

Retention-Irrigation SCM Performance in Austin

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Introduction

The retention-irrigation (RI) stormwater control measure (SCM) is unique to Austin and normally only used in areas covered by the Save our Springs (SOS) ordinance (SOS, 1992). The SOS ordinance was passed in 1992 to implement various development rules in the Barton Springs-Edwards Aquifer recharge zone and contributing area. Among other things, the SOS ordinance required new developments in the affected area to incorporate water quality controls that would achieve non-degradation of stormwater runoff. The main structural control used to achieve this goal is an RI SCM which provides virtually no discharge to receiving waters.

An RI system consists of three main components: a retention basin, an irrigation system, and an irrigation field. The retention basin collects and holds runoff from the area to be treated up to a given design volume based on the drainage area, impervious cover, and the 2-year, 3-hour rainfall event in the Austin area. Excess volumes are allowed to bypass the pond untreated. For detailed design criteria, refer to the City of Austin Environmental Criteria Manual (ECM, 2013).

The irrigation system in an RI SCM should be designed to deliver the volume of the retention basin uniformly to the irrigation field over a set time. Current rules require the full retention basin volume to be emptied within 72 hours after the rain ends with no irrigation during the first 12 hours. In addition, the irrigation cannot be continuous but must alternate application and rest periods. The irrigation field is used for runoff disposal rather than runoff being discharged into a waterway. The field should be large enough to accommodate the irrigation rates required based on the size of the retention basin and the hydraulic conductivity of the soils. There should be a minimum of 12 inches of soil and no direct recharge features.

Three pathways exist for pollutants to leave the treatment area: bypassing from the retention basin while it is full, deep percolation in the irrigation field, and runoff from the irrigation field due to malfunction or incorrect operation. This report will examine three measures of RI system performance:

- 1) if RI systems in Austin achieve non-degradation of stormwater runoff,
- 2) the treatment performance of the retention basin in RI systems, and
- 3) the potential for pollutants to reach ground water via deep percolation.

The RI systems which are included in this study are shown in Figure 1 and are listed in Table 1. Only one commercial RI system (#355967) is in this list and all others are RI systems for residential subdivisions. The pollutants analyzed in this study will be grouped into four general categories for discussion: solids (total suspended solids TSS and volatile suspended solids VSS), nutrients (total nitrogen TN, nitrate plus nitrite $\text{NO}_2 + \text{NO}_3$, total Kjeldahl nitrogen TKN, ammonia NH_3 , total phosphorus TP, and dissolved phosphorus

DP), metals (total lead Pb, total zinc Zn, total copper Cu, and total cadmium Cd), and oxygen demand and organic carbon (chemical oxygen demand COD and total organic carbon TOC).

