Cole and ASSOCIATES INCORPORATED

APPROVED 6/26/07 RKC

Storm Water Management Report

Sediment Trap B

Preston Woods
Phase II

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Sediment Trap B – Universal Soil Loss Calculations

Soil Loss (Tons/ac/yr) = A = R x K x (LS) x C x P

R = Rainfall Erosion Index = 220 (from Fig. 17.13)
K = Soil Erodibility Factor = 0.28 (Silty Clay- Table 17.6)

LS = Length – Slope Factor = $\left(\frac{L}{72.6}\right)^{m}\left(\frac{430x^2+30x+0.43}{6.574}\right)$

ADJ Factor

(0.50) Segment 1: L=204LF M=0.3, X=0.020

$$LS_1=\left(\frac{204}{72.6}\right)^{0.3}\left(\frac{430(0.02)^2+30(0.02)+0.43}{6.574}\right)$$

LS_1=0.25

(1.29) Segment 2: L=125LF M=0.5, X=0.064

$$LS_2=\left(\frac{125}{72.6}\right)^{0.5}\left(\frac{430(0.064)^2+30(0.064)+0.43}{6.574}\right)$$

LS_2=0.82

(1.18) Segment 3: L=200LF M=0.3, X=0.020

$$LS_3=\left(\frac{200}{72.6}\right)^{0.3}\left(\frac{430(0.02)^2+30(0.02)+0.43}{6.574}\right)$$

LS_3=0.25

(1.40) Segment 4: L=61LF M=0.5, X=0.1311

$$LS_4=\left(\frac{61}{72.6}\right)^{0.5}\left(\frac{430(0.1311)^2+30(0.1311)+0.43}{6.574}\right)$$

LS_4=1.64

$$LS=\left(\frac{(0.5)(0.25)+(0.91)(0.82)+(1.18)(0.25)+(1.40)(1.64)}{4}\right)$$

LS=0.87

Sediment Trap B Storage Calculations

Peak Runoff Rate

Q	=	CiA
C	=	0.5 (50% from Subsection B, Exhibit 2)
i	=	2.86 (6 month design for Sediment Basin taken from subsection C, Exhibit 3)
A	=	5.26ac
Q	=	(0.5) (2.86) (5.26)
Q	=	7.52cfs

Total Runoff Volume

VR	=	P x C x A x 3630
P	=	2.03 (6 month Basin design taken from Subsection D, Exhibit 4)
C	=	0.50 (50% from Subsection B, Exhibit 2)
A	=	5.26ac
VR	=	(2.03) (0.50) (5.26) (3630)
VR	=	19,380 Cubic feet

Total Soil Volume = VS = 9,200cf (per soil loss equation)

Total Soil Volume (V) = VR + VS
= 19,380cf + 9,200cf
= 28,580cf

(See Attached Trap Volume Calculations)

$$\text{Storage Elevation} = \frac{33{,}465\text{cf} - 28{,}580\text{cf}}{33{,}465\text{cf} - 23{,}393\text{cf}} = \frac{599-x}{599-598}$$

x = 598.51

Top of Basin = 600.50

(Al Sill Elevation 598.51)

2-Year High Water Elevation = $H = \left(\frac{Q}{CL}\right)^{2/3}$

$$H = \left(\frac{11.52}{(3.0)(12.67')}\right)^{2/3}$$

$$H = \left(\frac{11.52}{38.01}\right)^{2/3}$$

$$H = (0.30)^{2/3}$$

H = 0.45

2-Year High Water Elevation	=	0.45 + 598.51 (AI Sill Elevation)
2-Year High Water Elevation	=	598.96
10-Year Q	=	17.41
Overflow Elevation	=	599.00
10-Year High Water (See attached calculations)	=	599.47
Top of Basin	=	600.50

File.... S:\JOBS\Jobs2007\07-0041_C07-0041\POND PACK\SEDIMENT TRAP BCD.PPW

Elevation (ft)	Planimeter (sq.in)	Area (sq.ft)	A1+A2+sqr(A1*A2) (sq.ft)	Volume (cu.ft)	Volume Sum (cu.ft)
595.00	-----	6044	0	0	0
596.00	-----	7289	19972	6657	6657
597.00	-----	8360	23455	7818	14476
598.00	-----	9486	26751	8917	23393
599.00	-----	10669	30216	10072	33465
600.00	-----	11909	33851	11284	44748

