Espey Consultants, Inc.
Environmental & Engineering Services

DATE: March 15, 2004

TO: North Central Texas Water Quality Project

CC: Dr. George Ward

FROM: Espey Consultants, Inc.

RE: Qual2E Re-Calibration Results (Qual2E run 072)

Qual2E Re-Calibration Overview and Design

Model Configuration

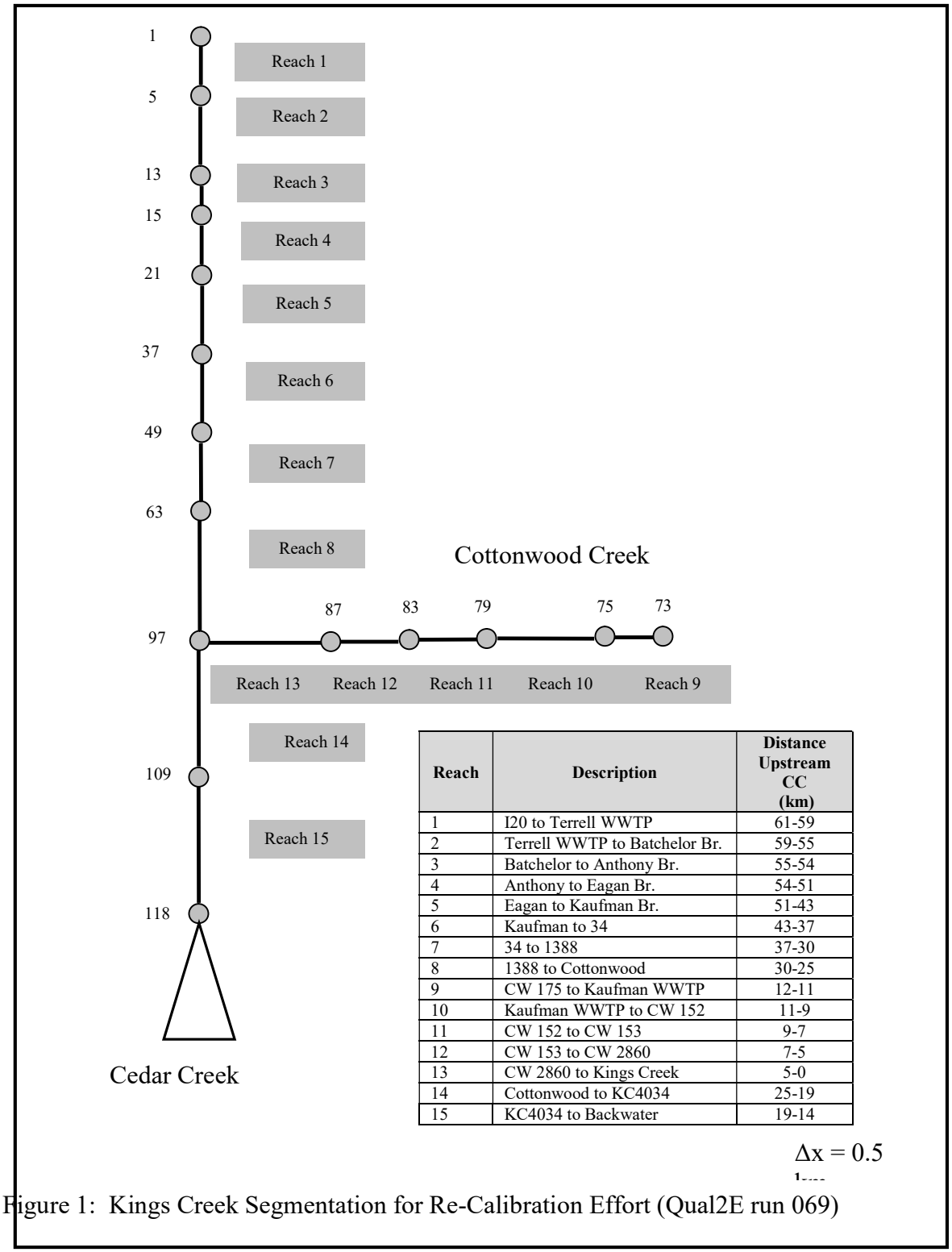
Because the WASP model will be used for the backwaters of Kings Creek, it was decided that the Qual2E model should be applied to Kings Creek downstream to the point where the backwater starts. According to the September 2002 field event and the reservoir elevation at that time, the backwater starts in Reach 15 of the original Qual2E configuration. As a result, the current re-calibration was focused on Reaches 1-15 of the King's Creek original Qual2E schematic. Figure 1 presents this new configuration.