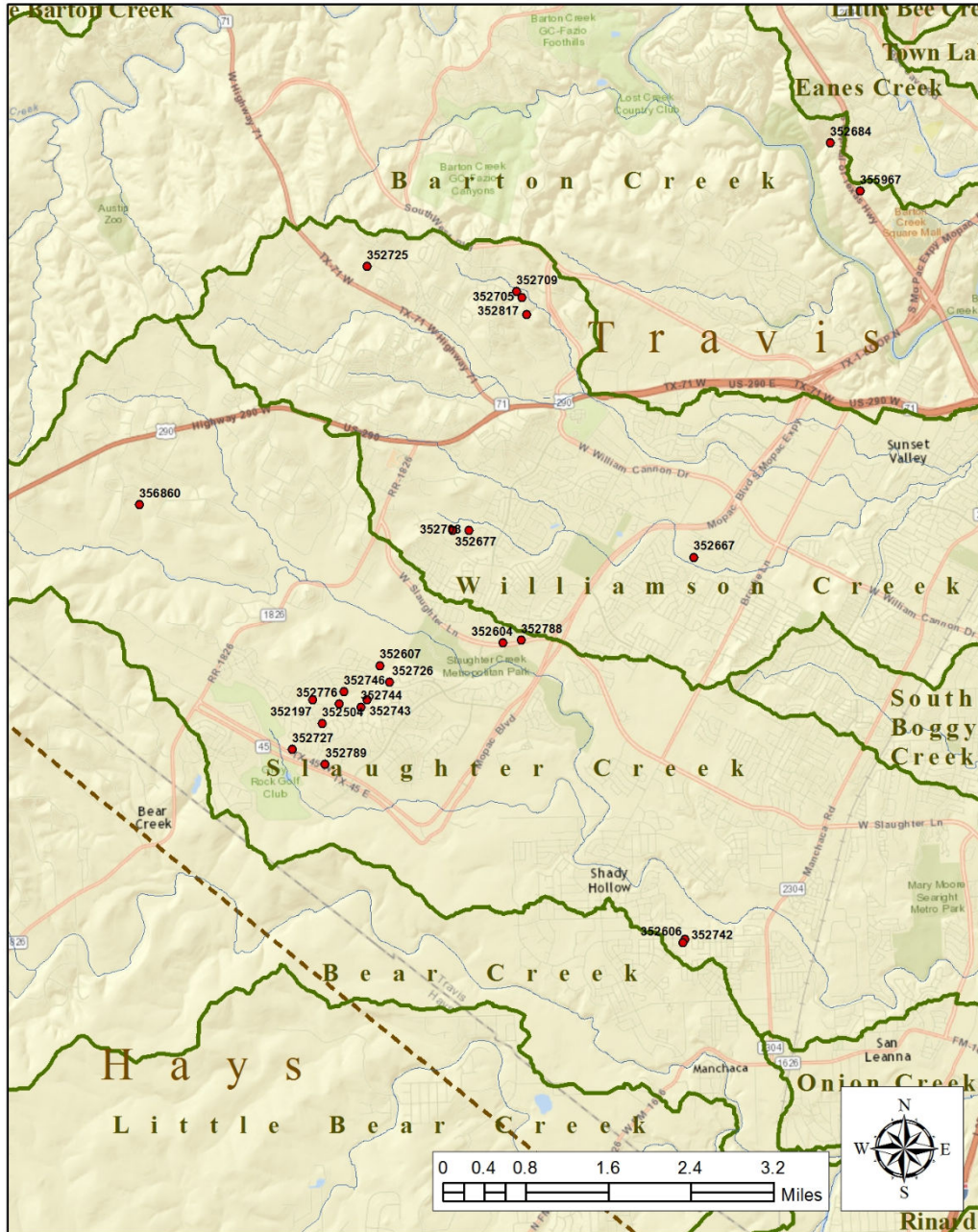


Figure 1. Map of Retention/Irrigation Systems

Table 1. Locations of Retention-Irrigation Systems

Pond ID	Address and Location	Watershed
352197	7408 Doswell Lane	SLA
352504	7240 Tanaqua Lane	SLA
352604	5700 West Slaughter Lane (PPE)	SLA
352606	11401 Arbor Downs Road	SLA
352607	6803 Hansa Loop	SLA
352667	7335 Pusch Ridge loop (CHO)	WMS
352677	6912 Via Ricco Drive	WMS
352684	1904 Real Catorce	BAR
352705	7120 Terravista Drive	WMS
352708	6517 Via Correto Drive	WMS
352709	Bonniebrook Drive	WMS
352725	8814 Mountain Shadow Cove	WMS
352726	La Crosse Avenue	SLA
352727	7225 Magenta Lane	SLA
352742	11401 Arbor Downs Road	SLA
352743	10800 Airock Lane	SLA
352744	6700 Maelin Drive	SLA
352746	10901 Cap Stone	SLA
352776	11104 Pairnoy Lane	SLA
352788	5600 York Bridge Circle	SLA
352789	11600 Spruce Canyon Drive	SLA
352817	5550 Othello Cove	WMS
355967	2451 Capital of Texas Hwy South (BBQ)	BAR
356860	Derecho Bend (DBO)	SLA

Bypass Quantity and Quality

RI systems were developed to meet the objectives of the SOS ordinance: no net increase of pollutants or runoff. The primary route for pollutants to surface waterways is via the bypass structure. Most SCMs include splitter boxes which divert runoff around the SCM when the design capacity of the SCM is reached. If the pollutants of concern exhibit a ‘first-flush’ characteristic, the majority of the pollutant will be in the first part of the storm. A more cost effective SCM may be designed by capturing the first part of the runoff for treatment and allowing the rest of the runoff to bypass treatment. Since RI systems are designed to be non-degradation SCMs, their capture volumes are much greater than other SCMs for a given catchment.

To examine if bypass runoff quality for RI systems in Austin met the requirement of non-degradation, the pollutant data for bypass runoff from four full range monitoring RI sites were analyzed and mean bypass pollutant concentrations (MC) were computed (Table 2). The four RI ponds include three residential ponds #352604, #352667, and #356860, and one commercial pond #355967 (see Table 1).

Table 2. Mean Concentrations at Bypass of RI Ponds

Parameter	Mean Concentrations
CD (ug/l)	0.259
COD (mg/l)	31.05
CU (ug/l)	4.165
DP (mg/l)	0.184
NH3 (mg/l)	0.0678
NO3+NO2 (mg/l)	0.409
PB (ug/l)	4.358
TKN (mg/l)	0.831
TN (mg/l)	1.244
TOC (mg/l)	8.188
TP (mg/l)	0.264
TSS (mg/l)	62.22
VSS (mg/l)	10.80
ZN (ug/l)	22.36

To compute the pollutant loads with the bypass MC data, the bypass runoff quantity for different impervious cover was estimated using a model of capture efficiencies (Adams & Papa, 2000) and the relationship of runoff quantity with impervious cover in Austin small watersheds which was recommended in a previous study (COA, 2009). Assuming the impervious cover of undeveloped sites is either 0% or 5%, the pollutant loads for undeveloped sites can be computed based on the estimated pollutant MC for Austin's small watersheds (COA, 2009).

The load and runoff ratios of RI bypass over undeveloped sites can then be computed and the results are shown in Table 3 for the pollutant parameters listed in the COA Environmental Criteria Manual (ECM). It can be seen that if the impervious cover of undeveloped (as background) sites is assumed to be 5%, then RI bypass load are less than background load for all pollutant parameters, which means the non-degradation requirement of SOS ordinance is met. If the impervious cover of background is assumed to be 0%, then only TP is out of SOS compliance for impervious cover greater than 90%. At 100% impervious cover, the TP has 12% excess load over background with 0%

impervious cover. Therefore, for bypass quantity, the non-degradation requirement of SOS ordinance for expected development is met for both 5% and 0% background impervious cover as shown in Table 3.

It is not unexpected that the load ratios of TSS are significantly lower than others since pollutants of solids exhibit strong first flush effects (COA 1991, COA 2009). This also explains the reduction in many of the other pollutants often adsorbed to solids. The issue with high TP load ratio at high impervious cover may be overstated since the bypass flow often passes through a vegetative waterway, providing additional treatment, before reaching a receiving water body.

Table 3. Load and Runoff Ratios of RI Bypass over Background Sites

IC (%)	Load and runoff ratio for 5% background impervious cover									
	10	20	30	40	50	60	70	80	90	100
Runoff	0.02	0.04	0.08	0.12	0.18	0.25	0.30	0.38	0.45	0.52
COD	0.01	0.02	0.04	0.06	0.09	0.12	0.15	0.19	0.22	0.25
PB	0.01	0.03	0.05	0.08	0.11	0.15	0.19	0.24	0.28	0.32
TN	0.01	0.03	0.05	0.08	0.12	0.16	0.19	0.24	0.29	0.33
TP	0.02	0.06	0.10	0.16	0.24	0.32	0.39	0.50	0.58	0.68
TSS	0.00	0.01	0.02	0.03	0.04	0.06	0.07	0.09	0.10	0.12
ZN	0.01	0.02	0.04	0.07	0.11	0.14	0.18	0.22	0.26	0.30
IC (%)	Load and runoff ratio for 0% background impervious cover									
	10	20	30	40	50	60	70	80	90	100
Runoff	0.01	0.03	0.05	0.08	0.11	0.15	0.19	0.23	0.27	0.32
COD	0.01	0.03	0.06	0.10	0.15	0.20	0.24	0.30	0.36	0.42
PB	0.02	0.04	0.08	0.13	0.19	0.25	0.31	0.39	0.46	0.53
TN	0.02	0.04	0.08	0.13	0.19	0.26	0.32	0.40	0.47	0.55
TP	0.03	0.09	0.17	0.27	0.39	0.53	0.65	0.81	0.96	1.12
TSS	0.01	0.02	0.03	0.05	0.07	0.09	0.11	0.14	0.17	0.20
ZN	0.02	0.04	0.07	0.12	0.18	0.23	0.29	0.36	0.43	0.50

Retention Basin Performance

Water quality samples were collected directly from the sprinkler heads in some RI systems during irrigation periods. Mean concentrations (MCs) of pollutants were computed using the results from the sprinkler head samples. To evaluate retention basin performance in RI systems, the MCs from the sprinkler heads (SPR) were compared to

MCs from bypass (BYP) stations, undeveloped land (UND) sites, single family residential (SFR) sites, effluents in sedimentation basin (SED) stations, effluents in Sand Filter (SF) SCM sites, and rainfall sampling stations which only collect samples for nutrients. It might be expected that the sprinkler head concentrations would be most similar to effluent from sedimentation basins, having only been treated by settling; lower concentrations could be due to the extended detention time in the larger retention basins required for RI systems or the pumping system itself. Table 4 summarized the comparison of MCs from different sources and the statistical relations (t-test) between different data sources. The box-and-whisker plots and lognormal non-exceedance probability plots of pollutant mean concentrations from different data sources for all pollutant parameters can be found in Appendix A.

