EDWARD F. CROSS SCHOOL OF ENGINEERING
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Prescott Soccer Field Design

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Abstract

Prescott High School District required a soccer field meeting regulation dimensions and adequate lighting for evening games. The scope of work involved information gathering for acceptable lighting systems, analysis and redesign of the irrigation system, and recommendations for grading the field. Discussions with Walla Walla University personnel regarding lighting suggested the best product was from Techline Sports Lighting Corporation. Two sprinkler systems with different operation and maintenance requirements were considered. Irrigation from the side of the field was the preferred alternative, which incorporated a double loop around the exterior of the field to limit interference to play during games. Grading of the field required movement of soil from the northeast to the southwest corner. The existing two feet elevation difference needed to be decreased to a 2% grade to comply with regulation field requirements.

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1 Introduction and Objectives

The soccer field for Prescott High School is 20 miles north of Walla Walla (Figure 1). To meet standard regulation field requirements, the following factors needed to be addressed: uneven ground, lighting, and an efficient irrigation system. These requirements were met, but certain areas were more heavily focused on due to priorities.

Figure 1 - Aerial view for project location

2 Grading

A Total Station was used to create a topography of the field, This analysis showed an elevation change of 2 feet from the northwest corner to the southeast corner (Figure 2). Basketball and tennis courts currently located at the northwest corner, but in accordance with Prescott's Schools plans, they demolish the courts to make space for a regulation sized soccer field. Grading for the site provided drainage from the east-northeast to west-southwest on a 2% slope; the maximum allowed for a regulation field, (Figure 3). The drainage is intercepted by a gravel-filled ditch on the west side of the channeled low point on the site to the southwest of the field, (not seen in picture). Regulation standards allow a minimum 2% slope for grass fields with Kentucky Blue grass. If the surface is changed to an engineered natural turf, the minimum slope is 1.5%. Natural turf fields with sub-surface drain systems have a minimum of 1% slope. Synthetic turf fields with sub-surface drain systems require a minimum of 0.5%. The soil type is a Walla Walla silt Loam with low plasticity silt. Precipitation for each types of these surface types would have to be increased to prevent dying grass from occurring, increasing the hours spent irrigating the field.