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

TRAPEZOIDAL CHANNEL ANALYSIS
NORMAL DEPTH COMPUTATION

June 11, 2007

PROGRAM INPUT DATA

DESCRIPTION	VALUE
Flow Rate (cfs)	17.41
Channel Bottom Slope (ft/ft)	0.01
Manning's Roughness Coefficient (n-value)	0.025
Channel Left Side Slope (horizontal/vertical)	3.0
Channel Right Side Slope (horizontal/vertical)	3.0
Channel Bottom Width (ft)	10.0

COMPUTATION RESULTS

DESCRIPTION	VALUE
Normal Depth (ft)	0.47
Flow Velocity (fps)	3.29
Froude Number	0.9
Velocity Head (ft)	0.17
Energy Head (ft)	0.63
Cross-Sectional Area of Flow (sq ft)	5.3
Top Width of Flow (ft)	12.79

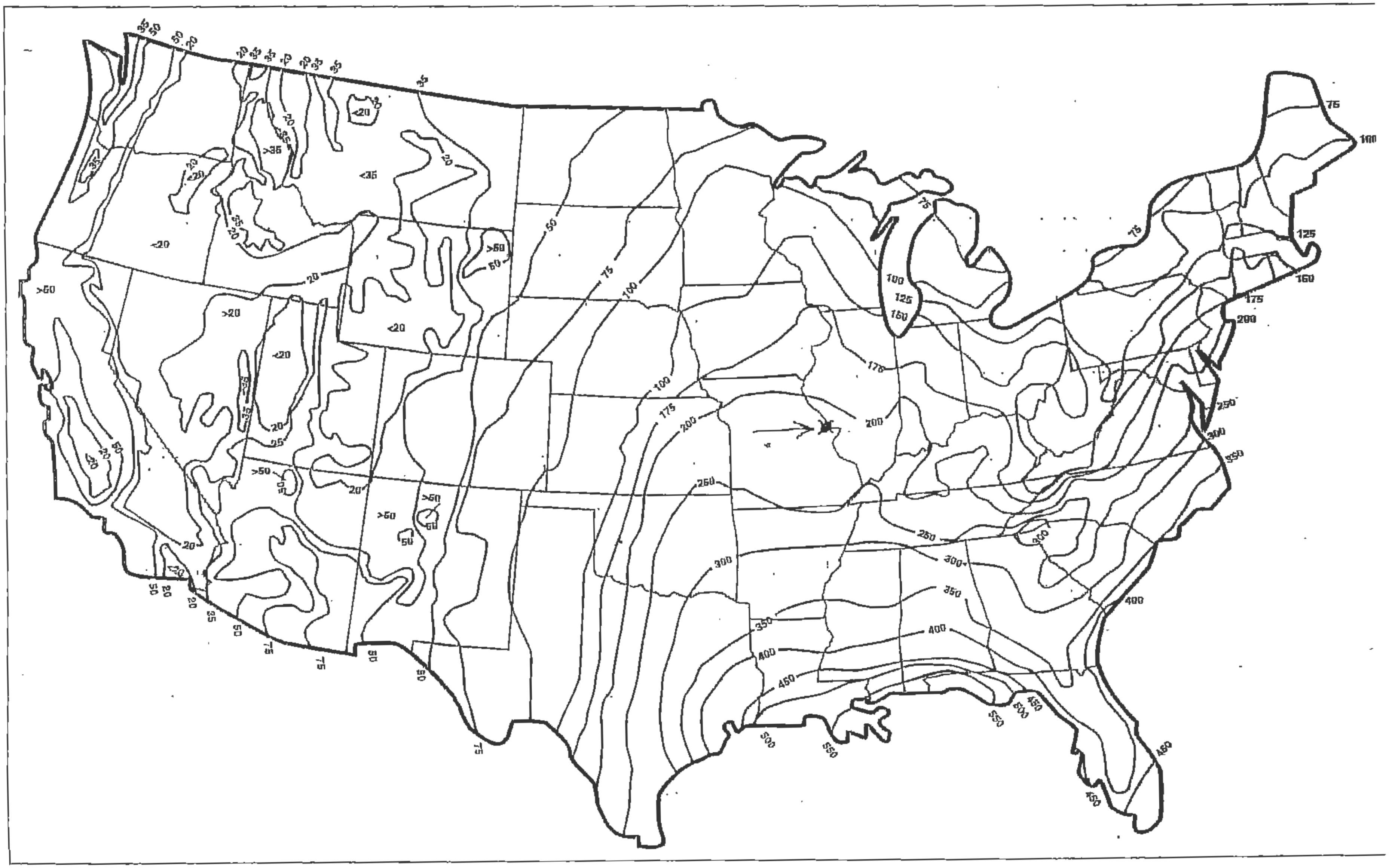


FIGURE 17.13 Average annual values of the *R* factor. (*Source:* USDA, SCS 1977.)

TABLE 17.[illegible] *K* Values for Generalized Soils

***K* VALUES FOR TOPSOIL**

TEXTURE OF SURFACE LAYER	ESTIMATED *K* VALUE
Clay, clay loam, loam, silty clay	.32
Fine sandy loam, loamy very fine sand, sandy loam	.24
Loamy fine sand, loamy sand	.17
Sand	.15
Silt loam, silty clay loam, very fine sand loam	.37

Source: Soil Conservation Service, *Water Management and Sediment Control for Urbanizing Areas*, Columbus, Ohio, 1978.

***K* VALUES FOR SUBSOIL**

GENERALIZED SOIL CATEGORY (TEXTURE OF MATERIALS)	ESTIMATED *K* VALUE OF EXPOSED SUBSOIL MATERIAL
A. Outwash soils	
Sand	.17
Loamy sand	.24
Sandy loam	.43
Gravel, fine to moderate fine subsoil	.24
Gravel, medium to moderate coarse subsoil	.49
B. Lacustrine soils	
Silt loam and very fine sandy loam	.37
Silty clay loam	.28
Clay and silty clay	.28
C. Glacial till	
Loam, fine to moderate fine subsoil	.32
Loam, medium subsoil	.37
Clay loam	.32
Clay and silty clay	.28
D. Loess	.37
E. Residual	
Sandstone	.49
Siltstone, nonchannery	.43
Siltstone, channery	.32
Acid clay shale	.28