Table 4. Comparison of Mean Concentrations from Different Source

	SPR ₁	BYP ₂	UND ₃	SFR ₄	SED ₅	SF ₆	Rain ₇
CD (µg/l)	0.0674	0.293 ^{3,6}	0.356 ^{2,6}	0.509 ⁵	0.612 ⁴	0.289 ^{2,3}	
COD (mg/l)	25.90 ^{2,6}	30.76 ^{1,5}	46.35 ⁵	62.50 ⁵	49.13 ^{2,4}	22.30 ¹	
CU (µg/l)	4.508 ^{2,3,6}	5.112 ^{1,3,4,6}	4.079 ^{1,2,6}	8.292 ^{2,5}	9.537 ⁴	5.179 ¹⁻³	
DP (mg/l)	0.246	0.164 ^{4,5}	0.0293	0.187 ^{2,5}	0.110 ^{2,4,6}	0.0840 ^{5,7}	0.0596 ⁶
NH ₃ (mg/l)	0.0813 ⁶	0.131 ^{5,6}	0.0441	0.218 ⁵	0.173 ^{2,4}	0.0942 ^{1,2}	0.385
NO ₃ +NO ₂ (mg/l)	0.358 ^{2,3,5}	0.449 ^{1,3-5,7}	0.457 ^{1,2,5,7}	0.603 ^{2,6,7}	0.445 ^{1-3,7}	0.655 ^{4,7}	0.649 ²⁻⁶
PB (µg/l)	2.172 ⁶	9.215 ^{4,5}	3.479 ⁶	16.27 ^{2,5}	8.189 ^{2,4}	3.128 ^{1,3}	
TKN (mg/l)	0.786 ^{2,5,7}	0.805 ^{1,3,5,7}	0.977 ^{2,5,7}	1.616	1.047 ^{1-3,7}	0.452	0.762 ^{1-3,5}
TN (mg/l)	1.139 ^{2,5-7}	1.260 ^{1,3,5-7}	1.451 ^{2,5,7}	2.243	1.498 ^{1-3,6,7}	1.112 ^{1,2,5,7}	1.458 ^{1-3,6,7}
TOC (mg/l)	8.927 ^{2,5}	8.694 ^{1,4,6}	11.75 ^{4,5}	12.81 ^{2,3,5}	12.80 ¹⁻⁴	7.264 ²	
TP (mg/l)	0.325 ⁴	0.227 ⁵	0.121 ⁶	0.378 ¹	0.222 ²	0.110 ^{3,7}	0.0746 ^{3,6}
TSS (mg/l)	29.05	79.72 ^{3,5}	101.1 ^{2,5}	153.9 ⁵	105.3 ^{2,4}	15.73	
VSS (mg/l)	5.947	10.05 ^{3,5}	16.56 ^{2,5}	34.52	13.96 ^{2,3}	2.061	
ZN (µg/l)	16.88 ^{3,6}	38.94 ^{4,5}	17.83 ^{1,6}	61.63 ^{2,5}	46.79 ^{2,4}	20.24 ^{1,3}	

Note: Subscript number indicates different data source and superscript number(s) indicates the data source has no significant difference ($t > 0.05$) with which other data source(s).

Comparisons between pollutant mean concentrations from sprinkler heads and from two land uses indicate that the MCs from sprinkler heads are more similar to MCs from undeveloped lands rather than MCs from single-family residential areas, as shown in Table 4. In almost all cases, SFR exhibits the highest pollutant mean concentrations, while the undeveloped sites or sand filters had the lowest values with the exception of a few constituents.

With respect to solids, the mean concentrations of TSS and VSS from sprinkler heads are significantly lower than MCs from other data sources except treated effluent from sand filters. The better treatment performance of solids from retention basin in RI systems than that from sedimentation basins is probably because runoff has longer retention time in retention basins than in sedimentation basins.

With respect to nutrients as well as COD and TOC, the NH_3 is the only pollutant which has significant lower mean concentration from sprinkler heads than from bypass stations. This indicates that the retention basin in RI systems doesn't have significant treatment on nutrients as well as COD and TOC or that conversion of organic material is occurring. However, the mean concentrations of nutrients as well as COD and TOC from sprinkler heads are significantly lower than MCs from single family residential sites for the nitrogen series, while the phosphorus, both TP and DP were elevated in the RI sprinkler water as well as effluent from the detention basin, suggesting that the detention features are acting similarly and in a different manner than filtration for the phosphorus components.

With respect to metals, the mean concentrations from sprinkler heads are significant lower than MCs from bypass stations except CU, and are significant lower than MCs from single family residential sites and from sedimentation basins. The generally good treatment performance of metals from retention basin in RI systems is not unexpected because metals are often adsorbed to solids.

In most cases, the mean concentrations from sprinkler heads are at or near those MCs from sand filters. The retention basins have lower MC for NO_3+NO_2 but have nearly equivalent MC for TN ($\text{NO}_3+\text{NO}_2+\text{TKN}$). The MCs from sand filters are much better for phosphorus, both total and dissolved. This is likely due to the sand filters removing smaller particles than settling alone and many of the adsorbed pollutants like phosphorus being associated with the smaller clay particles.