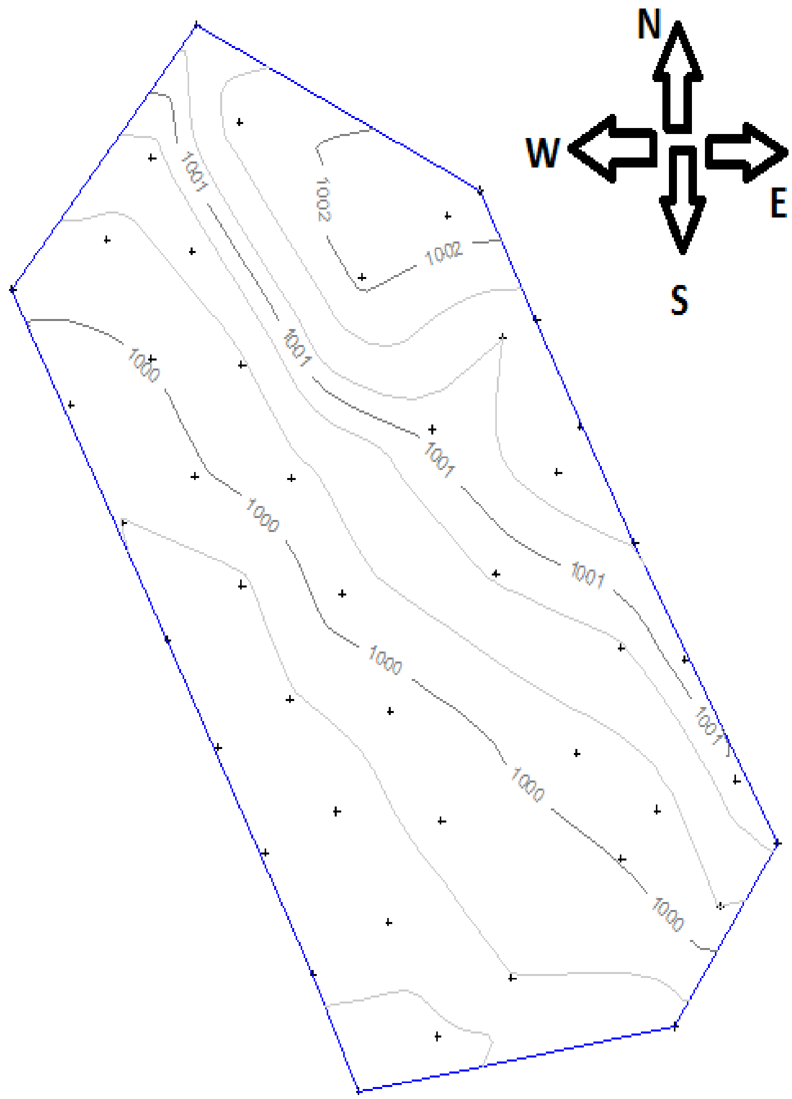

Figure 2 - Original topography of the soccer field

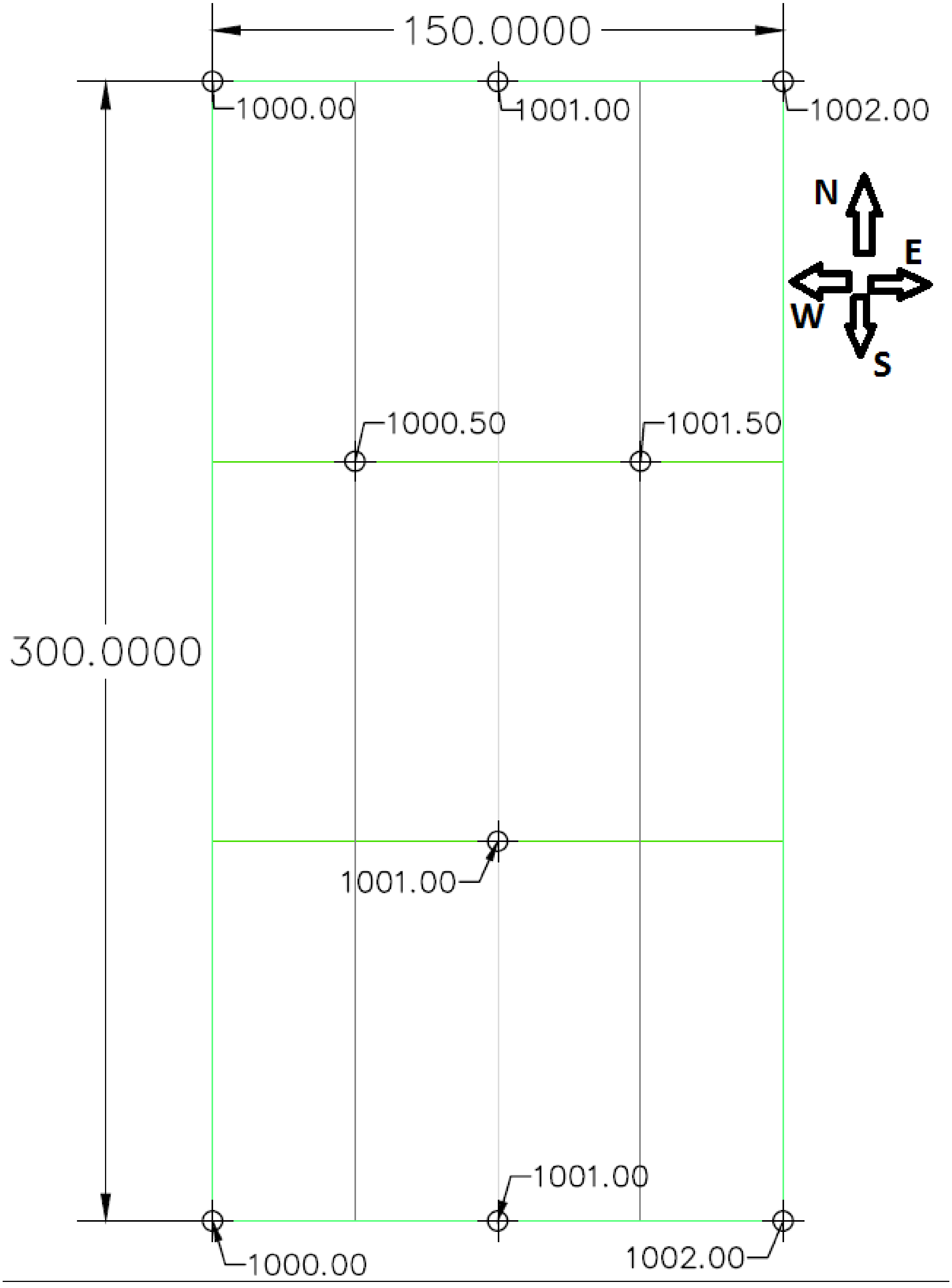

Figure 3 - Final elevation for soccer field location

3 Earthwork

In order to create the desired slope and elevation of the soccer field minimal grading will have to occur. Grading of the field would take soil from the northeast corner and spread through the south and southwest corner, this would create the elevation change Figure 3. Additional soil may be needed to create the 2% slope. Regulation standards allow a minimum 2% slope for grass fields like Kentucky Blue grass as on the Prescott Field.

4 Lighting

Prescott's soccer field has no lights, which prevents evening games from occurring. Techline Sports Lighting proposed the design found in Appendix B that would accommodate the requirements. No design analysis occurred on the design provided by Techline Sports. After discussions with professors, it was decided that it would be more economical to provide the drawings of the lighting to Prescott while suggesting four poles be used if this design was to be built.

5 Irrigation Systems

Prescott's existing pump is a submerged Gould Texas turbine 5CLC bowl assembly, 20 horsepower, 480 volt, 3-phase motor. Specifications of this pump appear in Table 1. The pump provides all the necessary water for the current and new irrigation systems. The current design for Prescott's pump are in Table 2. This pump irrigates a ½ acre and runs six to eight hours a week.

Table 1 - Pump Characteristics

Pipe Length	450 ft.
Pipe Casing	8 inch.
Pipe Diameter	2 inch.
Headloss	14.5 psi
Pressure	80 psi
GPM	60

Table 2 - Current Irrigation Demand

Pipe Diemeter	2.5 inch.
Gallons per hour	3600
Gallons per Week	22000

Prescott School had a previous analysis of the soil that indicated a range of 0.57 to 1.98 inches per hour of precipitation on the grass to prevent the grass from browning. The number of irrigation zones depends on the delivery rate and area of the zone.

Analysis of two possible layouts provided comparison of delivery efficiency, limited intrusion to the playing area, and kept the cost low. The piping was 2-inch schedule 40 PVC for both designs. Two sprinkler systems with different operation and maintenance requirements were considered, and irrigation from the side of the field was the preferred alternative, which incorporated a double loop around the exterior of the field to limit interference to play during games.

Design 1 required large turf rotor sprinkler guns along the outside of the field in trenches 12 inches below the ground surface. The pipe system isolated each sprinkler with three shut-off valves (Figure 4), which allowed flow rerouting and normal irrigation despite breakage to any single pipe.

Triple coverage was created by having rotation of the guns varying on location. Corner guns rotate 90 degrees, while guns 3, 5, 7, 12, 14, 16 rotate 180 degrees, and the remaining guns 2, 4, 6, 8, 11, 13, 15, and 17 rotate 45 degrees.