Calcareous clay shale or limestone residuum	.24

Source: Soil Conservation Service, *Water Management and Sediment Control for Urbanizing Areas*, Columbus, Ohio, 1978.

and $s_1 = 12$, $s_2 = 10\%$, $s_3 = 8\%$, and $s_4 = 5\%$ using equation (17.2). For example, a 12% slope is equivalent to 6.8° (sin 6.8° = .119).

$$(LS)'_{12\%} = \left(\frac{600}{72.6}\right)^{0.5} \times \left(\frac{430(.119)^2 + 30(.119) + 0.43}{6.574}\right) = 4.4 \quad (17.4)$$

Similarly, $(LS)_{10\%} = 3.5$, $(LS)_{8\%} = 2.4$, and $(LS)_{5\%} = 1.4$. From Table 17.7 the weighing factors are 0.50, 0.91, 1.18, and 1.40 and the effective LS is

$$(LS)_e = \frac{4.4(.50) + 3.5(0.91) + 2.4(1.18) + 1.4(1.40)}{4} = 2.5 \quad (17.5)$$

Chart Values for Successive Segments of a Slope Where the Slope-Length Exponent Equals 0.5.

Segment No. (Top to Bottom)	Number Equal-Length Segments into Which the Slope is Divided for Evaluation of *LS*			
	2	*3*	*4*	*5*
1	0.71	0.58	0.50	0.45
2	1.29	1.06	0.91	0.82
3		1.37	1.18	1.06
4			1.40	1.25
5				1.42

Source: Soil Conservation Service, *Water Management and Sediment Control for Urbanizing Areas*, Columbus, Ohio, 1978.

Cover Factor (*C*)

The cover factor is the vegetative cover or the cropping management factor. It is an index of the type of ground cover and the condition of the soil over the area. Specifically, it is a ratio of the soil loss from a specific cover condition to the soil loss from a clean, tilled, fallow condition for the same soil, slope, and rainfall conditions. For denuded construction sites a C factor of 1 is appropriate. This condition is similar to the agricultural definition of continuous fallow, tilled up- and down-slope where $C = 1$. Table 17.8 shows typical C values for undisturbed land. Table 17.9 shows C values for various types of soil covers.

