1. OVERVIEW OF METHOD

The method used to compute tennis rankings for Iowa girls high school tennis http://ighs-tennis.com/ is based on the Elo rating system (section 1.1) as adopted by the World Chess Federation ("FIDE") (section 1.3).

The tennis ranking system makes the following additional adjustments:

(1) Rankings are adjusted based on position played (section 1.4); and

(2) Wins in State tournament matches or regional finals are rated more highly than other wins (section 1.5).

Individual players (section 1) and doubles teams (section 2) are ranked using the same methodology. Schools are ranked based upon the expected results of singles and doubles matches between their respective players and doubles teams (section 3). **[*1]**

[*1] This discussion is based on a database which includes recorded Class 2A matches from 1994, the first year in which 2A and 1A players participated in separate State tournaments, through the completion of the 2007 State tournaments. Altogether the database for such period includes 25,250 matches, singles and doubles, played by 3,600 players from 54 schools in 2,500 meets and 240 tournaments. All matches and meets included are matches and meets between 2A players, doubles teams or schools

1.1 Elo Rating System [*2] http://en.wikipedia.org/wiki/Elo_rating_system

The Elo rating system is a method for calculating the relative skill levels of players in two-player games. The rating system is named after Arpad Elo, a Hungarian-born American physics professor who devised a statistical system to rank chess players.

[*2] The discussion of the Elo rating system borrows heavily from the linked Wikipedia entry.

The Elo system is based on a two formula approach:

First, compute the statistical probability of a player winning a game against another player based on their respective rankings (the first Elo formula); and

Second, increase or decrease the player's ranking by a fixed factor, the "K-Factor," multiplied by the actual result (1 for a win; 0 for a loss) less the expected result computed under the prior formula (the second Elo formula).

Under the first Elo formula, if Player A has a ranking RA and Player B has a ranking RB, the statistical probability of Player A beating Player B is EA calculated as follows:

$$E_A = \frac{1}{1 + 10^{(R_B - R_A)/400}}.$$

The probability of Player B beating Player A is 1 minus the probability of Player A beating Player B.

The rankings are scaled so that a difference of 200 points would mean that the stronger player has an expected winning probability of approximately 75% against the weaker player. [***3**]

[*3] The absolute ranking points of players is a matter of complete indifference in the Elo rating system. Only the point differential (RB-RA) matters. Thus, the probability that a player ranked 2000 will beat a player ranked 1800 is precisely the same as the probability that a player ranked 1200 will beat a player ranked 1000.

The table below illustrates the winning probabilities of a lower ranked player where the opponent's ranking exceeds that of the player by the number of points shown:

Excess Points	Win Probability
10	48.57%
25	46.41%
50	42.86%
75	39.38%
100	36.00%
150	29.67%
200	24.03%
300	15.10%
400	9.10%

The winning probability for the higher ranked player equals 100% less the winning probability shown for the lower ranked player.

When a player's actual results exceed the player's expected results, the Elo system takes this as evidence that the player's ranking is too low, and needs to be adjusted upward. Similarly, when a player's actual results fall short of the expected results, that player's ranking is adjusted downward.

This upward or downward adjustment is a simple linear adjustment proportional to the amount by which the player overperforms or underperforms the player's expected result. Elo's second formula makes this adjustment as follows:

$$R'_A = R_A + K(S_A - E_A)$$

Where SA is the player's actual result; EA is the player's expected result, based on the first Elo formula; and K is the adjustment factor

If Player A has a 1700 ranking and player B has a 1500 ranking, the probability of A winning a match (EA) under the first Elo formula is approximately 75%. Accordingly, under the second Elo formula where K = 32, if Player A wins, Player A's ranking will increase by 8 points and Player B's ranking will conversely decrease by 8 points. If B should pull off the upset with only a 25% probability of winning, B's ranking would increase and A's ranking decrease by 24 points.

Obviously, the amount of the adjustment depends on the K-Factor used. The K-Factor initially used by Elo was set at K = 16 for masters and K = 32 for weaker (i.e. the vast majority of) players. Although it might appear that a ranking system could select from an indefinite number of K-Factors, this is not the case. The appropriate K-Factor for a ranking system is considerably constrained by the "correlation" it produces between expected results and actual results as discussed in the following section.

1.2 Upsets, Correlation and the K-Factor

"Upsets" are a feature of statistics and probability, not a flaw. In the game of dice, the number 7 will appear twice as often as the number 4 (1+6, 2+5, 3+4, 4+3, 5+2 and 6+1 = 6 combinations versus 1+3, 2+2 and 3+1 = 3 combinations). Although rolling a 4 before a 7 might be considered an "upset," since it is less likely to occur than its opposite, it had better happen approximately 33% (3/9) of the time. Otherwise, either the casino or the gambler will be in for a rude surprise.

Therefore, a goal of a statistical ranking system is not to avoid or to limit the number of upsets which occur, but instead to match the actual number of upsets with the predicted number of upsets. This matching can be called "correlation" and an optimum ranking system should produce a correlation of very close to 100%.

[*4] The tennis ranking system and this discussion treat regional final matches as State tournament matches.