Nutrient Calibration

The majority of this re-calibration effort focused on nutrients such as nitrogen in the form of organic, nitrite and nitrate and phosphorus in the organic and dissolved forms. These respective nutrient cycles and how nutrient interactions are represented in Qual2E is presented in Figure 2. As seen in Figure 2, settling is the only option available in the model to effectively rid the system of either nitrogen or phosphorus in the organic forms hence decreasing there contribution to nitrite/nitrate (NOx) and dissolved phosphorus respectively. This is because while the algal respiration term can be used as a sink for nutrients, this term also controls algal death and subsequent recycling of organic nitrogen and phosphorus back into the system as a result of algal death. The previous memo describing Qual2E run 069 used high settling terms for organic nitrogen and phosphorus that were above the recommended range (0.25 versus a maximum of 0.1). In order to keep p with the current recommended ranges for Qual2E and SWAT, these settling rates were lowered to 0.1 and the associated algal respiration rate was lowered to decrease organic nitrogen and organic phosphorus recycling associated with algal death that is incorporated to the nutrient cycle by the algal respiration term. The associated graphs depicting the model predicted nutrient distributions versus the measured field data in Kings Creek from the September 2002 field event are presented as follows:

- Figure 3 – BODu, DO and NH3 Predicted Distributions Vs Field Data
- Figure 4 – Organic Nitrogen and Phosphorus Predicted Distributions Vs Field Data
- Figure 5 – Total Nitrogen and NO3 Predicted Distributions Vs Field Data
- Figure 6 – Total Phosphorus and Dissolved Phosphorus Distributions Vs Field Data

Table1 presents the global coefficients for SWAT and Table 2 presents the local SWAT coefficients.



Reach	Description	Distance Upstream CC (km)
1	I20 to Terrell WWTP	61-59
2	Terrell WWTP to Batchelor Br.	59-55
3	Batchelor to Anthony Br.	55-54
4	Anthony to Eagan Br.	54-51
5	Eagan to Kaufman Br.	51-43
6	Kaufman to 34	43-37
7	34 to 1388	37-30
8	1388 to Cottonwood	30-25
9	CW 175 to Kaufman WWTP	12-11
10	Kaufman WWTP to CW 152	11-9
11	CW 152 to CW 153	9-7
12	CW 153 to CW 2860	7-5
13	CW 2860 to Kings Creek	5-0
14	Cottonwood to KC4034	25-19
15	KC4034 to Backwater	19-14

Figure 1: Kings Creek Segmentation for Re-Calibration Effort (Qual2E run 069)