Deep Percolation

The primary method of disposing of runoff from an RI system, as the name implies, is irrigation. The water will be used by plants in the irrigation field but since the irrigation is applied shortly after a rainfall and over a fairly short time, the chance of deep percolation below the root zone is increased. This is particularly concerned in the Barton Springs Edwards Aquifer recharge zone because any deep percolation may enter the karst system and recharge directly into the aquifer. While the SOS Ordinance specifies no net increase in surface runoff loads, it is worth investigating deep percolation since the goal of the ordinance is to protect a groundwater feature. The Environmental Criteria Manual (ECM of Austin, 2013) requires a minimum of one foot of soil in the irrigation field but it was unknown if this provided adequate treatment of pollutants, especially dissolved

pollutants like dissolved phosphorus or nitrate, at the time the design criteria were written. The ECM was also silent with respect to the type of vegetation in the irrigation area.

Glass block lysimeters similar to those described by Barbee and Brown (1986) were installed at the irrigation field of RI site CHO. Lysimeters were placed at depths ranging from one to five feet in one foot increments in 4 areas with different irrigation and vegetative cover combinations: Bermuda grass - irrigated, Bermuda grass - non-irrigated, natural cover - irrigated, and natural cover - non-irrigated. Samples were collected after significant rainfall events when percolation in the non-irrigated areas would be likely. While samples from the lysimeters were analyzed for all parameters listed previously, only dissolved phase parameters (DP and NO_3+NO_2) were statistically compared to look for differences in depth and/or vegetative cover. This was done because dissolved phase pollutants are the primary concern with respect to deep percolation.

Mean concentrations of pollutants from the lysimeters can be found in Appendix B. Analyses of variance tests, CMH tests and Wilcoxon signed-rank test did not indicate any significant differences between the concentrations with respect to depth, vegetative cover or irrigation application. This appears to indicate that no additional treatment will be gained by using soils deeper than the required one foot minimum. It also appears that vegetative cover does not influence leachate concentrations. Another City of Austin study looked at the potential for nitrates from fertilizer to leach to shallow ground water. This study found that soil nitrate levels play an important role in the leachate concentrations. Given that and the relatively low levels of nitrate in the irrigation water (Table 4), it appears that deep percolation is not a likely route for increased pollutant loads to reach receiving water bodies absent any direct conduit.

Conclusions

The retention-irrigation (RI) system is the main SCM used to achieve the goal of SOS ordinance for non-degradation of stormwater runoff. To examine the performance of RI systems in Austin, this report studies the achievement of non-degradation of stormwater runoff by RI systems in Austin, the treatment performance of the retention basin in RI systems, and the potential for pollutants to reach ground water via deep percolation.

The ratios of runoff and pollutant load for RI bypass over undeveloped sites were computed for different impervious covers. The results show that the non-degradation requirement of SOS ordinance is met in all cases except for TP if impervious cover is greater than 90% and background impervious cover is assumed to be 0%. These results suggest the current sizing for RI may over-control at some levels, potential reducing stream flows.

By comparing pollutants mean concentrations from sprinkler head in RI systems with

concentrations from different SCM systems, it can be found that for solids and metals, the performance of retention basins in RI systems is better than sedimentation basins and is as good as sand filters. The retention basin in RI systems doesn't have significant treatment on nutrients as well as COD and TOC. The concentrations from retention basins in RI systems are more similar to concentrations from undeveloped lands rather than concentrations from single-family residential areas.

Statistical analyses of mean concentrations of pollutants from lysimeters did not indicate any significant differences between the concentrations with respect to depth, vegetative cover or irrigation application. Therefore, it appears that deep percolation is not a likely route for increased pollutant loads to reach receiving water bodies.

References

Adams, B. J., and F. Papa. 2000. *Urban Stormwater Management Planning with Analytical Probabilistic Models*. John Wiley & Sons. New York.

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Appendix A Box-and-Whisker Plots and Lognormal Non-Exceedance Probability Plots of Pollutant Mean Concentrations