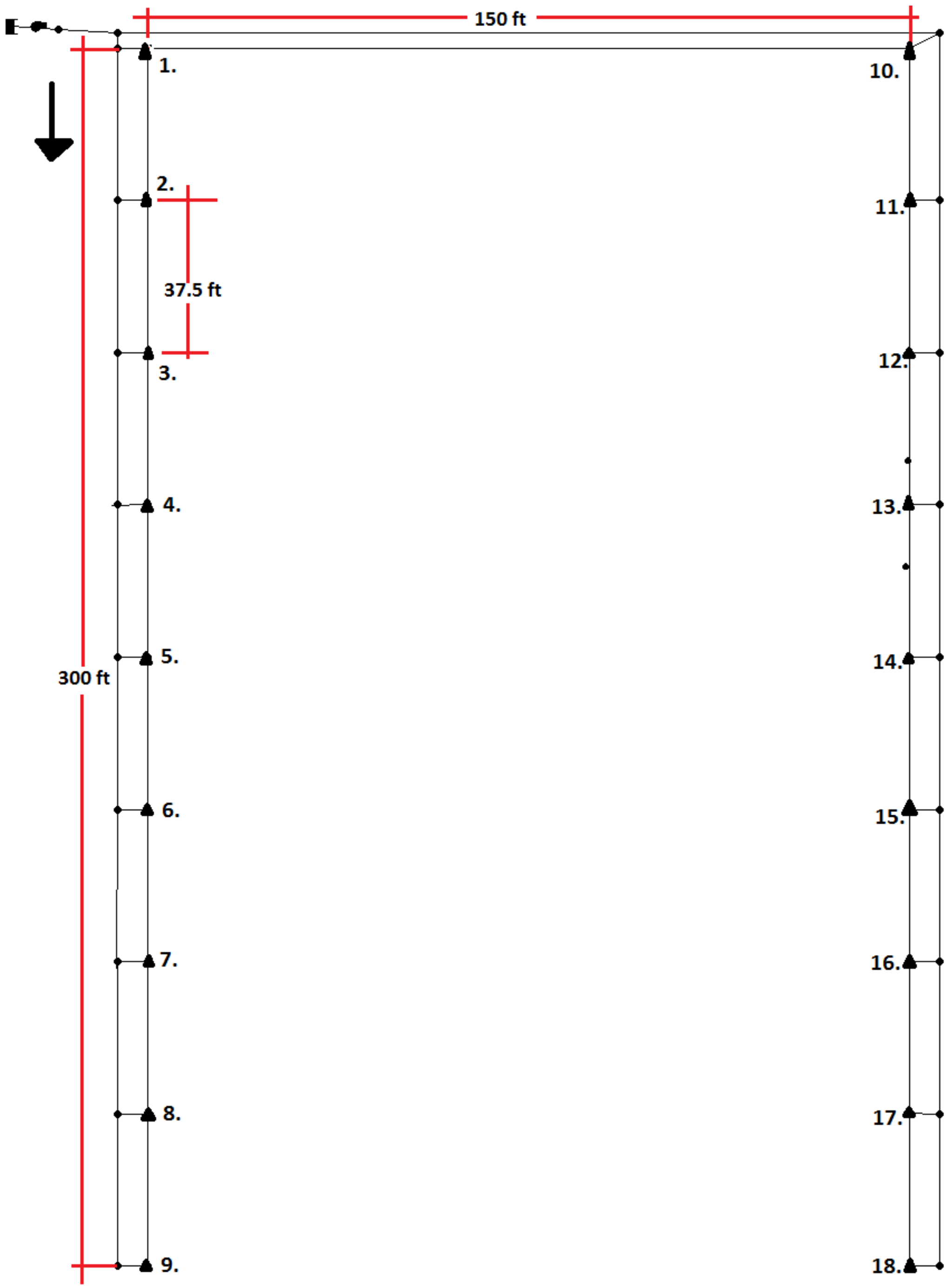

Figure 3 - Design 1: Exterior Loops. Triangles indicate sprinkler heads. Circles indicate connectors.

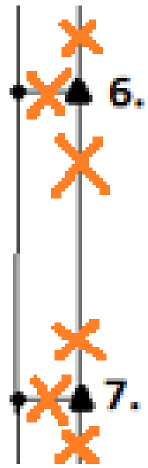

Figure 4 - Design 1: Exterior Loop Detail. Triangles indicate sprinkler heads, circles indicate connectors, and xs indicate shut-off valves.

To achieve the coverage necessary 18 guns total were required, and provided the pressure and flow indicated in Table 3.

Table 3 - Sprinkler specification for Design 1

Aqualine I50-532 1/2" FC Impact Sprinkler		
Pressure (PSI)	25	
Flow (GPM)	7	
Percipitation (in/hr)	0.09	
Radius (ft)	75	

Design 2 incorporated evenly-spaced pop-up sprinklers to create double coverage of precipitation to limit brown spots. Similar to Design 1, shut-off valves are located on each pipe segment connecting to the sprinklers. The south side of the network provides extra coverage that is needed in case of problems with the main pipe to the east side of the design.