Correlation can be illustrated by the table below, which displays all 2006 State tournament singles matches sorted by point spread, in descending order, between the higher and the lower ranked player. As marked in column (8), there were seven tournament matches **[*4]** where the lower ranked player at the time of the match beat the higher ranked player (i.e. “upsets”). Column (6) of the table shows, as a decimal, the probability of a win by the lower ranked player, ranging from approximately four-tenths of 1% (Jensen versus Heying) to 43% (Galles versus Williams and Bacevac versus Neiderhiser). The total of each upset probability equals the total predicted number of upsets (or 7.3153, rounding to 7) for the group of matches. Although the actual upsets are unpredictable, ranging from upsets by a player with an 18% chance of winning (Sadlek) to a player with a 36% chance of winning (Neiderhiser), the seven actual upsets match the total number of predicted upsets, for a 100% correlation.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Higher Ranked	Rank	Lower Ranked	Rank	Spread	Upset %	Score	Upset
Jensen, Hannah	2505	Heying, Emily	1530	975	.0036	(6-0, 6-0)	
Cochrane, Hilary	2428	Kaneda, Ayaka	1642	786	.0107	(6-0, 6-1)	
Cochrane, Hilary	2428	Mayer, Michelle	1657	771	.0117	(6-0, 6-0)	
Jensen, Hannah	2490	Kaneda, Ayaka	1844	646	.0237	(6-1, 6-0)	
McGaffigan, Chrissie	2254	Sadlek, Cassandra	1669	585	.0333	(6-0, 6-0)	
Xin, Frances	2159	Mayer, Michelle	1657	502	.0527	(6-2, 6-1)	
Russell, Ellen	1982	Heying, Emily	1530	452	.0690	(6-2, 6-4)	
Jensen, Hannah	2505	Porto, Anna	2079	426	.0793	(6-2, 6-0)	
McGaffigan, Chrissie	2254	Galles, Elyse	1848	406	.0881	(6-1, 6-1)	
McGaffigan, Chrissie	2184	Searles, Jessie	1815	369	.1068	(6-0, 6-0)	
McMullan, Mary Pat	2236	Neiderhiser, Haley	1879	357	.1135	(6-0, 6-0)	
Russell, Ellen	1959	Sadlek, Cassandra	1637	322	.1355	(6-0, 6-3)	
Cochrane, Hilary	2396	Xin, Frances	2083	313	.1416	(6-0, 5-3)	
Russell, Ellen	1982	Sadlek, Cassandra	1669	313	.1416	(1-6, 7-6, 6-4)	
McMullan, Mary Pat	2061	Galles, Elyse	1760	301	.1502	(6-1, 6-4)	
Bacevac, Mirela	1927	Kaneda, Ayaka	1642	285	.1624	(7-5, 6-3)	
Xin, Frances	2159	Searles, Jessie	1886	273	.1720	(6-0, 6-1)	
Jensen, Hannah	2505	McMullan, Mary Pat	2236	269	.1753	(7-6, 6-3)	
Bacevac, Mirela	**1927**	**Sadlek, Cassandra**	**1669**	**258**	**.1846**	**(6-1, 2-6, 4-6)**	**1**
Jensen, Hannah	**2505**	**McGaffigan, Chrissie**	**2254**	**251**	**.1908**	**(0-6, 2-6)**	**1**
Porto, Anna	2079	Galles, Elyse	1848	231	.2092	(0-6, 6-0, 6-2)	
Porto, Anna	2079	Searles, Jessie	1886	193	.2477	(6-0, 6-1)	
Cochrane, Hilary	**2428**	**McMullan, Mary Pat**	**2236**	**192**	**.2488**	**(4-6, 3-6)**	**1**
Xin, Frances	2159	Russell, Ellen	1982	177	.2652	(6-2, 6-2)	
Cochrane, Hilary	**2428**	**McGaffigan, Chrissie**	**2254**	**174**	**.2686**	**(0-6, 0-6)**	**1**
Porto, Anna	2079	Bacevac, Mirela	1927	152	.2942	(6-1, 6-2)	
Neiderhiser, Haley	**1881**	**Bacevac, Mirela**	**1734**	**147**	**.3002**	**(4-6, 3-6)**	**1**
Williams, Laura	**1800**	**Mayer, Michelle**	**1657**	**143**	**.3051**	**(2-6, 6-3, 4-6)**	**1**
Porto, Anna	1898	Mayer, Michelle	1761	137	.3125	(7-5, 6-1)	
Russell, Ellen	**1982**	**Neiderhiser, Haley**	**1879**	**103**	**.3560**	**(6-3, 3-6, 4-6)**	**1**
Xin, Frances	2159	Porto, Anna	2079	80	.3869	(3-6, 6-1, 6-3)	
McMullan, Mary Pat	2236	Xin, Frances	2159	77	.3910	(6-4, 7-5)	
Williams, Laura	1800	Heying, Emily	1729	71	.3992	(4-6, 6-4, 7-5)	
Russell, Ellen	1982	Bacevac, Mirela	1927	55	.4215	(4-6, 6-2, 6-4)	
Galles, Elyse	1848	Williams, Laura	1800	48	.4314	(6-0, 6-2)	
Bacevac, Mirela	1927	Neiderhiser, Haley	1879	48	.4314	(6-3, 6-2)	
				Totals	**7.3153**		**7**

A goal of a properly constructed ratings system is to produce this same correlation (100%) between predicted and actual upsets across the entire range of contests. Not surprisingly, this depends on the K-Factor used and the K-Factor used for Iowa girls high school tennis will differ from the K-Factor used in chess and, in fact, the K-Factor used for singles rankings differs from the K-Factor used for doubles team rankings.

Given a set of parameters, the range of acceptable K-Factors producing a 100% correlation is quite small. It is not an overstatement to say that the parameters are selected, the K-Factor is calculated. The simplest set of parameters would be a single K-Factor, applied to all matches. The chart below shows predicted upsets, actual upsets and correlation for a single parameter application of the Elo rating system to singles matches recorded in the Iowa girls high school tennis database **[*5] [*6]:**

[*5] This illustration is used for simplicity purposes only. As discussed below, the tennis ranking system uses several parameters.

[*6] Note from the chart that as the K-Factor is changed the number of predicted upsets changes much more rapidly than the number of actual upsets. This is what makes it possible to adjust the K-Factor to produce a 100% correlation. The higher the K-Factor the greater the swing in ranking point adjustments from any particular match and, on balance, the greater the ranking point differential between players. Since greater ranking point differentials reduce the calculated probability of upsets (see sidenote [*3]), a higher K-Factor will offset a top-heavy system (i.e. a system where the number of predicted upsets exceeds the number of actual upsets) while a lower K-Factor will offset a bottom-heavy system (i.e. a system where the number of actual upsets exceeds the number of predicted upsets).