Erosion Control Practice Factor (*P*)

The erosion control practice factor accounts for ground surface conditions that affect the runoff velocity. Specifically, P is defined as the ratio of soil loss with a given surface condition to soil loss with up-and-down-hill plowing. Such conditions would be contouring, terracing, roughening the soil, sediment basins, and control structures. Table 17.10 shows estimated P values that apply to construction areas.

Limitations of USLE

The USLE is an empirical equation that was initially developed for agricultural applications. The USLE applies to relatively large homogeneous soil areas and is based on long-term averages of rainfall and soil losses from runoff directly on the slope. It does not estimate deposition, nor does it estimate sediment yield at a downstream location.

Morphological features of agricultural land are different from urbanized developing land. Agricultural land typically is characterized by relatively long, regular, gentle slopes whereas construction sites may have discontinuous and irregular land patterns. The land patterns are a combination of steep slopes, sharp breaks, excavation holes, and average annual soil loss, the erosion from the relatively term denuding-stabilization sequence typical of a co tion site may not be indicative of the value obtaine the USLE. Runoff from an area above a disturbed slo not a factor in establishing the USLE, yet runoff fro slope areas does occur on construction sites. Therefo of the USLE, especially for construction sites, requi site area to be broken down into homogeneous area USLE is applied to each individual area and the sum i representative of the soil erosion estimate.

Use of the USLE provides an estimate of a site's e potential. Using the USLE to compare different prac a construction site is appropriate; however, using the to compare one construction site to another is not r mended. The equation does not account for depositio occurs in the nonhomogeneous, irregular land forms of land development projects. Not all sediment eroded a site can be classified as soil loss relative to the site b aries. Some soil is redeposited on site from natural d tion.

A revised version of the USLE, the RUSLE, is now able as computer software. The RUSLE, while still usi same terms, incorporates data and additional theory scribing hydrologic and erosion processes not inclu the original USLE. The new data and additional theory for more refinement for evaluating the terms to sui specific site conditions. The computer format facilita more complex calculations.

Another effort by the U.S. Department of Agri (USDA) in conjunction with the Agricultural Researc vice (ARS), the Soil Conservation Service (SCS), and t reau of Land Management (BLM) has begun to develo erosion prediction technology to replace the USLE. Th puter program resulting from this Water Erosion (WEPP) is expected to be available by the later part of

17.7 SEDIMENT TRAPPING FACILITIES

Sediment trapping facilities retain the eroded sedime site by impounding sediment-laden runoff long enou the sediment to settle out. Trapping facilities vary depending on the estimated runoff draining into the the volume of sediment, and whether they are tempo permanent. The facilities typically are either sedime or sediment basins; the distinction depends on the draining to the facility. Facilities with drainage areas about 3 acres are sediment traps (consult local de dards for specific acreage). Larger trapping facili ment basins, are frequently designed as permanen The location and design of permanent sediment such that they easily convert to retention or deten after the project area is stabilized.

Sediment Basins

Sediment basins operate by reducing the veloci bulence of the runoff to levels where the ma

TABLE 17.6-b *C* Factors for Mechanically Prepared Woodland Sites

Site Preparation	Mulch Cover[1]	Soil Condition[2] and Weed Cover[3]							
		Excellent		Good		Fair		Poor	
		NC	WC	NC	WC	NC	WC	NC	WC
	Percent								
Disked, raked, or bedded[4]	None	0.52	0.20	0.72	0.27	0.85	0.32	0.94	0.36
	10	.33	.15	.46	.20	.54	.24	.60	.26
	20	.24	.12	.34	.17	.40	.20	.44	.22
	40	.17	.11	.23	.14	.27	.17	.30	.19
	60	.11	.08	.15	.11	.18	.14	.20	.15
	80	.05	.04	.07	.06	.09	.08	.10	.09
Burned[5]	None	.25	.10	.26	.10	.31	.12	.45	.17
	10	.23	.10	.24	.10	.26	.11	.36	.16
	20	.19	.10	.19	.10	.21	.11	.27	.14
	40	.14	.09	.14	.09	.15	.09	.17	.11
	60	.08	.06	.09	.07	.10	.08	.11	.08
	80	.04	.04	.05	.04	.05	.04	.06	.05
Drum chopped[5]	None	.16	.07	.17	.07	.20	.08	.29	.11
	10	.15	.07	.16	.07	.17	.08	.23	.10
	20	.12	.06	.12	.06	.14	.07	.18	.09
	40	.09	.06	.09	.06	.10	.06	.11	.07
	60	.06	.05	.06	.05	.07	.05	.07	.05
	80	.03	.03	.03	.03	.03	.03	.04	.04

[1] Percentage of surface covered by residue in contact with the soil.