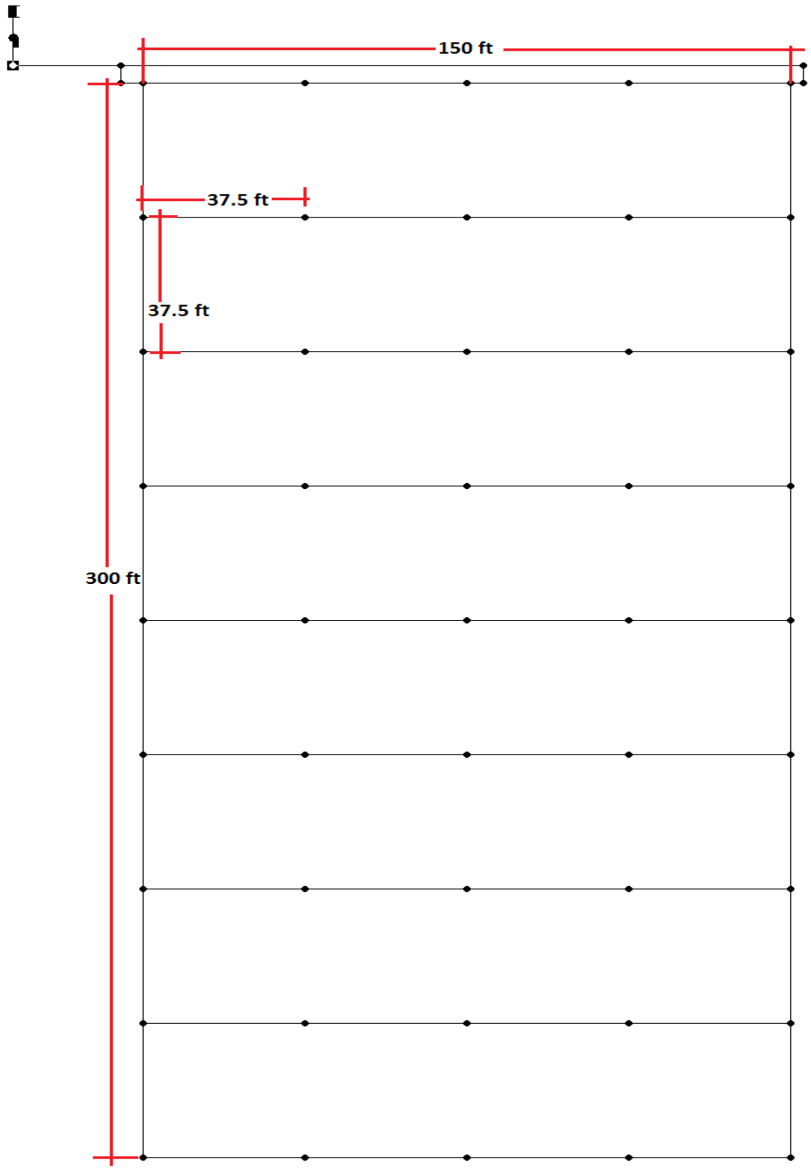

Figure 5 - Design 2 layout

All of the calculations for this design and pop up sprinklers are shown in Appendix C.

Table 4 - Sprinkler specification for Design 2

2045A Maxi-Paw Rotor	
Pressure (PSI)	12
Flow (GPM)	6.3
Percipitation (in/hr)	0.32
Radius (ft)	37.5

One advantage of Design 1 is that the pipeline on the outside of the field doesn't require digging in the middle of the field in case of maintenance problems, allowing soccer games to continue even if the sprinklers are down. The design loops, which allows irrigation to continue even if a section of the pipe is broken. Another advantage is fewer sprinkler guns in the design layout limit potential problems, keeping the cost of replacements down.

The disadvantages of Design 1 are that the pump will have to run at almost full capacity the during a 5 hour irrigation rotation, with little room for error as seen in the calculations in Appendix C. The large turf sprinklers will always be above ground, which is a tripping hazard during games and an obstacle when the grass is being mowed. They are easily removed and capped if necessary. Due to circular rotation of the guns, there is the potential of missing areas in the center of the field, which will have to be irrigated manually to prevent brown spots from occurring.

Design 2's main advantage is a reduced sprinkler radius compared to Design 1. Having pop-up sprinklers gives a higher precipitation rate. The disadvantage is that there are eight zones, increasing the total irrigation time. In order to maintain the desired precipitation rate over the entire field, multiple zones will have to run a day in order to get the zones to run twice a week as needed. Forty-five pop-up sprinklers create a higher chance of required maintenance and increased system cost. Another negative is the increased length of pipe required. The biggest drawback is the need for excavation in the middle of the field for a pipe break.

6 Cost Analysis

Without being able to get a cost estimate and exact value of how much dirt will be removed and needed to create the level field assumptions have been taken into account, and a cost analysis has been conducted. Project costs have been categorized by lighting, and irrigation systems. Lighting cost were an estimate from Techline Sports lighting, but labor costs were not included. Irrigation systems have been categorized into sprinklers, pipe, hydraulic trencher 18", and roller. Some of the costs are day rentals for parts of equipment. Design 1 costs $12,792 and Design 2 $13,252. The price will increase by adding the lights. Cost estimates are in Table 5.

Table 5 - Design Cost Estimates

		Description	Unit Cost ($)	Amount (units as per specific Item)	Total Cost($)
Irrigation systems	Design 1	Sprinklers	$14.00	18	$224.00
		2-inch Schedule 40 PVC 10 ft.	$8.00	153	$1,224.00
			Total		$1,448.00
	Design 2	Sprinklers	$17.00	45	$228.00
		2-inch Schedule 40 PVC 10 ft.	$8.00	213	$1,680.00
			Total		$1,908.00
Earth Work		Hydraulic Trencher 18 inch	$119.00	1 unit rental per day	$119.00
		Roller	$225.00	1	$225.00
		Earth Removal	$5,000.00	NA	$5,000.00
			Total		$5,344.00
Lighting		Cost Estimate	$6,000.00		$6,000.00
			Total		$6,000.00
			Design 1 Total		$12,792.00
			Design 2 Total		$13,252.00

7 Recommendations

Design 1 provides the better choice of the alternatives, since it is simpler to maintain and provides no hazards to play directly on the field. If the non-retractable sprinkler heads are a problem for lawn mowing, temporary removal and capping is possible. A new pump could provide higher pressure and flow to allow more zones to be run at a time. Lighting recommendations are summarized in Figure B2. Excess soil can be taken from the northeast corner and placed in the southwest corner of the field using a grader.

8 References

[1] Cox, Brett, *school planner and grounds keeper.* Prescott High School District: 2017.

[2] Wentland, Randy, *Grounds Manager,* Walla Walla University: 2017.