	K-Factor	Actual Upsets	Predicted Upsets	Correlation	
3	146	3553	3519	1.0097	26
	143	3550	3545	1.0014	
	142	3557	3557	1.0000	
5	141	3558	3568	.9972	27
	138	3553	3595	.9883	

1.3 The Two-Tier Approach

The tennis ranking system does not use a single K-Factor. Instead, it adopts the approach used by the World Chess Federation ("FIDE") in implementing the Elo rating system. Under the FIDE approach, there are two tiers of matches and different K-Factors applied to each tier. **[*7]** The form of the FIDE application of the Elo system is :

[*7] Technically, FIDE uses a third tier for players who have obtained a published ranking of 2400 and have completed at least 30 matches. A FIDE ranking of 2400 generally corresponds to the title of International Master, a title which substantially less than 1% of all active chess players obtain. The third tier uses a lower K-Factor than either of the other two tiers and therefore minimizes rating inflation for the very highest rated players. While a 2400 chess player may play thousands of matches over a career, the highest number of recorded singles matches for any Iowa girls high school tennis player is 83. Therefore, there is little utility in using a third tier in the tennis ranking system.

First tier matches, K = 1.67x until the player has completed at least g matches;

Second tier matches, K = x,

<where x = 15 and g = 30>

A purpose of using a higher K-Factor for first tier matches is to permit promising young players to move up in the rankings much more quickly than if a single lower K-Factor were used for all matches.

The tennis ranking system adopts the FIDE approach and sets g to equal the median number of singles matches played by all tennis players in the database, or eight. X in the formula is set at 122, the factor which produces

[*8] Technically, the base K-Factor for singles to produce a 100% correlation using the FIDE methodology would be 124. However, the tennis ranking system uses a base K-Factor of 122 in order to adjust for the effect of State tournament victories as discussed in section 1.5.

a 100% correlation, as discussed in section 1.2. **[*8]** Therefore, the K-Factor for second tier matches (the "base K-Factor") is 122 and the K-Factor for first tier matches (the "enhanced K-Factor") is 204 (or 122*1.67). The enhanced K-Factor is in turn adjusted to reflect the position played by the player in the match. This position adjustment is explained in the following section.

1.4 The Position Ranking

Although chess tournaments or pairings may be limited to players with rankings falling within certain ranges, in chess no player is assigned a position. In contrast, every singles player in an Iowa girls high school tennis meet plays an assigned position, from #1 to #6, with the player regarded as the best being assigned to the highest position and so on. All other things being equal, a player assigned to a higher position should have a higher starting ranking than a player assigned to a lower position to reflect the coach's assessment of the relative skill level of the players. The question is how should this positional difference be incorporated into a tennis ranking system.

Fortunately, Elo's first formula provides an answer to this question. So far Elo's first formula has been used only to calculate the statistical probability of one player beating another based on the ranking point spread between the two players. If, however, probability of upsets is calculated based on ranking point spread (Elo's first formula) and a ranking system produces a 100% correlation (section 1.2) between probable upsets and actual upsets, then ranking point spread could just as easily be calculated based on actual upsets.

[*9] There are a substantial number of matches between #1 and #2 position players (167) and between #1 and #3 position players (92). There are substantially fewer position matches between #1 position players and players playing positions 4, 5, and 6 (47, 41 and 12, respectively). The actual upsets for the first group of matches are taken directly from the match results for each particular group of position players, while the "actual" upsets from the second group of matches are extrapolated from the entire group of matches between different positioned players.

[*10] The actual position rankings assigned are arbitrary as only the point differential factors into the first Elo formula (see sidenote [*3]). The position rankings used in the tennis ranking system are selected to set the average player ranking, assuming at least 15 matches played, to 1600.

Since State tournament matches and many other tournament matches are not position specific (i.e. players in the draw are assigned to play other players regardless of their respective positions played during the year) the tennis database has a substantial number of matches (564 to be exact) between players playing different positions at the time of the match. The table opposite shows the percentages of upsets between the higher and lower ranked positions; the corresponding point differential derived from the first Elo formula; and the position ranking established based on the point difference. **[*9] [*10]**

(1) Position 1 Versus	(2) Actual Upsets	(3) Point Difference	(4) Position Ranking
1			1707
2	31.74%	133	1574
3	18.20%	261	1446
4	15.02%	301	1406
5	12.06%	345	1362
6	12.06%	345	1362

Column (2) from the table, showing the percentage of actual upsets between different position players, is also used to adjust the enhanced K-Factor which would normally apply to tier one matches. As discussed in the preceding section, the ranking adjustment

[*11] Position #1 players playing other position #1 players will win 50% of the time since one of the players will win each match and the other player will lose. There is no reduction in the enhanced K-Factor for position #1 players. Although there is no need to represent this fact by formula, if it were so represented, the actual winning percentage (or 50%) would need to be multiplied by 2 in order to avoid a reduction. Therefore, the actual winning percentages of the other position players must also be multiplied by 2 to avoid an excessive reduction of the enhanced K-Factor.

[*12] Victories in the semifinals and in the State championship match are awarded a further K-Factor enhancement of .83 and 1.17 of the basic K-Factor, respectively.

for the first eight singles matches is based on a K-Factor which is 1.67 times the K-Factor applying to the remaining matches. This enhanced K-Factor equals 204 and is the sum of the base K-Factor of 122 and an additional K-Factor of 82 (or 122 * .67). This additional K-Factor is reduced for first tier matches played other than at position #1. The amount of the reduced K-Factor for each position equals 82 times the actual upset percentage shown in Column (2) x 2. **[*11]** For example, for a player playing a match at position #3, with an 18.20% probability of defeating a position #1 player, the extra K-Factor is 30 (82 *36.40%) and the enhanced K-Factor is 152 (122 +30).