EPA

The Enhanced Stream Water Quality Models QUAL2E

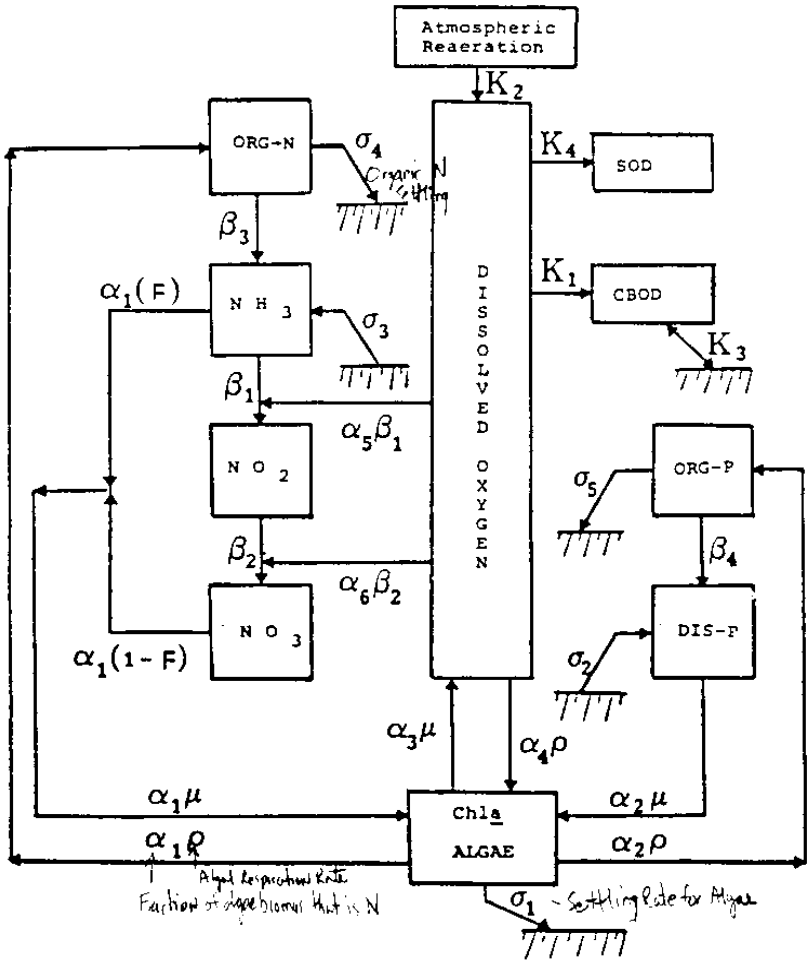


Figure 2: Major Nutrient Interactions in Qual2E

K1 = CBOD decay rate
K2 = Atmospheric Reaeration
K3 = CBOD Settling
K4 = SOD Uptake
μ = Algal Growth Rate
ρ = Algal Respiration Rate

α1 = Nitrogen Algae Biomass
α2 = Phosphorus Algae Biomass
α3 = O2 prod. From Algae Growth
α4 = O2 uptake Respiration
α5 = NH3 Oxidation
α6 = NO2 Oxidation

σ1 = Algae Settling Rate
σ2 = Dis. P Benthos
σ3 = NH3 Benthos
σ4 = Org. N Settling
σ5 = Org. P Settling

β1 = NH3 to NO2 decay
β2 = NO2 to NO3 decay
β3 = Org N Hydrolysis
β4 = Org. P to Dis. P decay