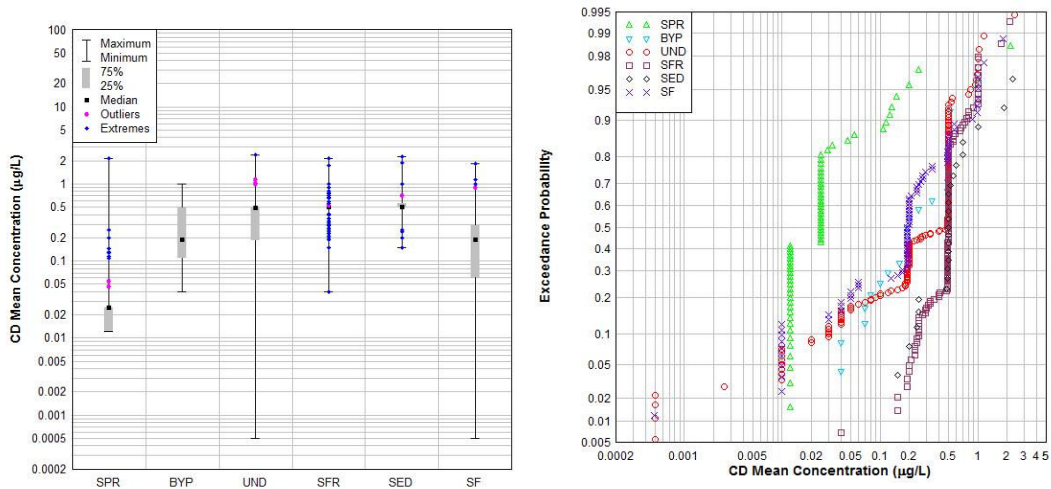


Figure A.1: Box-and-Whisker and Probability Plots for CD

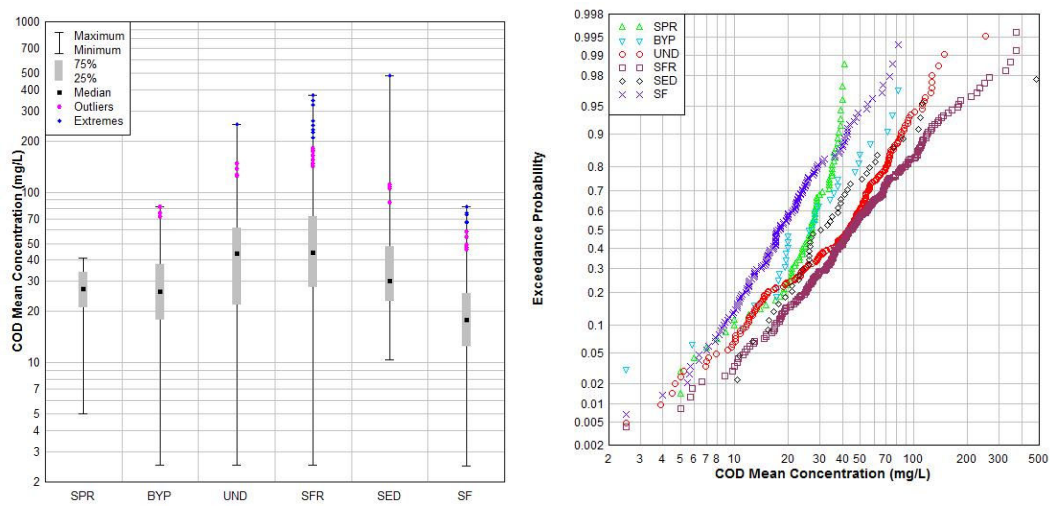


Figure A.2: Box-and-Whisker and Probability Plots for COD

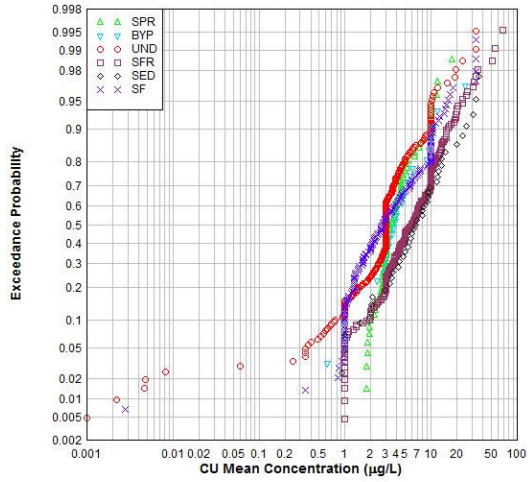
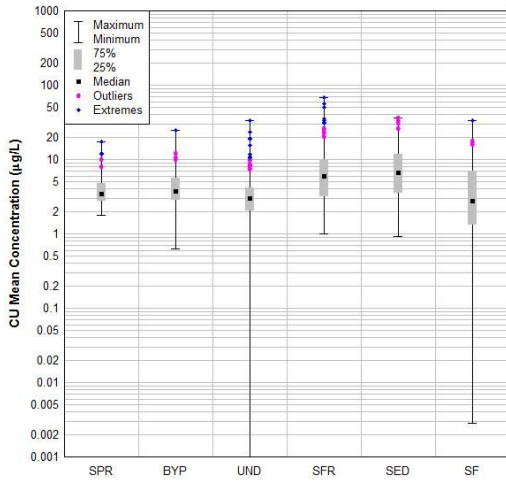


Figure A.3: Box-and-Whisker and Probability Plots for CU

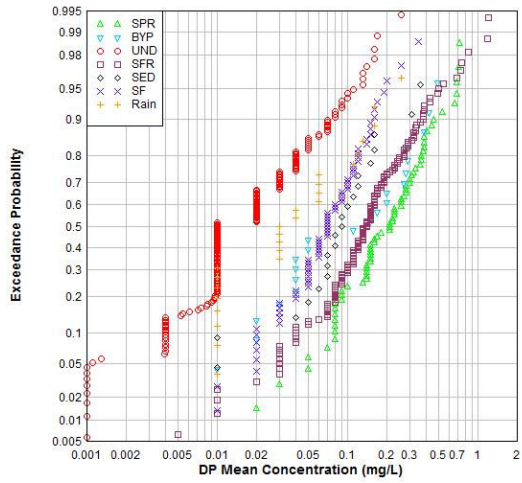
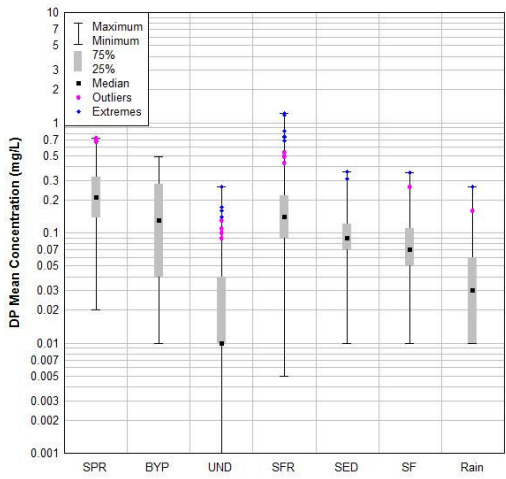


Figure A.4: Box-and-Whisker and Probability Plots for DP

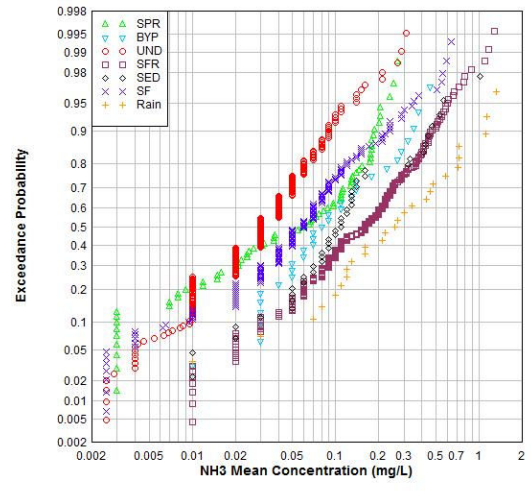
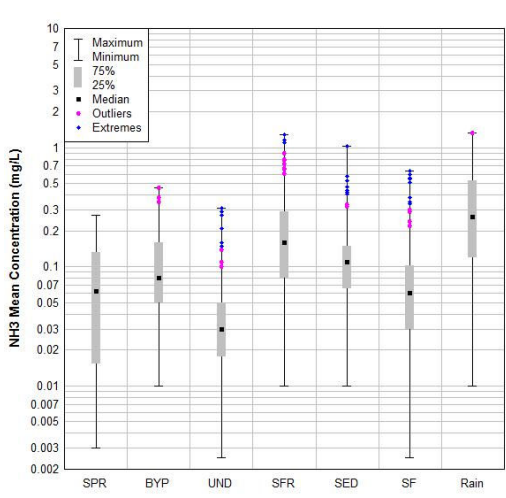