1.5 State Tournament Victories

There are two general types of rating systems. Competitive reward systems which award ranking points based upon subjective evaluations of the importance of the particular contests; and statistical systems, like the Elo rating system, which award points based on a uniformly applied system of underlying variables. The tennis ranking system is primarily a statistical based system with one competitive reward adjustment.

The competitive reward adjustment is to treat State tournament victories as if they were first tier matches played by position #1 players. In other words, Elo's second formula is applied to each State tournament singles victory using the enhanced K-Factor of 204. **[*12]** Even though this extra adjustment reflects a subjective assessment that State tournament victories are more indicative of the tennis quality of the winner than regular season matches, the adjustment is still statistically, rather than subjectively, calculated because it applies Elo's second formula to the match result rather than simply awarding bonus points to the match winner.

For example, in the 2006 State tournament match between Jensen and Heying shown below, Heying had a .0036 expected probability of winning. If Jensen were to win the match, as she in fact did, her ranking would be adjusted by .0036 * 204 or .73 points rather than by the .44 points she would have received (.0036 * 122) if the match had been a regular season match. In either event the ranking adjustment, which in this case is less than one point, would be based on Elo's second formula.

Higher Ranked Player	Rank	Lower Ranked Player	Rank	Point Spread	Upset Probability
Jensen, Hannah	2505	Heying, Emily	1530	975	.0036

There is no separate mathematical metric which would show the State tournament adjustment to produce a "better" or "worse" ranking result than a tennis ranking system without such an adjustment. Using the parameters described in this and the preceding sections and a K-Factor of 122, the tennis ranking system used predicts 3,521 singles upsets as opposed to the 3,523 singles upsets which actually occur for a 99.94% correlation. This is an almost perfect correlation, but is not statistically different from the correlation produced by using a two tier approach with no State tournament adjustments and a base K-Factor of 124 (3,514 singles upsets; 3516 predicted singles upsets; also a 99.94% correlation).

The State tournament adjustment is primarily justified because it produces end of the year rankings which correlate much more closely to the actual State tournament results than if no State tournament adjustment were made and, subjective or not, State tournament results are the primary measuring stick which Iowa tennis fans use to grade Iowa girls tennis players.

The chart opposite shows a comparison for both singles and doubles matches **[*13]** of end of year rankings and State tournament results between the hybrid statistical-reward approach used by the tennis ranking system and a purely statistical approach. In each category the system used produces end of the year ranking results which better match the State tournament results than a two tier-no State tournament adjustment approach **[*14]**:

	Ranking System Used	Alternative Ranking System
State Champion		
Singles	12	10
Doubles	13	10
Total	25	20
Accuracy		
Singles	44	41
Doubles	39	30
Total	83	71
+/-1 Accuracy		
Singles	82	76
Doubles	84	67
Total	166	143
All	274	234

- Of the 28 State champions, the system used ranks 25 as number 1 at the end of the season as opposed to 20 under the alternative approach. **[*15]**

- Of the 216 State tournament place finishes (1-8 for 13 years and 1-4 for 1996) for each of singles and doubles the system used ranks 83 players or doubles teams exactly as they finished in the State tournament as opposed to 71 under the alternative approach.

- Of the same 216 State tournament place finishes, the system used ranks 166 players or doubles teams within one spot of their State tournament finish as opposed to 143 under the alternative approach.

[*13] The tennis ranking system as applied to team doubles matches, which is discussed in detail in section 2 below, uses the same form as that used for singles. Accordingly, a comparison of doubles results, as well as singles results, between the system actually used and an identical system but without a State tournament victory adjustment is instructive even though the actual parameters of the team doubles rankings are yet to be described.

[*14] An Iowa girls high school tennis player must choose between singles and doubles at the State tournament. Accordingly, players playing doubles at State are not included in the singles comparison and doubles teams with at least one player playing singles at State are not included in the doubles comparison.

[*15] The three State champions not ranked number 1 at the end of the year are:

1) The doubles team of Katie Callaghan and Hannah Jensen in 2007. They were outranked by Leesa and Sarah Caldwallader, whom they beat for the State doubles team championship but who had beaten the State champions prior to the State tournament and then again in the State school tournament, and who are the number 1 ranked doubles team of all time.

2) Vilsa Curto, ranked behind Kimiko Glynn in 2004, who beat Glynn for the State singles championship but was in turn beaten by Glynn in the 2004 State school tournament; and

3) Megan Racette, the number one ranked all-time singles player, who in her freshman year of 1999 was ranked behind Cassie Haas, the 1997 State champion (who did not play in Iowa in 1998).

1.6 Ranking Periods and Position Adjustment

The regular season is divided into three rankings periods which split the regular season into an equal number of matches. There is one additional ranking period which begins just before the State tournaments and one just after the State singles and doubles portion of the State tournaments. The Elo calculations are applied to each player's ranking as of the beginning of the ranking period during which the match is played. Such ranking equals the player's ranking as of the end of the prior ranking period adjusted to reflect the average position played by the player as of the end of the current ranking period.

As discussed in section 1.4, each position has an associated position ranking (1707 for position #1, 1574 for position #2, and so forth). For the ranking period during which the player plays her first match, the player's ranking as of the end of the prior ranking period is zero and the player's beginning ranking is based solely on the average position played by the player during such first period. Thus a player who played all her initial matches at position #1 would have a beginning ranking of 1707 and a player who played all her initial matches at position #2 would have a beginning ranking of 1574 and so on. If the player played some matches during her first ranking period at different positions, the beginning ranking would be based on the average position played (i.e. a player playing four matches at position #1 and six matches at position #2 would have an average position played of 1.6 and a beginning ranking of 1627 (1707 - (.6 x (1707-1574))).

