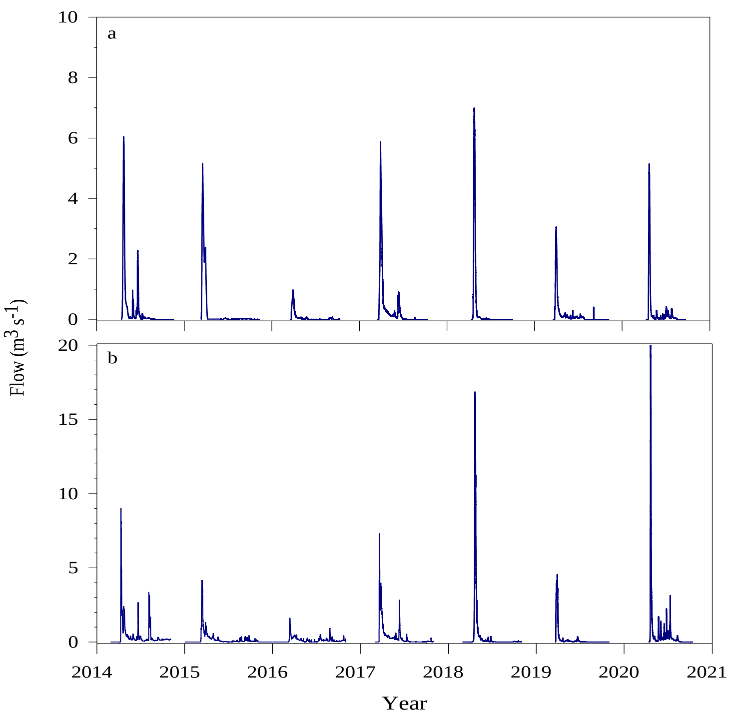

Figure 9. Hydrographs for (a) TIN and (b) THC from 2014 to 2020. Data for THC in 2020 were considered preliminary at the time of this report.

In all seven study years, the TIN watershed had lower annual flows than the THC sub-watershed. The average annual flow for the TIN Watershed from 2014–2020 was 3,902,532 m^3 yr^{-1}, while the average annual flow for the THC sub-watershed from 2014–2020 was 6,488,671 m^3 yr^{-1}. The highest flows for the TIN and THC watersheds occurred in 2017 and 2020, respectively, though the 2020 flow data for the THC sub-watershed was considered preliminary at the time of this report. The year with the next highest flow for the THC sub-watershed was 2018. The lowest flows for the TIN and

THC Watersheds occurred in 2016 (Seitz Vermeer et al. 2019).

On average, the ACME Watershed had lower annual flows than the LPT Watershed. The average annual flow for ACME from 2014–2018 was 1,403,782 $m^3\ yr^{-1}$, and the average annual flow for the LPT Watershed from 2014–2018 was 2,423,922 $m^3\ yr^{-1}$. The highest flows for the ACME and LPT watersheds occurred in 2018 and 2014, respectively. The lowest flows occurred in 2016 in both watersheds.

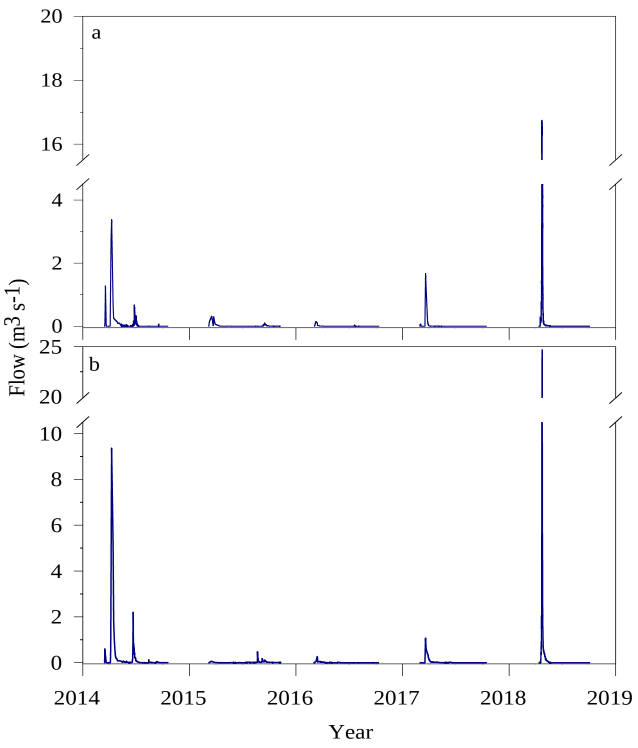

Figure 10. Hydrographs for (a) Acme and (b) LPT from 2014 to 2018.