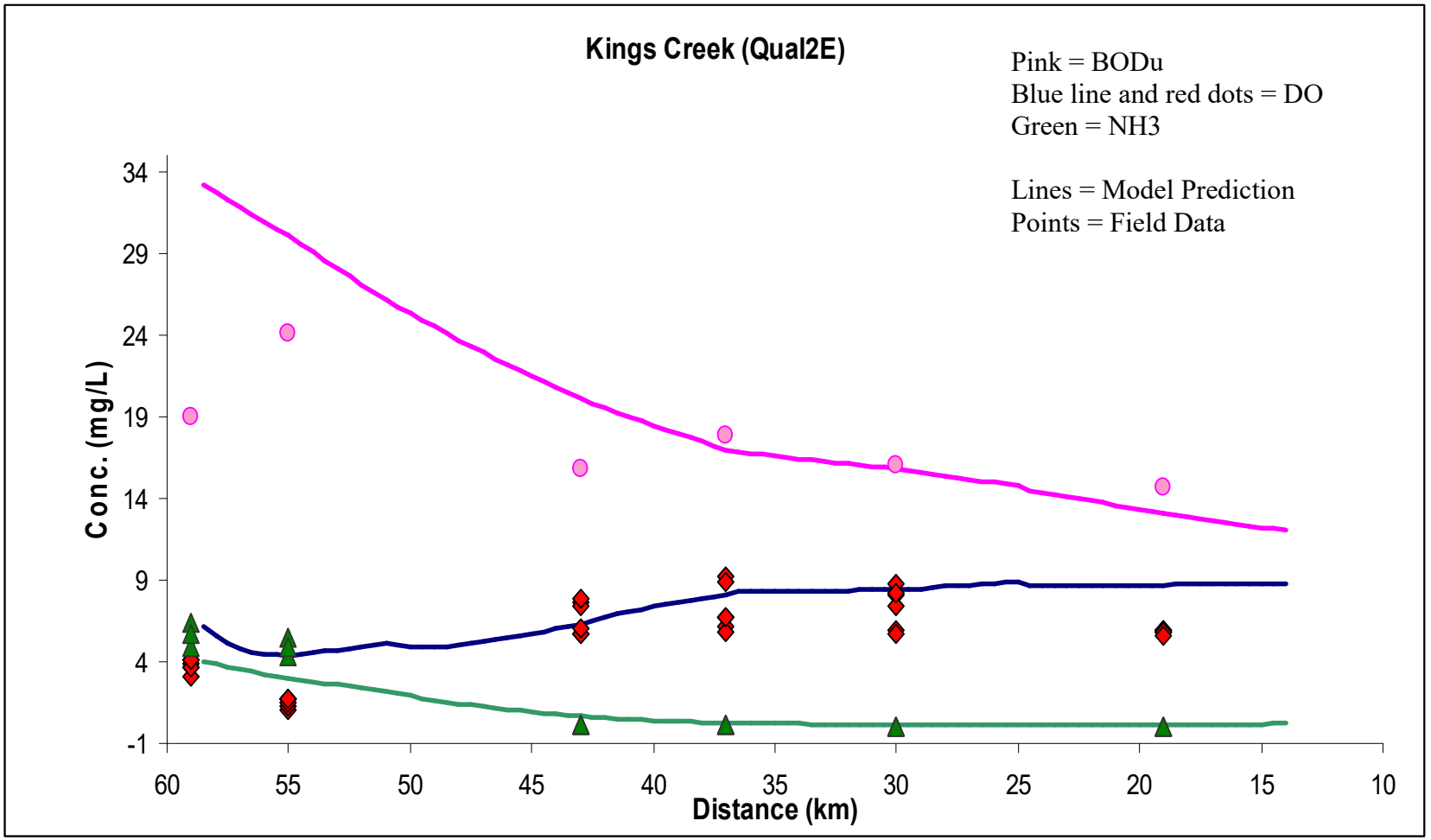


Figure 3: BOD, DO and NH3

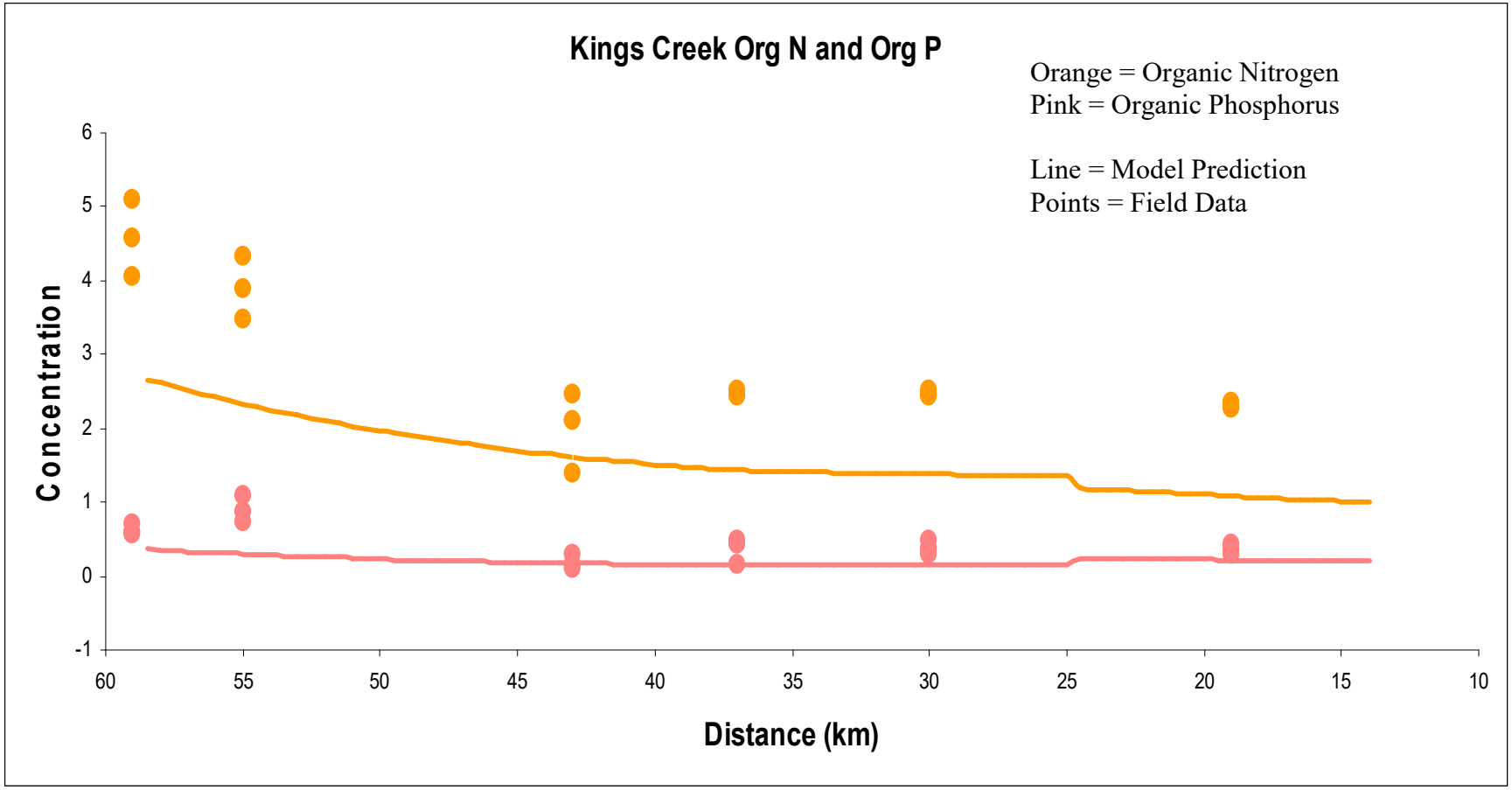


Figure 4: Organic Nitrogen and Phosphorus

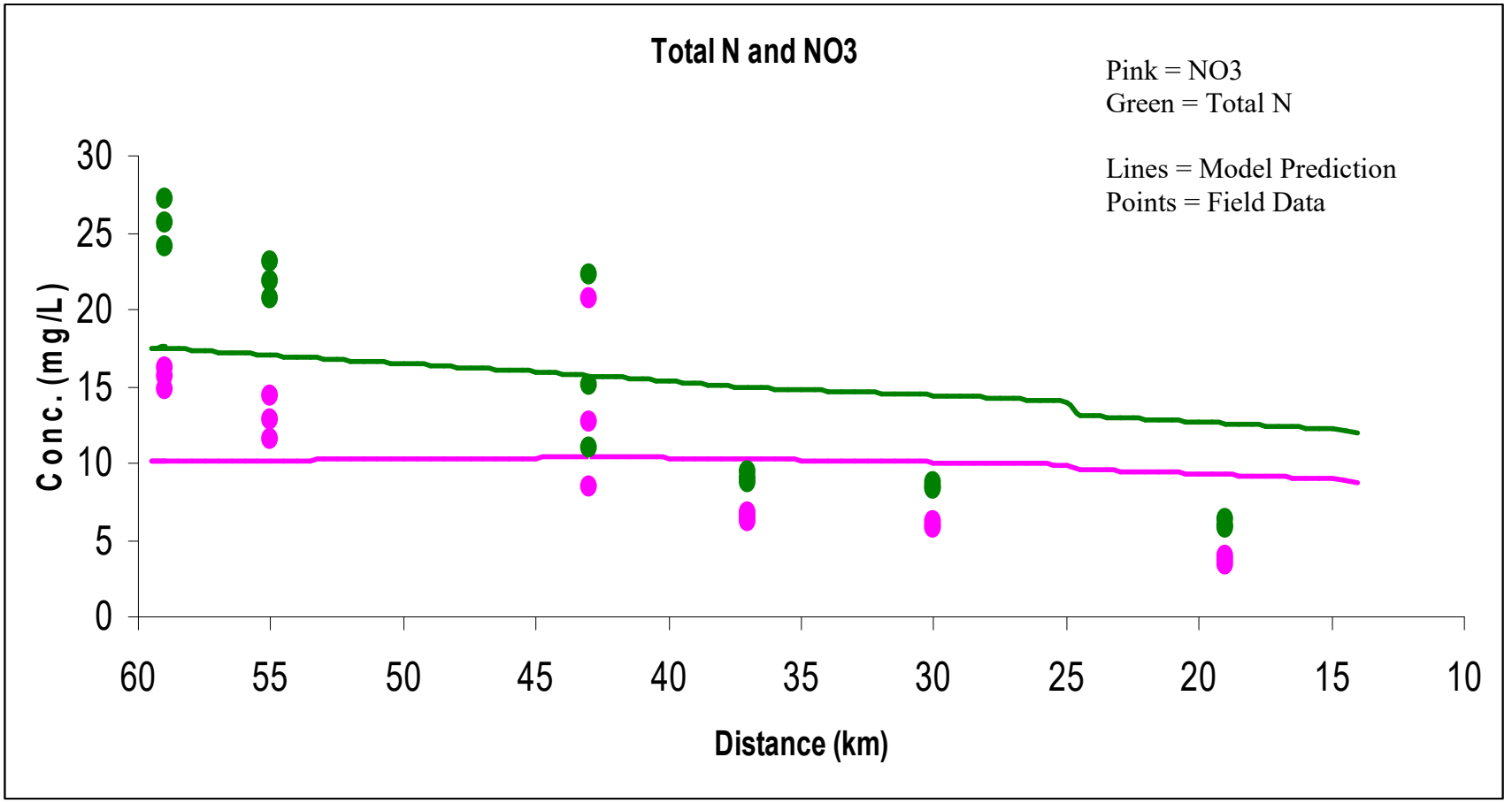


Figure 5: Total Nitrogen and NO3

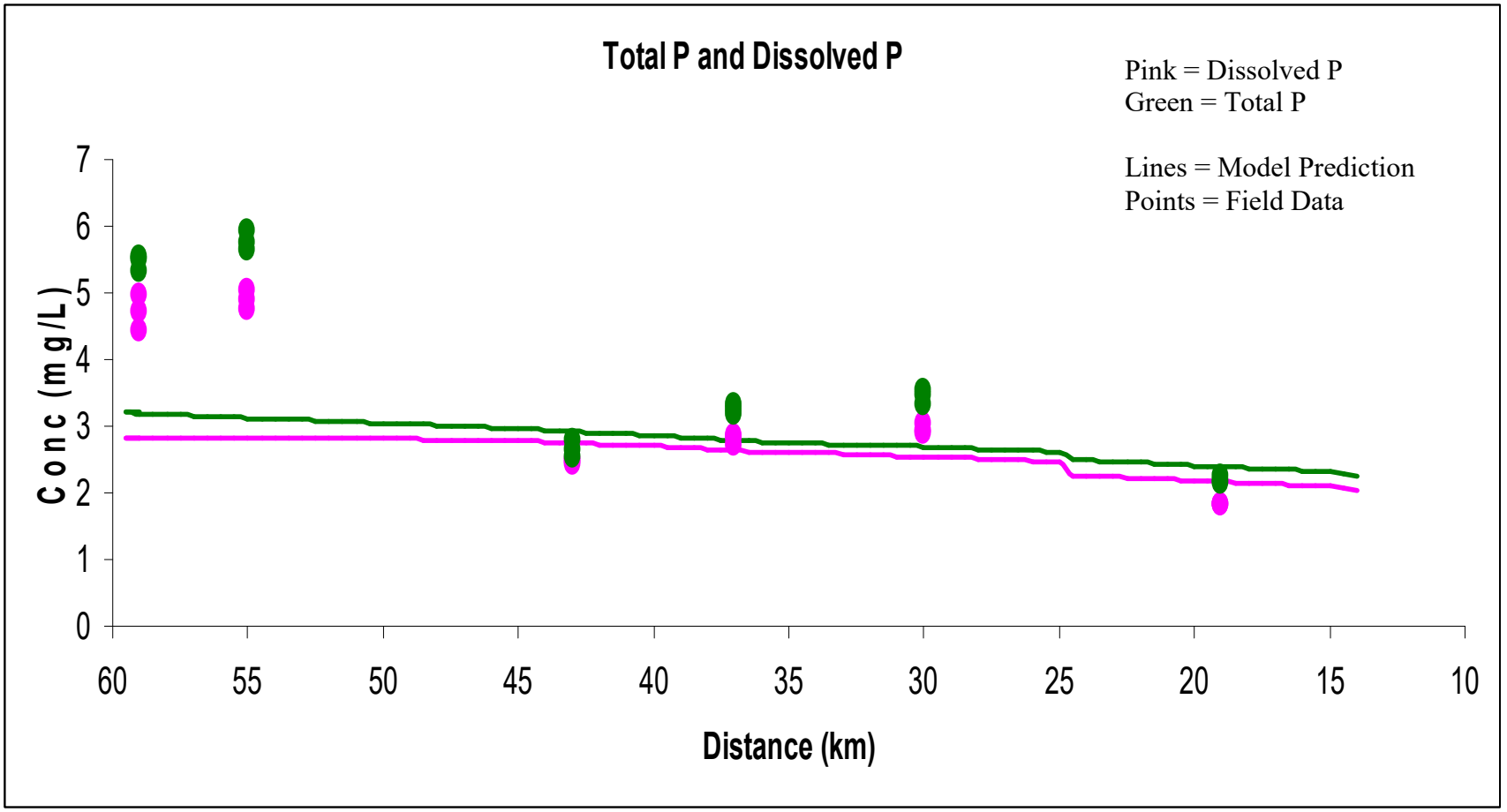


Figure 6: Total Phosphorus and Dissolved Phosphorus

Table 1: Global Coefficients for Input to SWAT General Water Quality File

SWAT Input File	Variable Name	Qual2E Cal. (072)	Definition
WWQ (file extension) *SWAT general water quality input file*	LAO	2.0	The depth average algal growth attenuation factor for light computed from daylight average solar radiation value (user supplied)