After a player's initial ranking period, the player's beginning ranking will equal the ranking as of the end of the prior ranking period adjusted by the change in the average position played as of the end of the ranking period compared to the average position played as of the end of the prior ranking period. If the player in the preceding example played five matches at position #1 during her second ranking period, the player's average position played would equal 1.4 ((9 * 1)+(6 * 2) = 21; 21 / 15 = 1.4). Since the player's ranking position changed from 1.6 to 1.4, the player's beginning ranking would equal the player's ranking as of the end of the prior ranking period increased by 27 points (.2 x (1707-1574)).

1.7 The Top Ranked Singles Players

Note: All-time rankings are based on the highest year end ranking attained by each player.

The table below shows the top thirty all-time singles players (fifteen match minimum) as determined under the tennis ranking system described above:

All Players: Singles 15+

#	Player	School	Rate (15+)	W	L	Singles %	%Sets	P	State Results Singles	State Results Doubles
1	Racette, Megan	Urbandale	3051	45	0	100.00	97.83	1	1-1-1-1	
2	Haas, Cassie	Wahlert	2957	56	3	94.92	92.05	1	1-3-3	
3	McGaffigan, Chrissie	Bettendorf	2884	36	0	100.00	100.00	1	1-1	
4	Saluri, Heather	Urbandale	2815	43	6	87.76	84.76	2	1-2-3	2
5	Fiala, Molly	CRTJ	2801	72	6	92.31	87.18	1	1-3-3-4	
6	McGaffigan, Jenny	Bettendorf	2771	48	6	88.89	85.37	1	3-3	1-1
7	Saluri, Jennifer	Urbandale	2766	38	6	86.36	83.33	1	1-2-4	
8	Glynn, Chelsea	Valley	2723	40	7	85.11	85.11	1	2-3	1
9	Glynn, Kimiko	Valley	2722	48	3	94.12	91.26	2	2-2	1-8
10	McGaffigan, Laura	Bettendorf	2703	56	3	94.92	93.55	2	1-2	1-1
11	McGaffigan, Katie	Bettendorf	2694	46	2	95.83	92.00	2	2	1-1-3
12	Zeff, Naomi	Roosevelt	2694	23	2	92.00	91.84	1	1-1	
13	Curto, Vilsa	IC West	2690	62	7	89.86	89.47	1	1	1-4-4
14	Fick, Lynsey	Bettendorf	2676	66	6	91.67	86.61	1	2-4-5	1
15	Jensen, Hannah	IC West	2636	76	7	91.57	87.68	1	2-2	1-1
16	Crowley, Amie	IC West	2597	63	9	87.50	85.15	2	5-7	4
17	Mowery, Heather	CRK	2584	32	5	86.49	81.36	1	2-8	
18	Jedlicka, Diane	IC West	2564	25	1	96.15	94.87	2	3	
19	Rovner, Allison	Valley	2552	40	8	83.33	82.98	1	5	
20	McMullan, Mary Pat	Boone	2523	31	7	81.58	80.77	1	2-3	
21	Kothari, Karen	Valley	2509	27	3	90.00	85.94	1	2-3	
22	Fraser, Megan	PV	2504	24	14	63.16	59.02	1	5-7	
23	Eslick, Molly	Fort Dodge	2475	52	15	77.61	74.45	1	3-6-7	
24	Cochrane, Hilary	Fort Dodge	2474	44	11	80.00	76.15	2	4-5	
25	White, Jenni	CRK	2409	52	9	85.25	81.72	2	4-5	
26	Leese, Kendra	Bettendorf	2407	50	3	94.34	92.21	1	2-4	1
27	Peters, Jane	IC West	2404	50	0	100.00	98.70	3		2-3-6
28	Barnes, Jennifer	Bettendorf	2399	39	11	78.00	73.68	2	3	5-6
29	Staudt, Genevieve	Dowling	2396	55	13	80.88	78.99	1	5-7	3
30	Stouffer, Jill	Valley	2394	24	5	82.76	81.36	1	3	

2. DOUBLES TEAMS

2.1 The Ranking of Doubles Teams

Doubles teams are ranked using the same general method as used to rank singles players:

(1) A two tier approach is used with the first tier K-Factor set at 1.67 of the base K- Factor, adjusted for matches played at positions other than position #1. Matches are first tier matches until a doubles team has played more than the median number of matches played by doubles teams.

(2) Teams are assigned positions based on the average position of their matches and position rankings are calculated and adjusted based on changes in average positions. A doubles team playing #1 would have the same position ranking as a #1 singles player and so on.

(3) State tournament victories are assigned the same K-Factor that applies to first tier matches played by position #1 doubles teams with an additional K-Factor assigned to semifinal and final victories.

(4) Doubles matches are divided into the same ranking periods as singles matches.

The K-Factor for doubles is set at 119, which is 3 points below the singles K-Factor. Once again, this is a matter of calculation not of selection.

With the K-Factor set at 119 there are 2,388 doubles upsets and 2,389 predicted upsets for a correlation of 99.96%. Doubles are much more volatile than singles, as approximately 1/3rd of all doubles matches are upsets while less than 1/4th of all singles matches are upsets. The lower K-Factor causes a greater number of doubles matches to be predicted as upsets (see sidenote [*6]) and helps bring the correlation between predicted and actual upsets to nearly 100%.

2.2 The Top Ranked Doubles Teams

Note: All-time rankings are based on the highest year end ranking attained by each doubles team.