Figure A.5: Box-and-Whisker and Probability Plots for NH3

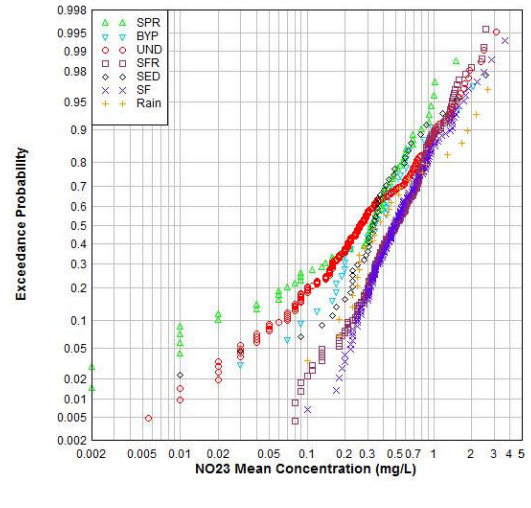
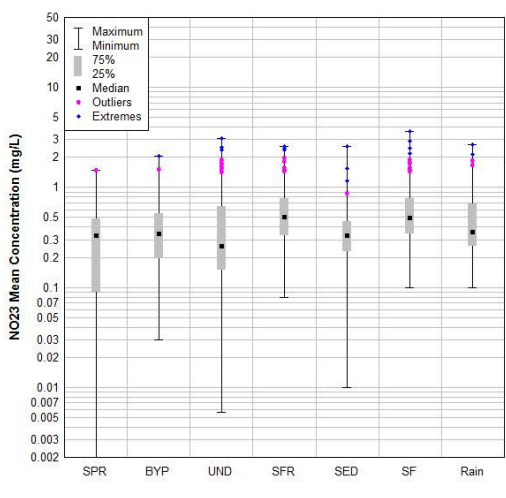


Figure A.6: Box-and-Whisker and Probability Plots for NO23

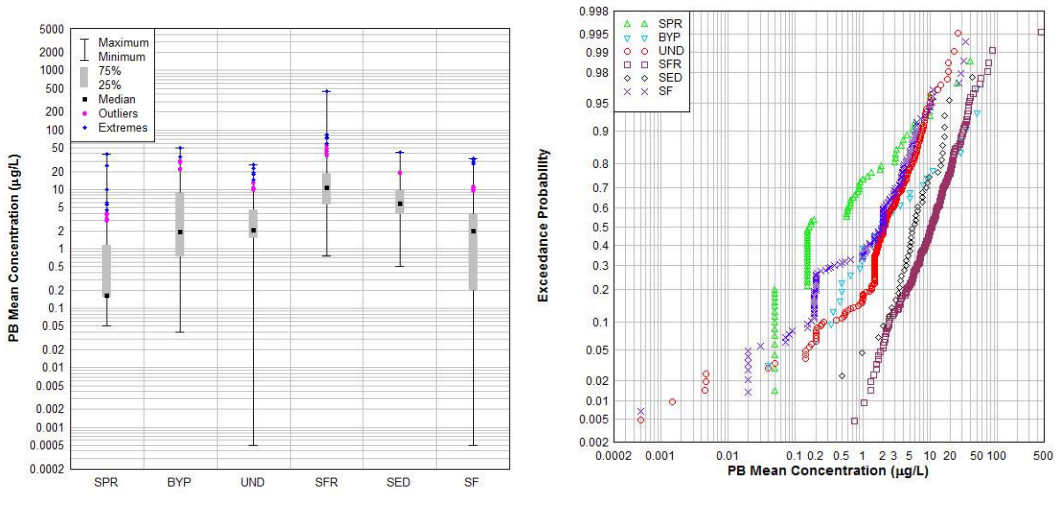


Figure A.7: Box-and-Whisker and Probability Plots for PB

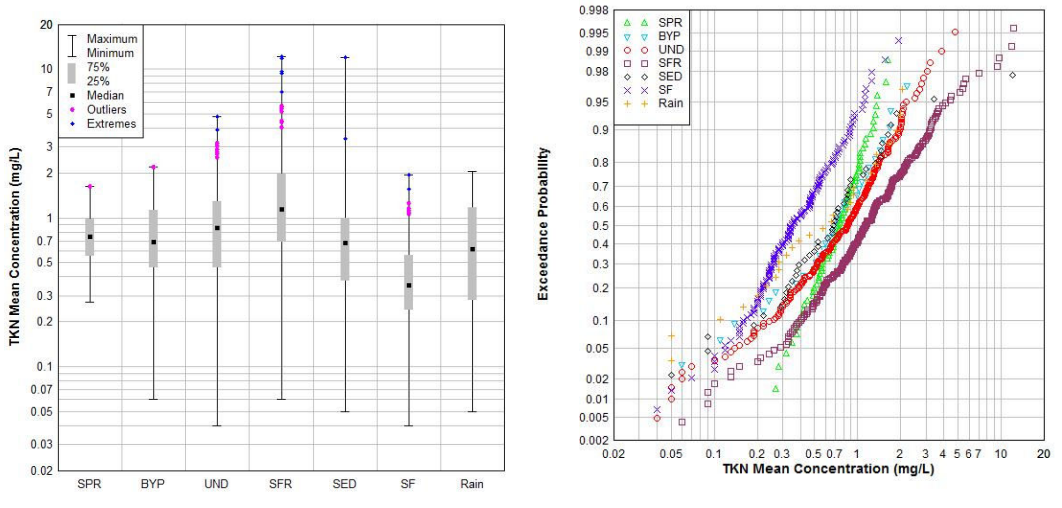


Figure A.8: Box-and-Whisker and Probability Plots for TKN

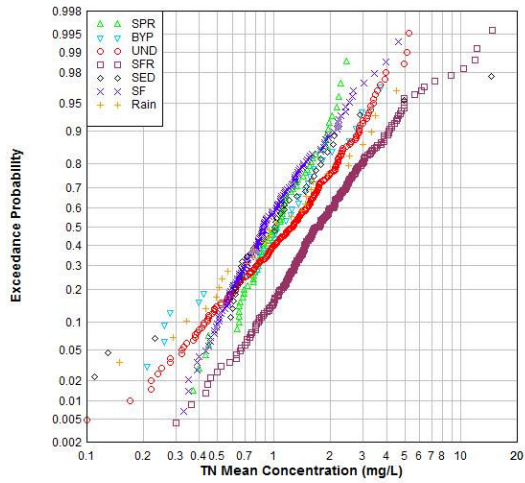
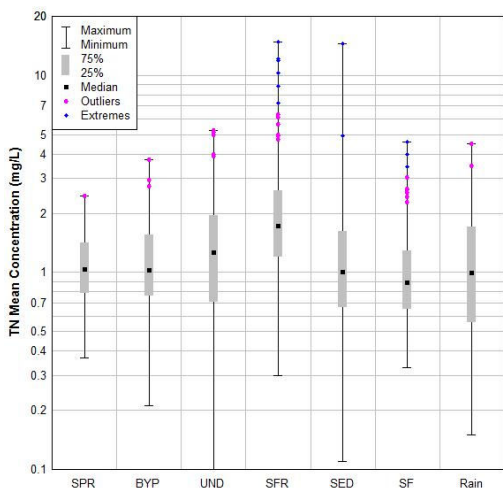