4. Summary of Key Findings

This report highlights the work that was done in the APWP from 2018–2020 and was published to supplement the work done in the first five years of the project from 2013–2017. Some additional progress was made during the last three years:

- The Alberta Phosphorus Management Tool has been posted online and is available for the public to use (AAF 2020).
- An additional 25% of the TIN watershed was assessed with the APMT for a total of 47% of the watershed.
- An additional 14% of the ACME watershed was assessed with the APMT for a total of 31% of the watershed.
- An additional 11 producers had their land assessed by APMT (nine in TIN; two in ACME).
- Seven BMPs were implemented on five additional quarter sections, which increased the total area of the watershed with BMPs to 7%, a difference of 2% from 2014–2017.

There were also several findings that were consistent between the first five years and last three years of the project:

- Producer engagement was more gradual than expected. It took time to build relationships and trust with the producers, which influenced BMP implementation.
- The Alternative Land Use Services program had the most success in implementing BMPs in the TIN watershed, due to the participation of Red Deer County in this program.
- Average nutrient concentrations in water were generally higher in the treatment watersheds than in the control watersheds.
    - Higher proportions of TDP compared to PP were observed in all watersheds in all years.
    - Higher proportions of ON compared to DIN were observed in all watersheds in all years.
- Average nutrient concentrations at the outlets are not indicative of BMP implementation, but rather show a response to annual flow.
- From 2018–2020, no major improvements in water quality were identified at the outlets (i.e. watershed scale).

5. Concluding Statements

No major improvements in water quality were observed at the study watershed outlets from 2018–2020. Though seven additional BMPs were implemented in the TIN watershed, increasing the total proportion of the watershed with BMPs to 7%, the effects of the additional BMPs on water quality at the outlet (station TIN-8) are likely negligible. This was the same outcome observed in the APWP from 2013–2017, which saw 5% of the TIN watershed implemented with BMPs, and 8% of the ACME watershed implemented with BMPs, and no improvement in water quality at the watershed scale. As outlined in Seitz Vermeer et al. (2019), it is likely that:

- Not enough BMPs on a large enough area have been implemented to see a response in water quality;
- Widespread adoption of BMPs throughout the watersheds would elicit a response in water quality after several years of monitoring owing to lag effects;
- Much of the land within the study watersheds are not at high risk for P loss; and
- Water is of decent quality in most years.

For interested producers, funding for BMPs is available through the Canadian Agricultural Partnership[2] (CAP 2020). Developing an Environmental Farm Plan (EFP) is also a good first step. There are resources, including technicians, available to assist producers with their CAP applications and developing an EFP. These resources may also be available through local counties.

Additionally, the ALUS program is delivered by 13 participating municipal districts or counties in Alberta (ALUS Canada 2020), and funds are available to producers who are especially interested in BMPs for livestock management, including off-stream watering, exclusion fencing, cattle access bridges, feeding practices, seasonal feeding/bedding site moves, and riparian planting. Producers interested in reducing their P loss and environmental effect should consult with their local counties to discuss technical or financial resources that are available to assist with the implementation of BMPs, such as through ALUS or similar programs.

[2] Available online at: https://cap.alberta.ca/CAP/index.html

6. References

Alberta Agriculture and Forestry (AAF). 2020. Alberta Phosphorus Management Tool. Alberta Agriculture and Forestry, Edmonton, Alberta, Canada. [Online] Available at https://www.alberta.ca/phosphorus-management-tool.aspx [Accessed Nov 2021].

Alternative Land Use Services Canada (ALUS Canada). 2020. [Online] Available at https://alus.ca/ . [Accessed Nov 2021].

Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Sharpley, A.N., and Smith, V.H. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecol. Applic. **8**: 559–568.

Canadian Agricultural Partnership (CAP). 2020. [Online] Available at https://cap.alberta.ca/CAP/index.html [Accessed Nov 2021].

Environment and Climate Change Canada (ECCC) 2020. Real-time hydrometric data search results for station number 05CE018. [Online] Available at https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=05CE018 [Accessed Nov 2020].

Lorenz, K.M., Depoe, S.L., and Phelan, C.A. 2008. Assessment of Environmental Sustainability in Alberta's Agricultural Watersheds Project. Volume 3. AESA Water Quality Monitoring Project. A summary of surface water quality in Alberta's agricultural watersheds: 1995–2006. Alberta Agriculture and Rural Development, Edmonton, Alberta, Canada. 487 pp.

Paterson Earth & Water Consulting Ltd. and Alberta Agriculture and Rural Development (AARD). 2014. Nutrient Beneficial Management Practices Evaluation Project. Volume 1: Summary and recommendations. Lethbridge, Alberta, Canada. 134 pp.

Seitz Vermeer, N., Kerr, J.L., Wallace, T., Buruma, W., Jedrych, A., Kobryn. M., Axelson, R., Ormann, T., and Olson, B. 2019. Alberta Phosphorus Watershed Project Progress Report 2013–2017. Alberta Agriculture and Forestry, Lethbridge, Alberta, Canada. 213 pp. [Online] Available at https://open.alberta.ca/publications/alberta-phosphorus-watershed-project-progress-report-2013-2017 [Accessed Nov 2021].