The table below shows the top thirty all-time doubles teams (ten match minimum) as determined under the tennis ranking system:

All Teams: 10+

#	Team	School	Rate (10+)	W	L	Doubles %	%Sets	P	State
1	Caldwallader, Leesa - Caldwallader, Sarah	CRK	2662	58	5	92.06	91.43	1	1-1-2-2
2	Callaghan, Katie - Jensen, Hannah	IC West	2622	39	6	86.67	84.93	1	1
3	Curto, Vilsa - Jensen, Lauren	IC West	2573	54	8	87.10	83.52	1	1-4-4
4	Jensen, Hannah - Jensen, Lauren	IC West	2528	14	0	100.00	95.45	1	1
5	Cilek, Emmy - Cilek, Kate	City High	2525	54	10	84.38	83.87	1	1-2-4
6	McGaffigan, Katie - McGaffigan, Laura	Bettendorf	2524	16	0	100.00	100.00	1	1
7	Glynn, Chelsea - Glynn, Kimiko	Valley	2502	9	1	90.00	90.00	1	1
8	Fick, Lynsey - Leese, Courtney	Bettendorf	2500	20	0	100.00	96.88	1	1
9	McConnell, Kelly - Peters, Jane	IC West	2410	55	7	88.71	84.62	2	2-3-6
10	Curto, Carina - Curto, Roxanna	IC West	2405	27	3	90.00	89.74	1	1
11	Noyce, Jamie - Rovner, Becky	Valley	2342	32	7	82.05	80.77	1	2-3-4
12	Takemoto, Beth - Weindruch, Julie	Bettendorf	2338	14	3	82.35	81.82	1	3-5
13	Baker, Andrea - Johnson, Emily	PV	2320	19	4	82.61	81.08	1	3-5
14	Baehr, Hillary - Esbeck, Meredith	Roosevelt	2314	20	1	95.24	92.31	1	2
15	Holland, Kerry - Williams, Laura	CRTJ	2302	20	7	74.07	68.42	2	3
16	Emrick, Amanda - Irey, Jenny	Dav Central	2295	11	7	61.11	62.96	1	2
17	Callaghan, Katie - McConnell, Lyndsay	IC West	2284	8	2	80.00	66.67	1	5
18	Berger, Kelly - Staudt, Genevieve	Dowling	2281	11	6	64.71	64.86	1	3
19	Becker, Melanie - Lindeman, Kendra	CRTJ	2275	19	3	86.36	82.35	1	2-2
20	Funk, Melissa - Leringe, Marika	CRK	2273	17	1	94.44	91.67	1	2
21	Carver, Natalie - Hunt, Meghann	Ames	2269	13	2	86.67	81.25	1	3
22	Allemang, Tash - Funk, Julie	CRK	2269	49	8	85.96	79.57	1	2-3-4
23	Barnes, Jennifer - Takemoto, Beth	Bettendorf	2249	15	2	88.24	85.29	2	5
24	McGaffigan, Laura - Weindruch, Julie	Bettendorf	2235	14	0	100.00	95.45	2	
25	Lalk, Jessica - Ridenour, Minette	CBAL	2232	11	4	73.33	63.64	1	3-8
26	Hupfer, Luyre - Powers, Missy	Clinton	2220	17	4	80.95	76.32	1	5
27	McGaffigan, Chrissie - Searles, Jessie	Bettendorf	2205	9	1	90.00	83.33	1	
28	Qin, Evelyn - Winkleblack, Mandy	Ames	2197	11	2	84.62	84.62	1	5
29	Glynn, Chelsea - Leavenworth, Sarah	Valley	2186	15	4	78.95	79.49	1	
30	Lein, Kathy - Saluri, Heather	Urbandale	2183	13	2	86.67	84.38	1	2

3. SCHOOL RANKINGS

The tennis ranking system does not rank schools in the same way it ranks singles players and doubles teams, by applying the Elo formulas to actual meet results. Instead it builds the school rankings entirely from the singles and doubles rankings. The ranking system treats school meets as the aggregate of the individual matches which make up the meets and ranks schools based on the predicted results of such matches.

3.1 The Hypothetical Meets

The tennis ranking system ranks Cedar Rapids Kennedy, the actual 2007 State champion, as the number one school for 2007. This ranking is not based on any meet played by Cedar Rapids Kennedy, including the actual State championship meet, but is instead calculated on the assumption that every qualifying school plays every other qualifying school (the "hypothetical meets") and realizes a win, loss or tie based on the individual rankings of their respective players and doubles teams. The number one ranked school is then the school that compiles the best overall record from among this group of hypothetical meets.

Players and doubles teams are generally slotted into their positions based on the position most frequently played during the year, but players and doubles teams from schools playing in the school State championship (the final four) are placed in the positions played at the championship. In order to qualifty to be part of the school ranking calculation:

> (1) A school must either be a final four school or have at least six recorded meets and must have at least six players and three doubles teams which meet the requirements of (2) or (3) below, as the case may be;
>
> (2) A player must either be on the final four roster or have at least four recorded matches during the year; and
>
> (3) A doubles team must either be on the final four roster or have at least three recorded doubles matches during the year.