[2] *Excellent* soil condition—Highly stable soil aggregates in topsoil with fine tree roots and litter mixed in. *Good*—Moderately stable soil aggregates in topsoil or highly stable aggregates in subsoil (topsoil removed during raking), only traces of litter mixed in. *Fair*—Highly unstable soil aggregates in topsoil or moderately stable aggregates in subsoil, no litter mixed in. *Poor*—No topsoil, highly erodible soil aggregates in subsoil, no litter mixed in.

[3] NC—No live vegetation. WC—75% cover of grass and weeds having an average drop fall height of 20 in. For intermediate percentages of cover, interpolate between columns.

[4] Modify the listed *C* values as follows to account for effects of surface roughness and aging. *First year after treatment:* multiply listed *C* values by .40 for rough surface (depressions > 6 in); by .65 for moderately rough; and by .90 for smooth depressions (< 2 in). *For 1–4 years after treatment:* multiply listed factors by .7.

[5] *For first 3 years:* use *C* values as listed.

(*Source:* USDA, SCS 1977.)

TABLE 17.9 *C* Factor for Various Quantities of Mulch

Mulch Adequately Crimped into Soil	*C* Factor
Bare area	1.00
¼ ton straw mulch per acre	.52
½ ton straw mulch per acre	.35
¾ ton straw mulch per acre	.24
1 ton straw mulch per acre	.18
1½ ton straw mulch per acre	.10
2 ton straw mulch per acre	.06
3 ton straw mulch per acre	.03
4 ton straw mulch per acre	.02

Source: Soil Conservation Service, *Universal Soil-Loss Equation*, Agronomy Note #50, Colorado SCS, 1977.

cility. Rainfall–runoff volumes and soil types are highly regionalized. Sizing a sediment basin depends on local municipalities' design standards, which are developed according to regional conditions. In some cases determining the basin's volume may be as uncomplicated as applying a single constant to the drainage area (e.g., 100 cy of required storage volume per drainage acre). This design parameter approximates an upper limit for the amount of sediment expected to be delivered to the facility for the design storm. The assumption here is that the design storm erodes a constant amount of sediment. This blanket value does not consider the soils or topographical features that vary from site to site nor the daily variations of the site conditions. In other cases sizing the basin requires a detailed analysis of the on-site soils and their particle size distribution. This information is then used with USLE or discrete particle settling theory to set the sediment basin size.

TABLE 17.10 Erosion Control Practice Factor P for Construction Sites (Ports, 1973)

Surface Condition With No Cover	*Factor P*
1. Compact, smooth, scraped with bulldozer or scraper up and down hill	1.30 ←
2. Same as above, except raked with bulldozer root, raked up and down hill	1.20
3. Compact, smooth, scraped with bulldozer root, raked across the slope	1.20
4. Same as above, except raked with bulldozer root, raked across the slope	0.90
5. Loose, as in a disked plow layer	1.00
6. Rough irregular surface, equipment tracks in all directions	0.90
7. Loose with rough surface greater than 12-inch depth	0.80
8. Loose with smooth surface greater than 12-inch depth	0.90
Structures	
1. Small sediment basins:	
0.04 basin/acre	0.50
0.06 basin/acre	0.30
2. Downstream sediment basins	
with chemical flocculants	0.10
without chemical flocculants	0.20
3. Erosion control structures	
normal-rate usage	0.50
high-rate usage	0.40
4. Strip building	0.75

(*Source:* SWMM Users Manual which references *Use of the Universal Soil Loss Equation as a Design Standard,* ASCE Water Resources Engineering Meetings, Washington, D.C. 1973. Reprinted with permission from ASCE.)

Discrete Particle Settling Theory

A discrete particle is one that does not change in size, shape, or weight as it settles. Discrete particle settling theory describes the settling behavior of particles in an ideal basin in quiescent water. Particle settling in such ideal conditions depends only on fluid properties and particle characteristics. Interaction between particles is assumed to be negligible.