Figure A.9: Box-and-Whisker and Probability Plots for TN

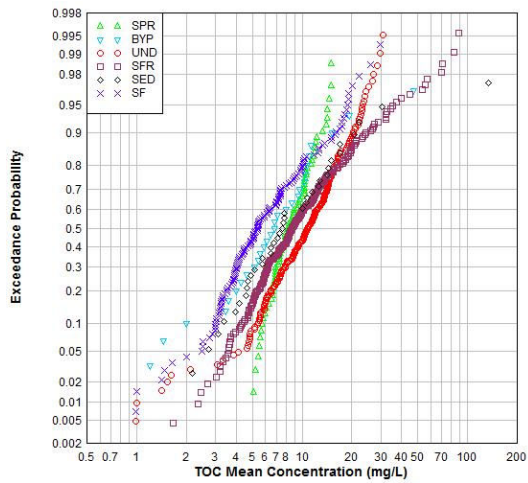
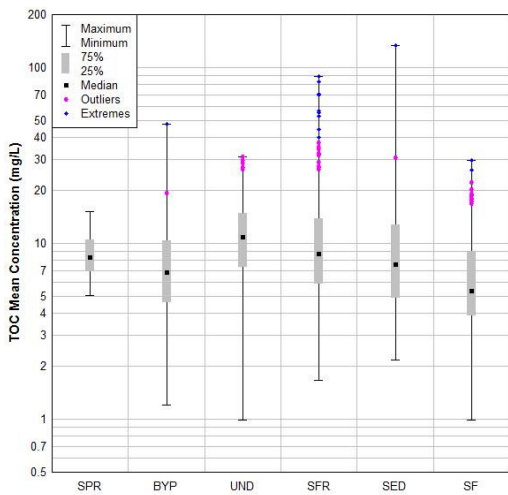