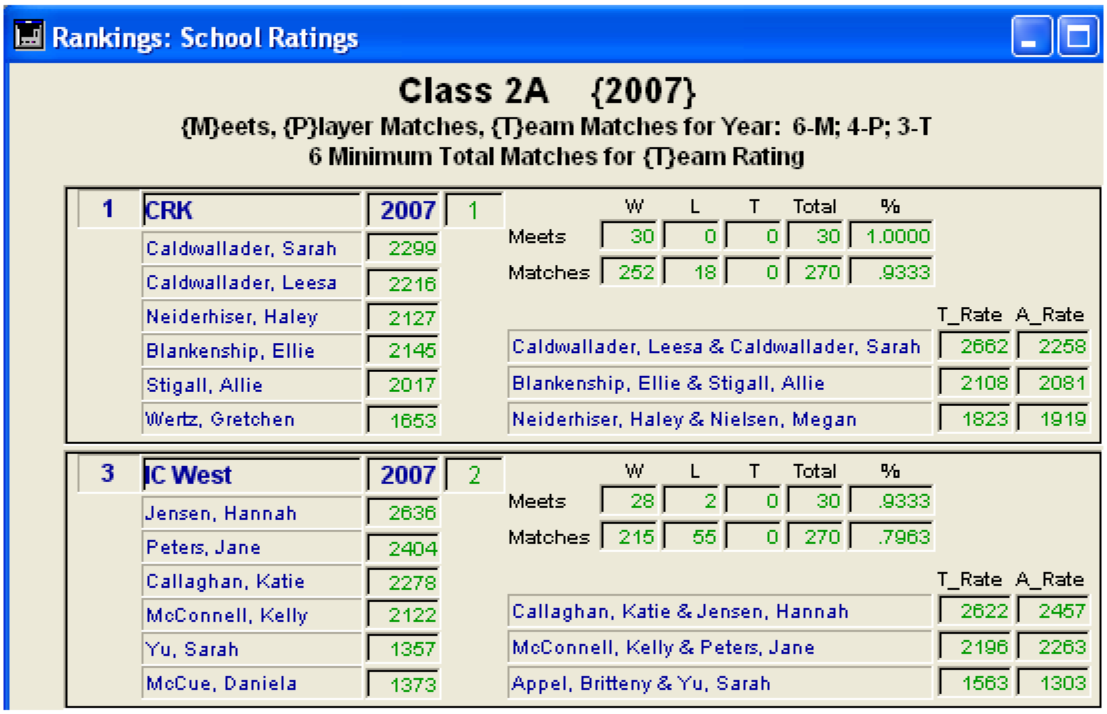
The picture on the next page displays the top six singles players for each of Cedar Rapids Kennedy and Iowa City West, the two schools playing for the 2007 State championship, listed from top to bottom, and the top three doubles teams for the two schools listed in the same order together with the respective rankings of the players and doubles teams. **[*16]** The picture also shows the results for the entire series of hypothetical 2007 meets, with

[*16] The doubles teams have two rankings, a "T_Rate" which is their ranking computed under the ranking system applicable to doubles and outlined in section 2 and an "A_Rate," which is the average of the individual player rankings of the two doubles teammates computed under the ranking system applicable to singles and outlined in section 1. For purposes of the hypothetical meet calculation, the tennis ranking system assumes that a doubles team has a ranking equal to the higher of the two rankings. Doubles teams are not assigned a T_Rate unless they have played at least six matches.

Cedar Rapids Kennedy calculated to win all 30 of its hypothetical meets and 252 of its 270 hypothetical matches and Iowa City West calculated to lose 2 of its hypothetical meets and 55 of its hypothetical matches.

One of Iowa City West's hypothetical losses would occur against Cedar Rapids Kennedy where, based on the end of the year rankings shown below, Kennedy would be a 5-4 winner, losing the first three singles matches and #2 doubles while winning the last three singles matches and #1 and #3 doubles. **[*17]**

[*17] In fact, Kennedy did beat Iowa City West in the State championship final 5-4, offsetting a mild Iowa City West upset at #4 singles, with a larger Kennedy upset at #2 doubles, where Blankenship and Stigall beat the State third place doubles team of McConnell and Peters.



3.2 School Ranking Statistics

The table opposite shows a comparison of the results of the actual State school championships with the end of the year school rankings produced by the ranking system. As shown by the chart, 10 of the 14 actual team champions are ranked number one as of the end of the year **[*18]**, 22 schools, out of the 56 final four schools, are ranked precisely as they finished in the State championships; and 43 schools, out of the same 56 final four schools, are ranked within one spot of their State championship result. **[*19]**

	Ranking System	Total
State Champion	10	14
Accuracy	22	56
+/-1 Accuracy	43	56

[*18] Only three out of the first seven State champions (from 1994 to 2000] are ranked number 1 under the tennis ranking system while all seven of the State champions from 2001 to 2007 are ranked number 1.

[*19] There are approximately 2,400 meets with sufficient rankings at the time the meet is played to predict a winner using the method described in this section. Using the comparative player and doubles teams rankings of the meet participants as of the beginning of the ranking period during which the meet was played would correctly predict the outcome in all but 372 of these meets. This means that approximately 15% of the meet results are upsets. This compares with singles, where approximately 23% of the matches are upsets, and doubles, where approximately 32% of the matches are upsets.

3.3 The Top Ranked Schools

The table immediately below shows the top thirty all-time schools and the table on the next page shows the detail for the top six of these schools:

	School	Year	W	L	T	%	Mtch%	State
1	Bettendorf	1998	392	2	0	.9949	.9712	1
2	IC West	2004	392	2	0	.9949	.9673	1
3	IC West	2005	390	4	0	.9898	.9698	1
4	IC West	2006	390	4	0	.9898	.9509	1
5	Bettendorf	1997	390	4	0	.9898	.9499	1
6	CRK	2007	390	4	0	.9898	.9473	1
7	City High	1998	387	7	0	.9822	.9450	2
8	Valley	2000	386	8	0	.9797	.9502	3
9	Valley	2001	384	10	0	.9746	.9570	1
10	Urbandale	2000	384	10	0	.9746	.9217	2
11	IC West	2007	383	11	0	.9721	.8281	2
12	Bettendorf	2001	381	13	0	.9670	.9353	2
13	Urbandale	2001	380	13	1	.9657	.9034	
14	Bettendorf	1999	380	14	0	.9645	.9333	1
15	Bettendorf	2000	379	15	0	.9619	.9181	1
16	IC West	2003	378	16	0	.9594	.9215	2
17	City High	1999	377	16	1	.9581	.9141	2
18	Ames	2005	376	18	0	.9543	.9199	2
19	Bettendorf	1996	375	19	0	.9518	.9233	1
20	Bettendorf	2003	374	20	0	.9492	.9113	1
21	CRK	2004	374	20	0	.9492	.9083	2
22	City High	1997	371	23	0	.9416	.9067	
23	Ames	2007	370	24	0	.9391	.9146	3
24	CRK	2001	368	26	0	.9340	.9010	3
25	Boone	2007	368	26	0	.9340	.8896	3
26	Urbandale	1999	368	26	0	.9340	.8725	3
27	Valley	1996	367	27	0	.9315	.9067	2
28	Urbandale	2002	367	27	0	.9315	.8658	1
29	CRTJ	2005	367	27	0	.9315	.8488	
30	Bettendorf	2006	365	29	0	.9264	.8766	

Note: Bettendorf (1998) and IC West (2004) have identical hypothetical meet records (392-2), but Bettendorf earns the #1 ranking as a result of a predicted 5-4 victory over IC West.