[3] "Sprinkler Warehouse." RainBird: 2012: http://sprinklertalk.com/product_manuals/manuals/Rain_Bird/Rotors/2045A_Maxi-Paw/2045a_maxi_paw_spec.pdf

[4] "Sprinkler Warehouse." 2007 http://www.sprinklerwarehouse.com/Aqualine-Brass-Impact-Sprinkler-p/i50-532.htm

[5] Gupta, Ram S. "*Hydrology and Hydraulic Systems Third Edition.*" Waveland Press, Inc. 2014, United States.

[6] Helton, Mike. *Regioinal Sales Director,* TECHLINE SPORTS LIGHTIN, LLC: 2017.

[7] Wells, John. *Prescott School District Water Right and Supply Issues,* ANDERSON PERRY & ASSOCIATES, INC: August 30, 2013

[8] United States Department of Agriculture. *Web Soil Survey,* Nautral Resources Conservation Service. https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

[9] McCadden, Shawn. Journal of Light Construction Washington State.

[10] East Bay Chapter. American Institute of Architects, November 2008.

Appendix A – Irrigation layout

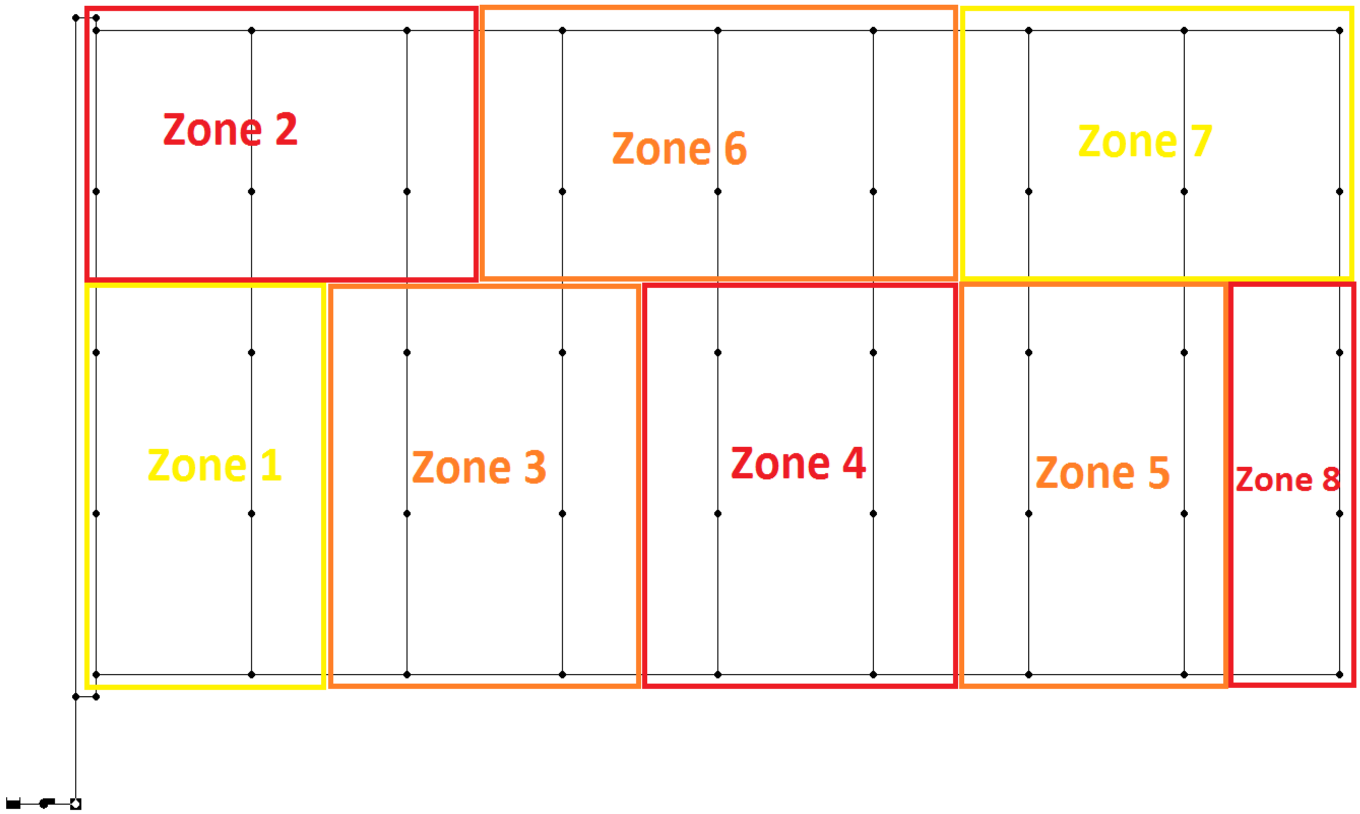

Figure A1 – Zone coverage layout for Design 1

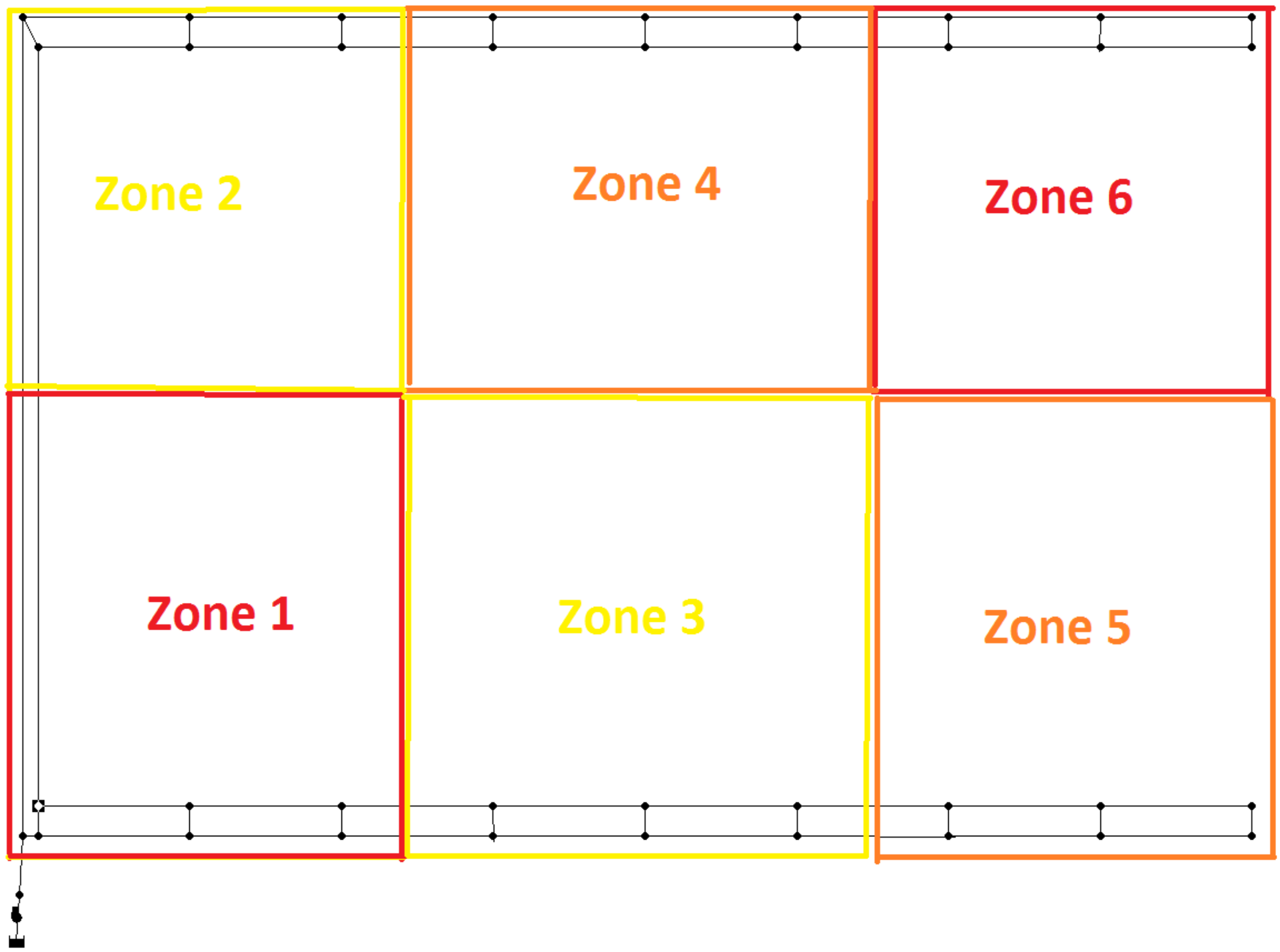

Figure A2 – Zone coverage for Design 2

Appendix B – Lighting Design

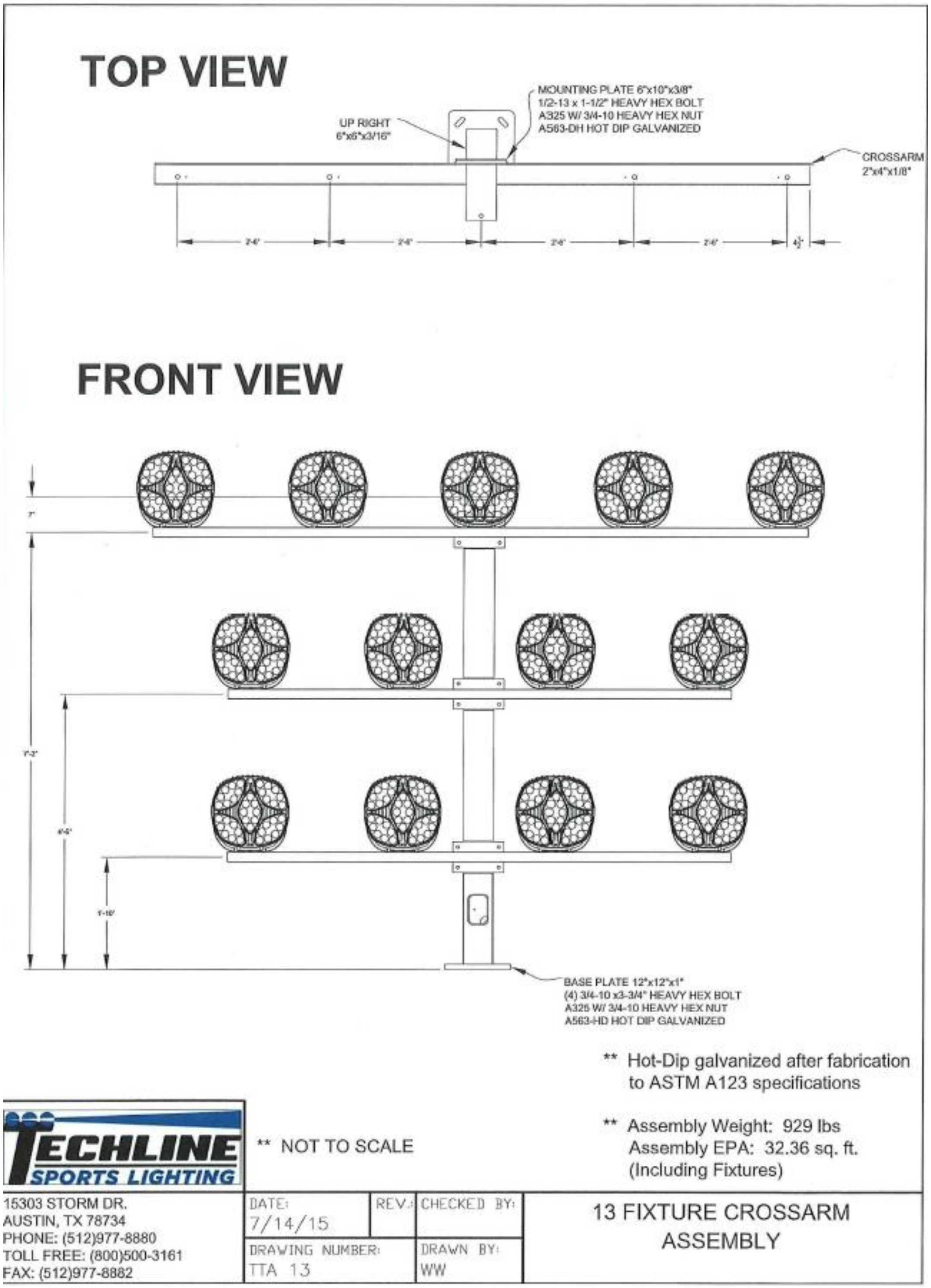

Figure B1 – Top/Front View of Lighting Cross Section

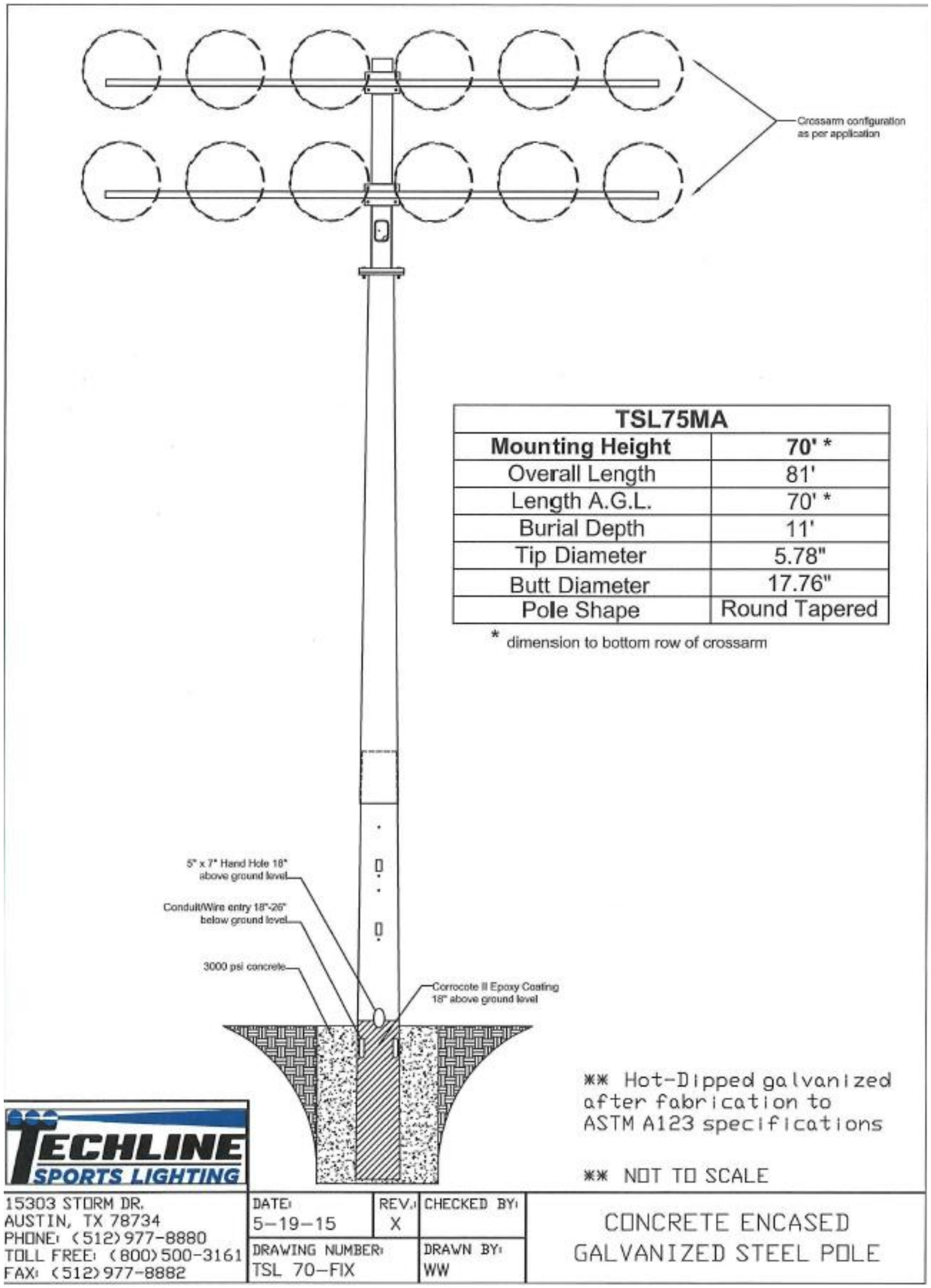

Figure B2 – Pole Design and Specs

Appendix C – Calculations

Table C1 - Maximum Head loss Calculations for Design 1

Hazen-Williams Equation for Pressure Loss in Pipes		Gal/min	psi
		60	80
Imperial Units			
Specified Data			
l = length of pipe (ft)	450		
c = Hazen-Williams roughness constant	140		
q = volume flow (gal/min)	60		
dh = inside or hydraulic diameter (inches)	2		
Calculated Pressure Loss			
f = friction head loss in feet of water per 100 feet of pipe (ft H20 per 100 ft pipe)	7.53		
f = friction head loss in psi of water per 100 feet of pipe (psi per 100 ft pipe)	3.24		
Head loss (ft H20)	33.86		
Head loss (psi)	14.56		
Calculated Flow Velocity			
v = flow velocity (ft/s)	6.13		