Figure A.10: Box-and-Whisker and Probability Plots for TOC

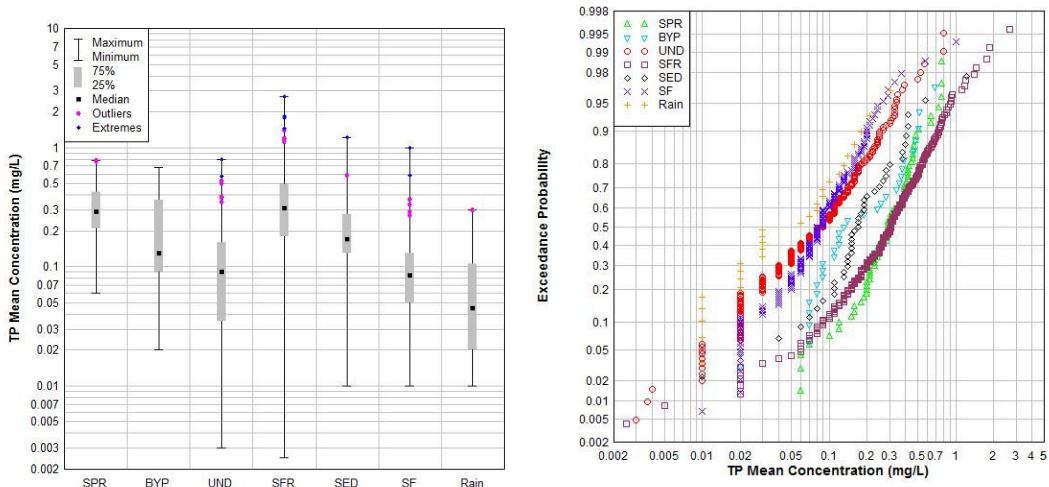


Figure A.11: Box-and-Whisker and Probability Plots for TP

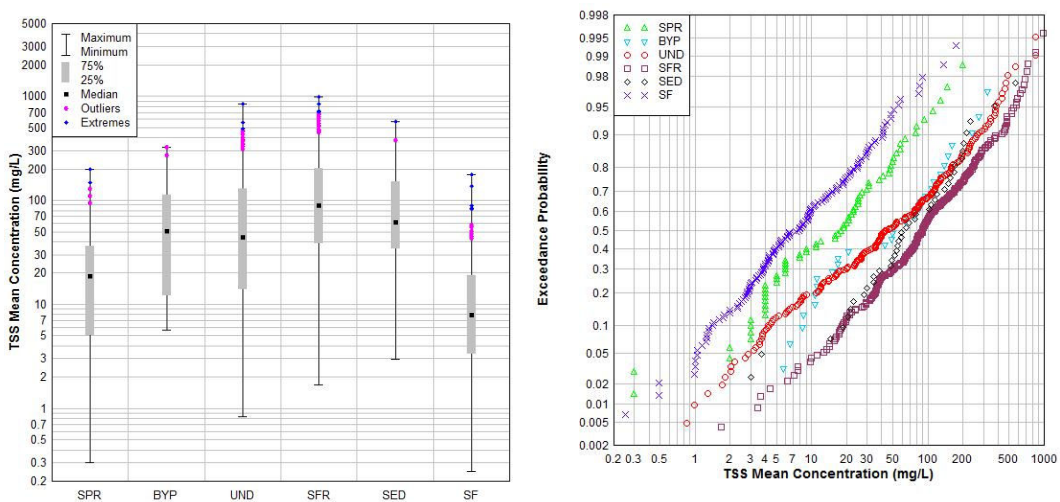


Figure A.12: Box-and-Whisker and Probability Plots for TSS

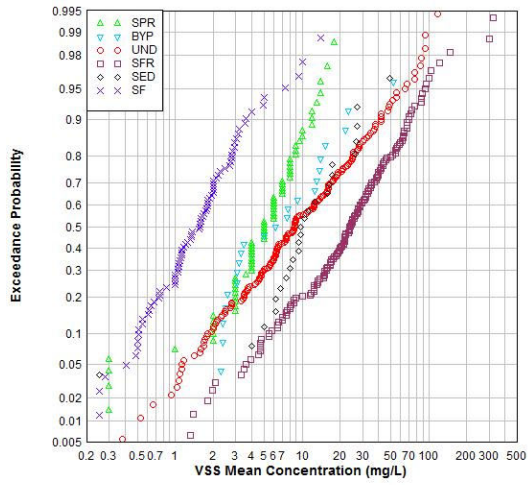
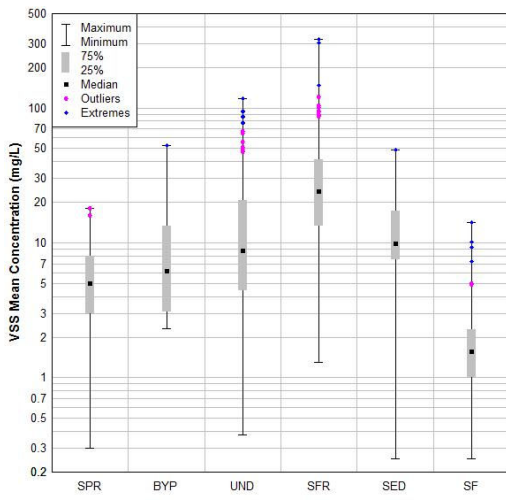


Figure A.13: Box-and-Whisker and Probability Plots for VSS

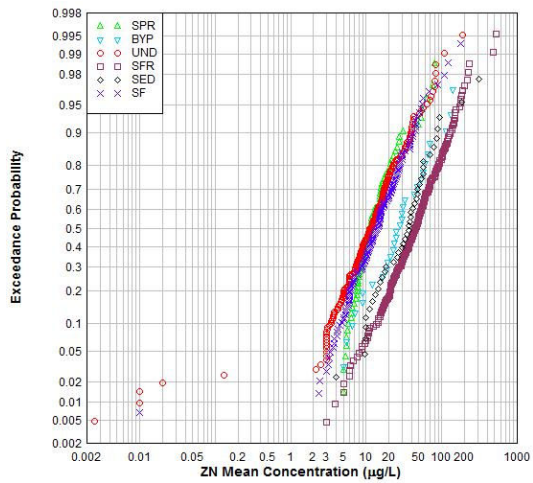
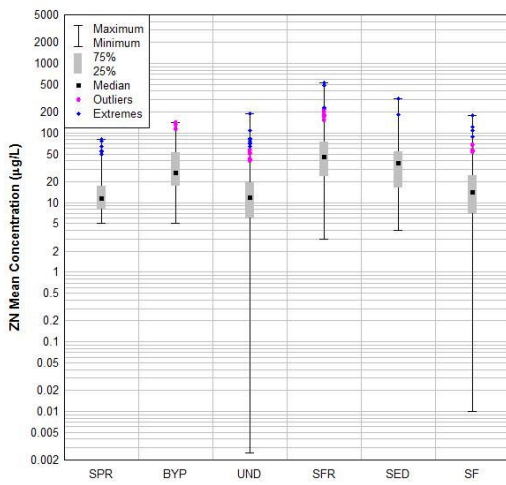


Figure A.14: Box-and-Whisker and Probability Plots for ZN

Appendix B Mean Concentrations of Pollutants from Lysimeters

Table B.1: CD Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.11	0.15	0.28	0.34
2	*	0.17	0.32	0.25
3	*	0.29	0.22	0.38
4	0.21	0.14	0.24	*
5	0.01	0.23	0.22	N/A

Table B.2: COD Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	21.53	22.73	22.60	23.09
2	*	18.24	29.91	79.03
3	*	17.33	21.50	40.64
4	12.50	38.77	25.06	*
5	16.67	15.56	26.15	N/A

Table B.3: CU Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	2.90	3.65	3.66	5.39
2	*	2.77	3.22	4.85
3	*	2.59	3.02	5.31
4	1.96	4.12	3.47	*
5	1.18	2.57	3.36	N/A

Table B.4: DP Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.019	0.030	0.024	0.050
2	*	0.038	0.016	0.020
3	*	0.020	0.021	0.017
4	0.050	0.019	0.019	*
5	0.021	0.016	0.019	N/A

Table B.5: NH₃ Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.023	0.080	0.198	0.043
2	*	0.037	0.144	0.052
3	*	0.052	0.156	0.416
4	0.042	0.058	0.052	*
5	0.044	0.066	0.047	N/A

Table B.6: NO₃+NO₂ Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.215	0.227	1.885	0.655
2	*	0.563	0.455	0.397
3	*	1.042	0.314	0.289
4	0.310	1.036	0.656	*
5	0.401	0.827	1.496	N/A

Table B.7: PB Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.87	3.60	4.06	6.86
2	*	2.26	5.23	5.07
3	*	1.24	2.78	5.42
4	0.67	3.67	3.81	*
5	0.14	1.39	3.32	N/A

Table B.8: TKN Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.56	1.28	0.87	0.65
2	*	0.64	1.21	0.48
3	*	0.60	0.91	1.55
4	0.27	1.18	0.92	*
5	0.67	0.62	0.87	N/A

Table B.9: TN Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.771	1.506	2.759	1.306
2	*	1.202	1.665	0.882
3	*	1.640	1.224	1.843
4	0.580	2.212	1.575	*
5	1.070	1.449	2.368	N/A

Table B.10: TOC Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	8.34	6.05	6.56	6.16
2	*	5.63	7.30	6.59
3	*	6.11	6.10	6.19
4	4.70	10.10	7.13	*
5	9.66	6.14	6.03	N/A

Table B.11: TP Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	0.081	0.173	0.114	0.120
2	*	0.046	0.121	0.343
3	*	0.051	0.108	0.364
4	0.011	0.108	0.118	*
5	0.049	0.065	0.165	N/A

Table B.12: TSS Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	6.8	199.8	229.9	357.7
2	*	78.9	168.0	2649.7
3	*	56.4	175.3	2985.0
4	2.7	139.5	947.5	*
5	16.4	106.0	1025.8	N/A

Table B.13: VSS Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	3.3	21.9	40.3	39.0
2	*	8.7	22.3	867.9
3	*	7.6	31.3	570.4
4	1.7	18.5	81.9	*
5	4.2	12.4	517.3	N/A

Table B-14: ZN Mean Concentrations from Lysimeters

Depth (ft)	Irrigated Bermuda	Non-Irrigated Bermuda	Irrigated Natural	Non-Irrigated Natural
1	8.96	11.87	14.81	21.50
2	*	11.57	13.39	26.56
3	*	13.53	11.38	27.85
4	7.77	12.03	12.32	*
5	4.27	8.67	19.62	N/A