Note also: The 3-6 teams have identical hypothetical meet records (390-4) and are ranked based on their hypothetical match records.

Rankings: School Ratings

Class 2A {1994-2007}

{M}eets, {P}layer Matches, {T}eam Matches for Year: 6-M; 4-P; 3-T

6 Minimum Total Matches for {T}eam Rating

1 Bettendorf 1998 1

McGaffigan, Jenny	2771
Fick, Lynsey	2676
McGaffigan, Katie	2125
McCoy, Shannon	1919
McCoy, Emmalee	2032
Gierke, Tiana	1783

	W	L	T	Total	%
Meets	392	2	0	394	.9949
Matches	3444	102	0	3546	.9712

Bettendorf v IC West (5-4)	T_Rate	A_Rate
Fick, Lynsey & McGaffigan, Katie	0	2401
Gierke, Tiana & McGaffigan, Jenny	1800	2277
McCoy, Emmalee & McCoy, Shannon	1999	1976

2 IC West 2004 1

Curto, Vilsa	2690
Jensen, Lauren	2205
Jensen, Hannah	2227
Diaz, Diana	2137
Traynelis, Laura	1891
McConnell, Lyndsay	1883

	W	L	T	Total	%
Meets	392	2	0	394	.9949
Matches	3429	115	2	3546	.9673

IC West v Bettendorf (4-5)	T_Rate	A_Rate
Curto, Vilsa & Jensen, Lauren	2573	2448
Diaz, Diana & Jensen, Hannah	1983	2182
Houlahan, Keeley & Raife, Sydney	1809	1834

3 IC West 2005 1

Jensen, Hannah	2565
Callaghan, Katie	2332
McConnell, Lyndsay	2078
Peters, Jane	2041
Raife, Sydney	2013
McConnell, Kelly	1953

	W	L	T	Total	%
Meets	390	4	0	394	.9898
Matches	3439	107	0	3546	.9698

	T_Rate	A_Rate
Callaghan, Katie & Jensen, Hannah	2117	2449
McConnell, Kelly & Peters, Jane	2123	1997
McConnell, Lyndsay & Raife, Sydney	1909	2046

4 IC West 2006 1

Jensen, Hannah	2551
Callaghan, Katie	2306
Peters, Jane	2235
McConnell, Lyndsay	2068
McConnell, Kelly	2085
Yu, Sarah	1666

	W	L	T	Total	%
Meets	390	4	0	394	.9898
Matches	3372	174	0	3546	.9509

	T_Rate	A_Rate
Callaghan, Katie & Jensen, Hannah	2155	2429
McConnell, Kelly & Peters, Jane	2410	2160
McConnell, Lyndsay & McCue, Daniela	1555	1724

5 Bettendorf 1997 1

McGaffigan, Jenny	2585
Fick, Lynsey	2336
Leese, Courtney	2184
Milim, Mary Jo	1960
McCoy, Shannon	1679
McCoy, Emmalee	1962

	W	L	T	Total	%
Meets	390	4	0	394	.9898
Matches	3368	177	1	3546	.9499

	T_Rate	A_Rate
Fick, Lynsey & Leese, Courtney	2500	2260
McGaffigan, Jenny & Milim, Mary Jo	1970	2273
McCoy, Emmalee & McCoy, Shannon	1858	1821

6 CRK 2007 1

Caldwallader, Sarah	2299
Caldwallader, Leesa	2216
Neiderhiser, Haley	2127
Blankenship, Ellie	2145
Stigall, Allie	2017
Wertz, Gretchen	1653

	W	L	T	Total	%
Meets	390	4	0	394	.9898
Matches	3359	187	0	3546	.9473

	T_Rate	A_Rate
Caldwallader, Leesa & Caldwallader, Sarah	2662	2258
Blankenship, Ellie & Stigall, Allie	2108	2081
Neiderhiser, Haley & Nielsen, Megan	1823	1919

4. SUMMARY

The tennis ranking system uses the following methodology:

- Rankings are computed using the two formula approach of the Elo rating system.

- The basic K-Factor is 122 for singles and 119 for doubles teams.

- The K-Factor for players or doubles teams is 1.67 times the basic K-Factor until the player or team has played more than the median number of matches.

- The additional K-Factor for the first tier of matches is adjusted downward if the matches played are at a position other than #1.

- The K-Factor for State tournament victories is also 1.67 times the basic K-Factor (2.50 and 2.84 for semifinal and final victories).

- Players and doubles teams start with different initial rankings based on average positions played and their Elo rankings are adjusted to reflect changes in average position played.

- The ranking point spread between positions is based on the actual percentage of upsets occuring between players and doubles teams with different positions.

- Ranking adjustments are calculated based on the Elo rankings of the opponents as of the beginning of each ranking period.

- The regular season is divided into three ranking periods with an approximately equal number of matches in each period. There is one additional ranking period beginning just before the State singles and doubles team tournaments and one just after the conclusion of the singles and doubles team tournaments.

- Schools are ranked based on the predicted results of the singles and doubles matches between the schools' respective singles players and doubles teams.