	IGROPT	2.0	Limiting Nutrient option calculates the local algal growth rate as limited by light and either nitrogen or phosphorus. The nutrient/light effects are multiplicative, but the nutrient/nutrient effects are alternate. The algal growth rate is controlled by the nutrient with smaller growth limitation factor. Approach mimics Liebig's Law of Minimum.
	A10	10	Ratio of chlorophyll-a to algal biomass (range: 10-100)
	A11	0.09	Fraction of algal biomass that is nitrogen (range: 0.07-0.09)
	A12	0.02	Fraction of algal biomass that is phosphorus (range: 0.01-0.02)
	A13	1.6	The rate of oxygen production per unit of algal photosynthesis (range: 1.4-1.8)
	A14	2.3	The rate of oxygen uptake per unit of algal respiration (range: 1.6-2.3)
	A15	3.5	The rate of oxygen uptake per unit of NH3-N oxidation (range: 3.0-4.0)
	A16	1.0	The rate of oxygen uptake per unit of NO2-N oxidation (range: 1.0-1.14)
	MUMAX	1.8	Max specific algal growth rate at 20C (range: 1.0-3.0)
	RHOQ	0.1	Algal respiration rate at 20C (range: 0.05-0.5)
	*TFACT	N/A	*Fraction of solar radiation computed in Temp Heat Balance that is photosynthetically active (range: 0.01-1)
	K_L	0.4184	Half-saturation coefficient for light (range: 0.2227-1.135)
	K_N	0.4	Michaelis-Menton half saturation constant for nitrogen (range: 0.01-0.3)
	K_P	0.04	Michaelis-Menton half-saturation constant for phosphorus (range: 0.001-0.05)
	LAMBDA0	1.5	Non-algal portion of the light extinction coefficient
	LAMBDA1	0.00246	Linear algal self-shading coefficient (range: 0.0065-0.065)
	LAMBDA2	0.054	Non-linear algal self-shading coefficient (recommended 0.0541)
	P_N	0.1	Algal preference factor for ammonia (range: 0.01-1.0)

