STATUS REPORT #6 for the DES MOINES AND RACCOON RIVERS OF IOWA

NITRATE NITROGEN and *ESCHERICHIA COLI*

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Des Moines Water Works

For

Iowa Department of Natural Resources

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WEATHER AND HYDROLOGIC CONDITONS IN THE DES MOINES RIVER WATERSHED, 3rd QUARTER of 2007

Dry conditions prevailed in the upper Raccoon River watershed in July through early August. High groundwater tables from the wet spring sustained the crops through the dry summer. Unusually heavy rain fell in the upper North Raccoon and Des Moines River Watersheds in August with sections receiving more than 12 inches of rain (fig 1). Rainfall in the South Raccoon stayed close to normal. A reverse pattern occurred in September where the North Raccoon received below normal precipitation while the South Raccoon Watershed received above normal precipitation, mostly from a single rain event on September 6 when western parts of the watershed received more than three (3) inches of rain. Overall, rainfall amounts during this quarter where above normal.

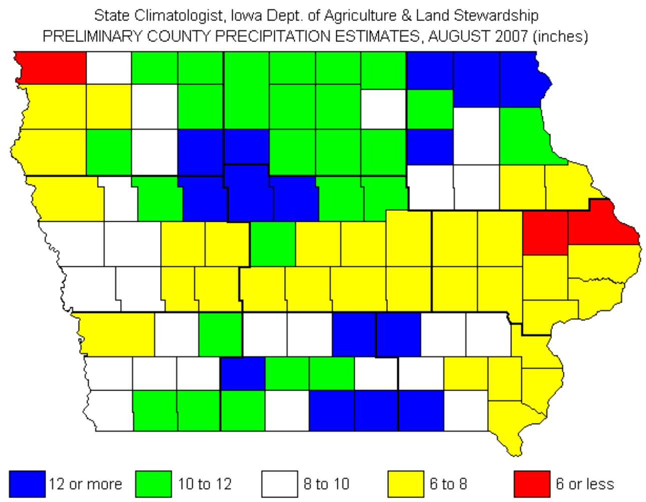

fig 1. August 2007 rainfall distribution

Beaver Creek contribution to flow in the Des Moines River

The late August rainfall in the Beaver Creek watershed resulted in flows well above the 46 year mean. The early September rain on saturated soils created a secondary runoff event. Discharge from Saylorville Lake also increased in late August and slowly decreased throughout the month of May. Flow in the Des Moines River greatly exceeded flow from Beaver Creek throughout this monitoring period. Flow in Beaver Creek is barely discernable on the scale needed for Des Moines River flow (fig 2).

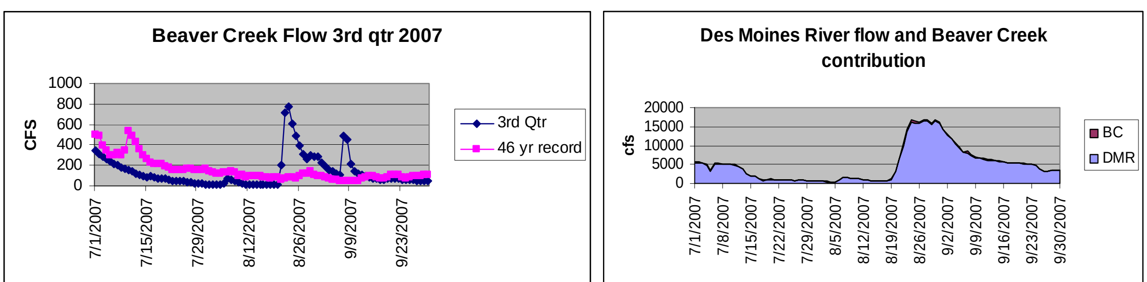

fig 2. Beaver Creek flow during 3rd quarter monitoring

Tributary contributions to flow in the Raccoon River

Walnut Creek

Flow hydrographs in Walnut Creek are very compressed with high flow per unit land area following a rain. This is a function of both small watershed size and high percentage of impervious surfaces in the urban section of the watershed. The large human population within the urban area increases the risk of a large fecal discharge to this stream should the sanitary sewer system fail. The close proximity of Walnut Creek to the DMWW intake and short time of travel accentuates this contribution as fecal loading in Walnut Creek is discharged into the Raccoon River before elevated flow from upstream sources dilutes this contribution. However, this flow pattern was not observed during the 3rd quarter. Flow from the Raccoon River was already elevated due to major rain events in the North Raccoon Watershed. Flow in Walnut Creek barely registers on the scale used for Raccoon River flow (fig 3). Counts would need to be very high to produce a measurable increase in counts in the Raccoon River.