A particle settling in a quiescent fluid accelerates under the influence of gravity until the driving force of gravity is balanced by the resisting drag force. At this point the particle's terminal velocity is a maximum and remains constant during the remainder of the falling distance. The terminal settling velocity, v_s, for a spherical particle is

$$V_s = \sqrt{\frac{4g(\rho_p - \rho_w)d_p}{3C_D\rho_w}} \tag{17.6}$$

where ρ_p = density of the spherical particle (kg/m³), ρ_w = density of water (kg/m³), g = acceleration due to gravity (m/s²), C_D = coefficient of drag for the particle and d_p = diameter of the particle (m).

The drag coefficient C_D is approximated by

$$C_D = \frac{24}{N_R} \quad \text{for} \quad N_R < 1 \tag{17.7}$$

$$C_D = \frac{24}{N_R} + \frac{3}{N_R} + 0.34 \quad \text{for} \quad N_R \geq 1$$

where N_R, the dimensionless Reynolds number, is

$$N_R = \frac{V_s d_p \rho_w}{\mu} \tag{17.8}$$

with μ = the absolute viscosity of water. Note that when N_R is less than 1, the settling velocity for a sphere reduces to

$$V_s = \frac{g(\rho_p - \rho_w)d_p^2}{18\mu} \tag{17.9}$$

which is Stoke's Law for the settling velocity of a sphere in laminar flow. This can be reduced to

$$V_s = 2.8 d_p^2 \tag{17.10}$$

where v_s is in feet per second and d_p is in millimeters, assuming the specific gravity of the particle = 2.75 and a water temperature of 70°F.

An idealized rectangular settling basin (figure 17.14) consists of four zones: the inlet zone, the removal zone, the outlet zone, and the settling zone. The length L is the distance between the inlet and outlet zones, H is the depth of the settling zone, and W is the basin width. Under such idealized conditions the incoming flow Q_i is steady and constant for the width of the basin. Particles in the incoming flow move horizontally through the basin with a horizontal velocity $v_h = Q_i/(WH)$. The vertical velocity component is the settling velocity, v_s.

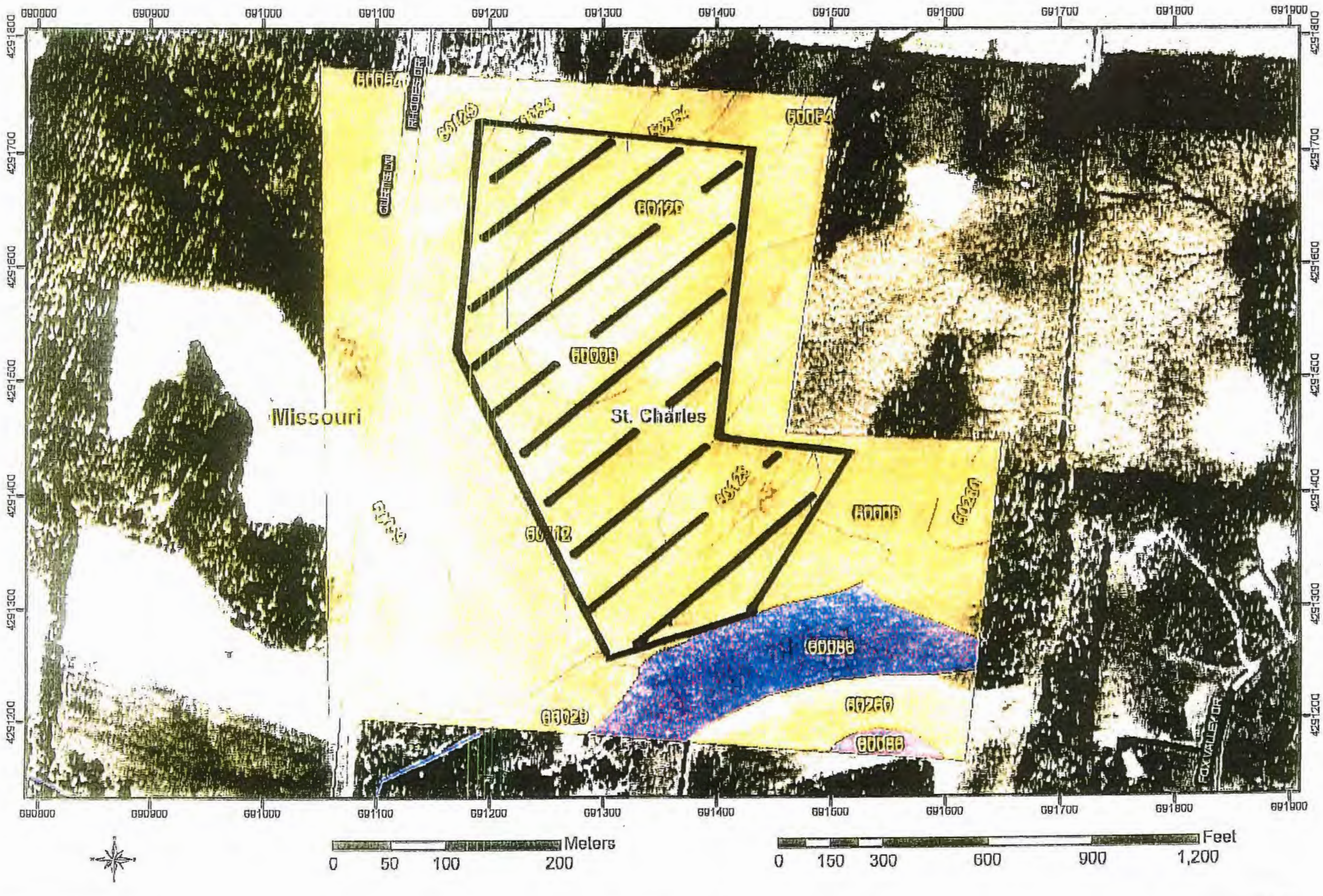
The design of an effective settling basin is such that an incoming particle travels the vertical height H and settles out before it travels the horizontal length L and is discharged. At or below the distance H the particle is in the settling zone and is considered removed from suspension. The time T_L for the particle to travel the horizontal length L of the basin is given as