N/A = Not Applicable or Not Used for this modeling/calibration effort

Table 2: Local Coefficients for SWAT

Qual2E Reach	Qual2E (072) RK1	Qual2E (072) RK2	Qual2E (072) RK3	Qual2E (072) RK4	Qual2E (072) RS1	Qual2E (072) RS2	Qual2E (072) RS3	Qual2E (072) RS4	Qual2E (072) RS5
	BOD decay rate (0.02 to 3.4)	Reaeration Rate (0.1 to 100)	BOD settling rate (-0.36 to 0.36)	Benthic oxygen demand (SOD)	Local Algal Settling (0.15 to 1.82)	Benthos source rate for dissolved P	Benthos source rate for NH4-N	Org N settling rate (0.001 to 0.10)	Org P settling rate (0.001 to 0.1)
1	0.055	15.89	0.01	0.8	0.1	0.0	0.0	0.1	0.1
2	0.055	1.82	0.01	0.8	0.1	0.0	0.0	0.1	0.1
3	0.055	1.52	0.03	0.8	0.1	0.0	0.0	0.1	0.1
4	0.055	1.52	0.03	0.8	0.1	0.0	0.0	0.1	0.1
5	0.055	1.42	0.03	0.8	0.1	0.0	0.0	0.1	0.1
6	0.055	2.15	0.02	0.8	0.1	0.0	0.0	0.1	0.1
7	0.055	5.36	0.01	0.8	0.1	0.0	0.0	0.1	0.1
8	0.055	1.86	0.01	0.8	0.1	0.0	0.0	0.1	0.1
9	0.055	15.89	0.01	0.8	0.1	0.0	0.0	0.1	0.1
10	0.055	1.17	0.05	0.8	0.1	0.0	0.0	0.1	0.1
11	0.055	4.53	0.1	0.8	0.1	0.0	0.0	0.1	0.1
12	0.055	4.68	0.1	0.8	0.1	0.0	0.0	0.1	0.1
13	0.055	9.38	0.1	0.8	0.1	0.0	0.0	0.1	0.1
14	0.055	8.62	0.05	0.8	0.1	0.0	0.0	0.1	0.1
15	0.055	8.57	0.05	0.8	0.1	0.0	0.0	0.1	0.1

Qual2E Reach	Qual2E (072) BC1	Qual2E (072) BC2	Qual2E (072) BC3	Qual2E (072) BC4
	Decay rate for NH4 to NO2 (0.1 to 1.0)	Decay rate for NO2 to NO3 (0.2-2.0)	Decay rate for Org N to NH4 (0.2 to 0.4)	Decay rate for Org P to Dissolved P
1	0.2	0.08	0.001	0.05
2	0.2	0.08	0.001	0.05
3	0.2	0.08	0.001	0.05
4	0.2	0.08	0.001	0.05
5	0.4	0.08	0.001	0.05
6	0.4	0.08	0.001	0.05
7	0.4	0.08	0.001	0.05
8	0.4	0.08	0.001	0.05
9	0.6	0.15	0.05	0.05
10	0.6	0.15	0.05	0.05
11	0.6	0.15	0.05	0.05
12	0.6	0.15	0.05	0.05
13	0.6	0.15	0.05	0.05
14	0.3	0.08	0.1	0.05
15	0.3	0.08	0.1	0.05