Table C2 - Maximum Head loss Calculations for Design 2

Hazen-Williams Equation for Pressure Loss in Pipes		Gal/min	psi
		60	80
Imperial Units			
Specified Data			
l = length of pipe (ft)	460		
c = Hazen-Williams roughness constant	140		
q = volume flow (gal/min)	60		
dh = inside or hydraulic diameter (inches)	2		
Calculated Pressure Loss			
f = friction head loss in feet of water per 100 feet of pipe (ft H20 per 100 ft pipe)	7.53		
f = friction head loss in psi of water per 100 feet of pipe (psi per 100 ft pipe)	3.24		
Head loss (ft H20)	34.62		
Head loss (psi)	14.89		
Calculated Flow Velocity			
v = flow velocity (ft/s)	6.13		

Table C3 – Precipitation Rate Calculations for Design 1

Precipitation Calculations	
Pressure in psi	25
Diameter of sprinkler nozzle (in)	0.21875
Efficiency of sprinklers	0.75
Radius of Sprinkler in X coordinates (ft)	75
Radius of Sprinkler in Y coordinates (ft)	75
Sprinkler heads in the zone	3
Amount of Coverage (double, triple ect.)	3
Amount of water needed (gpm)	6.914551
Precipitation by sprinkler (in/hr)	0.088737
One Zone	
Total psi used in system 75	
Total gpm used 20.74365	
Precipitation times coverage 0.26621	

Table C4 - Precipitation Rate Calculations for Design 2

Precipitation Calculations	
Pressure in psi	12
Diameter of sprinkler nozzle (in)	0.25
Efficiency of sprinklers	0.75
Radius of Sprinkler in X coordinates (ft)	37.5
Radius of Sprinkler in Y coordinates (ft)	37.5
Sprinkler heads in the zone	6
Amount of Coverage (double, triple ect.)	2
Amount of water needed (gpm)	6.257034
Precipitation by sprinkler (in/hr)	0.321194
One Zone	
Total psi used in system 72	
Total gpm used 37.5422	
Precipitation times coverage 0.642389	

Appendix D – Surveying

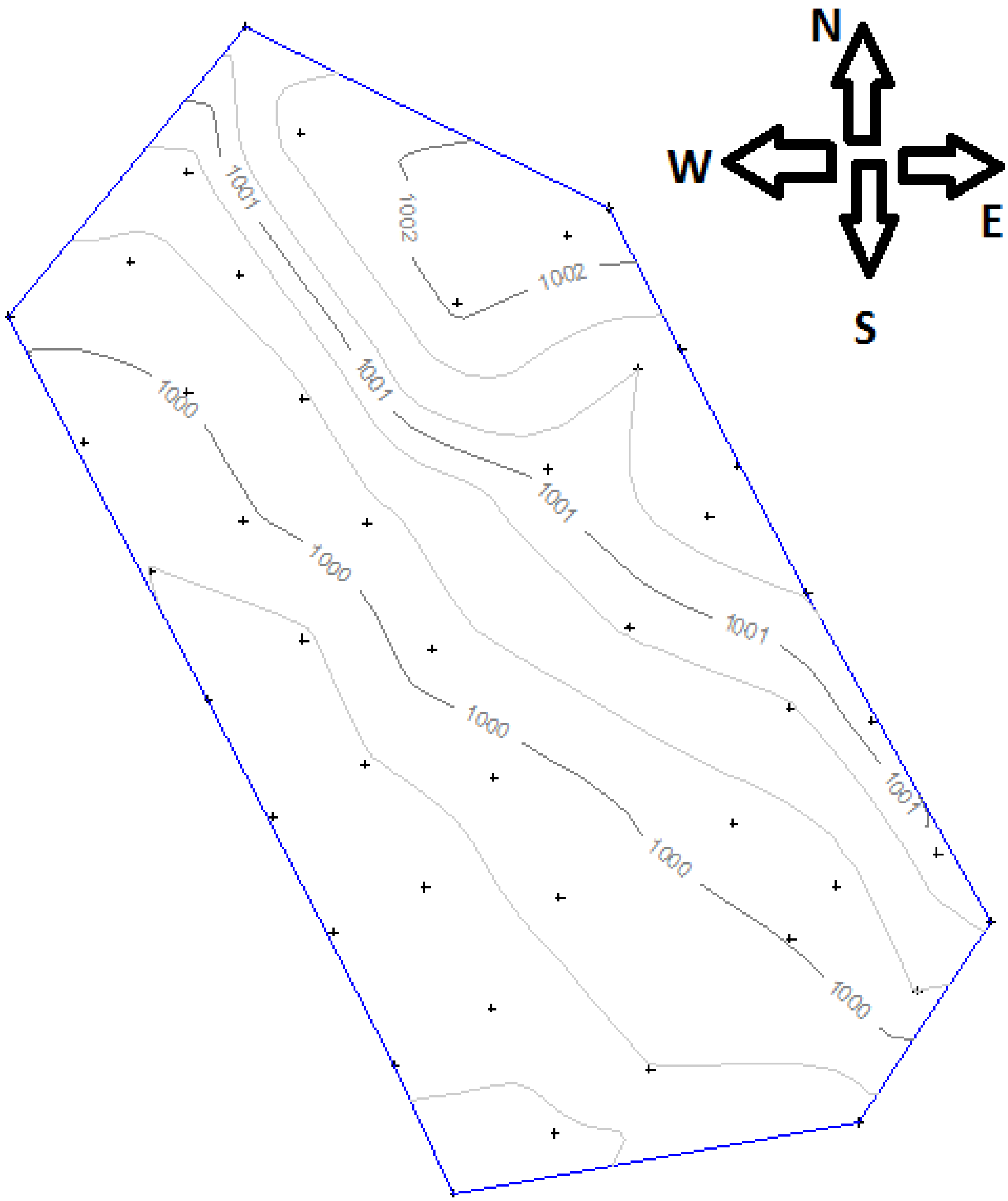

Figure D1 - Elevation Change Topography for Soccer Field