$$T_L = \frac{L}{Q_i/(W \times H)} \tag{17.11}$$

The time to travel the height H is

$$T_H = \frac{H}{V_s} \tag{17.12}$$

HYDROLOGIC GROUP RATING FOR ST CHARLES COUNTY, MISSOURI



HYDROLOGIC GROUP RATING FOR ST CHARLES COUNTY, MISSOURI

MAP LEGEND

Hydrologic Group
(Dominant Condition, <)

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available
- Soil Map Units
- Cities
- Detailed Counties
- Detailed States
- Interstate Highways
- Roads
- Rails
- Water
- Hydrography
- Oceans

MAP INFORMATION

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov

Coordinate System: UTM Zone 15

Soil Survey Area: St Charles County, Missouri
Spatial Version of Data: 3
Soil Map Compilation Scale: 1:24000

Map comprised of aerial images photographed on these dates:
1995

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables - Hydrologic Group

Summary by Map Unit - St Charles County, Missouri

Soil Survey Area Map Unit Symbol	Map Unit Name	Rating	Total Acres in AOI	Percent of AOI
50009	Keswick silt loam, 9 to 14 percent slopes, eroded	C	11.9	16.6
50054	Armster silt loam, 5 to 9 percent slopes	C	2.1	3.0
50059	Mexico silt loam, 1 to 4 percent slopes, eroded	D	1.5	2.1
60086	Crider silt loam, 9 to 14 percent slopes, eroded	B	6.0	8.4
60112	Goss gravelly silt loam, 14 to 45 percent slopes	C	35.4	49.6
60129	Hatton silt loam, 5 to 9 percent slopes	C	8.9	12.4
60260	Weller silt loam, 5 to 9 percent slopes	C	3.8	5.3
66029	Dockery silt loam, 0 to 2 percent slopes, occasionally flooded	C	1.8	2.6

Description - Hydrologic Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are placed into four groups A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Definitions of the classes are as follows:

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

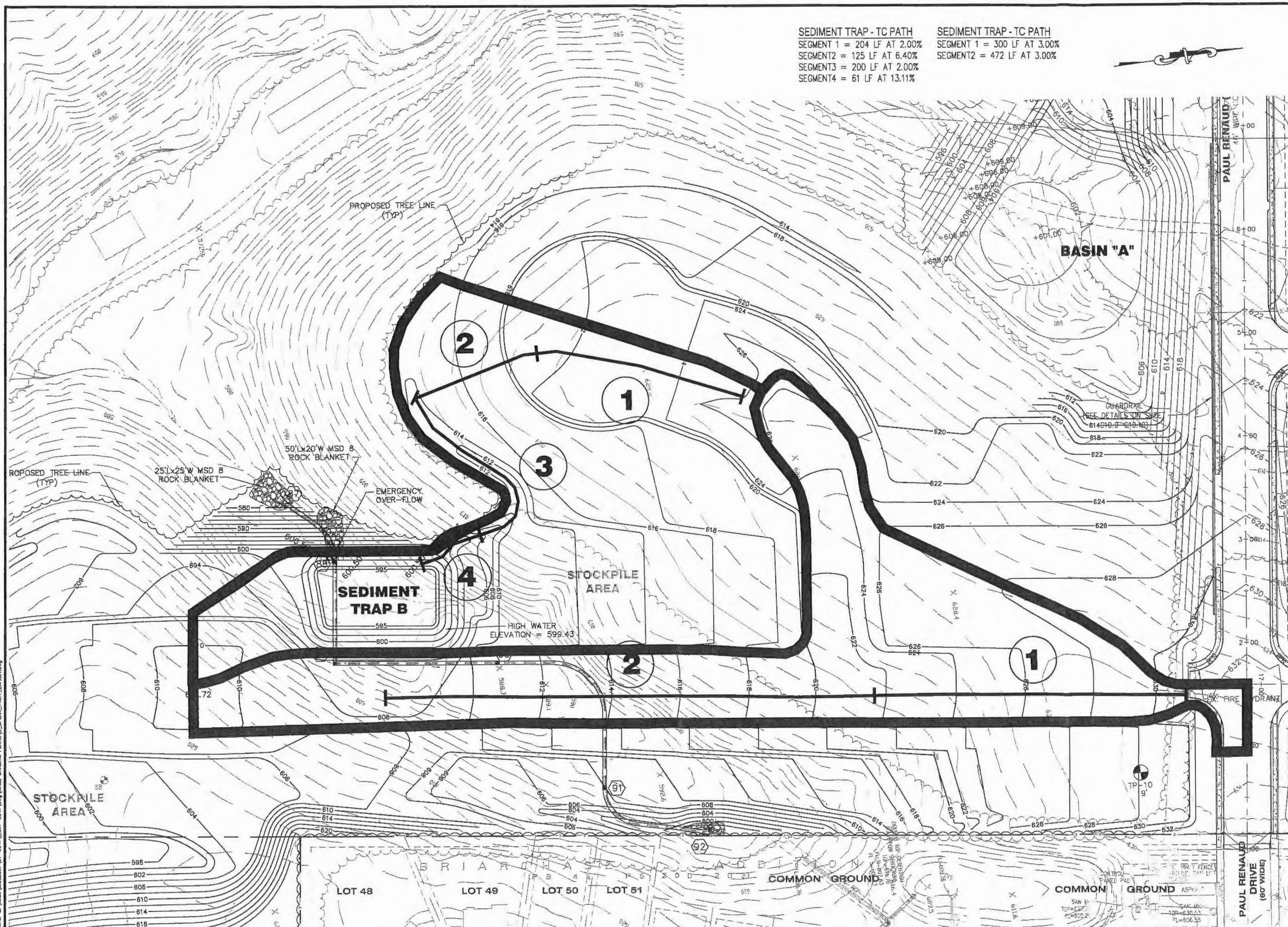
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only soils that are rated D in their natural condition are assigned to dual classes.

Parameter Summary - Hydrologic Group

Aggregation Method: Dominant Condition

Component Percent Cutoff:

Tie-break Rule: Lower



REVISIONS

DATE		DESC.
4/5/07	1	OWNER COMMENTS
5/21/07	2	CITY COMMENTS

DEVELOPER/OWNER:
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SEAL:

PRESTON WOODS - PHASE II

MASS GRADING PLANS
+ PARTIAL STORM SEWER
ST. CHARLES, MO. 63366

SEDIMENT TRAP "B"

planning • engineering • surveying • landscape architecture
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DRAWN BY JKW
CHECKED BY JFH
DATE 3/1/07
Job Number 07-0041
Sheet Number P-B