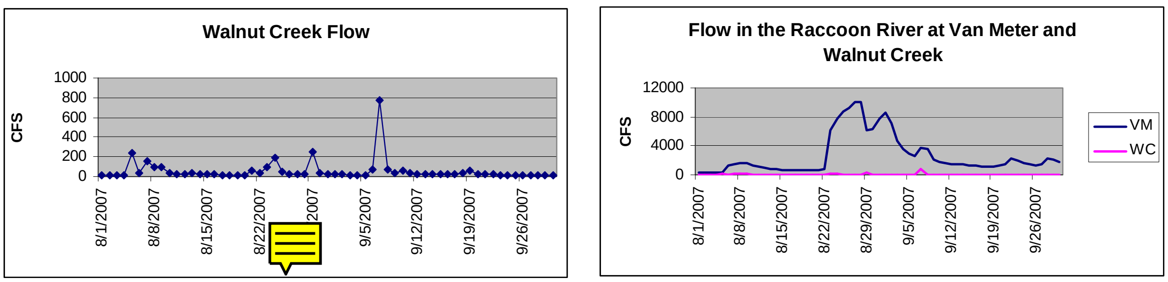

Fig 3. Walnut Creek and Raccoon River flow

North and South Raccoon

Flow contributions from the North Raccoon and South Raccoon varied according to the differences in the rainfall distribution. The North Raccoon exceeded flood stage in late August while the South Raccoon contributed little flow. The flow hydrograph of the Raccoon River at Van Meter closely mirrors the North Raccoon (at Perry) except for the single spike in flow from the South Raccoon (Redfield) on September 7 (fig 4).

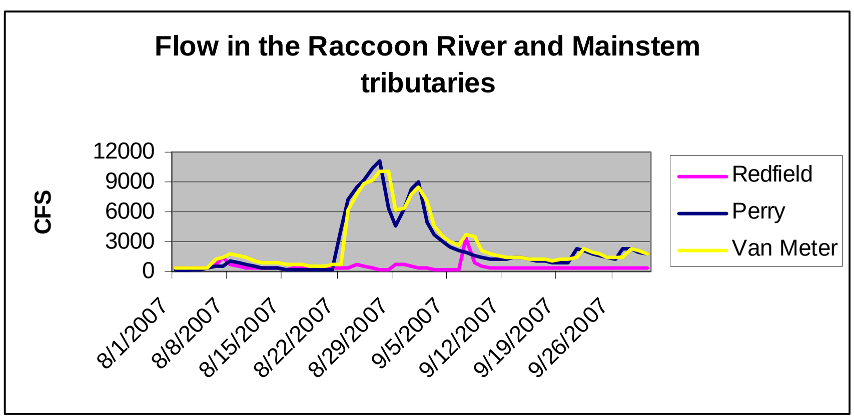

fig 4. Flow hydrographs of the Raccoon River and main-stem tributaries

WATER QUALITY AT THE DES MOINES RIVER INTAKE

Water quality in the Des Moines River at the Des Moines Water Works intake was much more dynamic this quarter than may be expected from its sources. The large storage capacity of Saylorville Lake dampens daily fluctuation in water quality and flow while water in Beaver Creek can change rapidly, especially following a rain event. Therefore rapid changes in water quality at the DMWW intake can usually be attributed to changes in Beaver Creek, such as following a large rain event when it contributes a disproportionately high volume of water to the Des Moines River. This quarter, counts could not be readily explained on the basis of flow contributions. There was a poor correlation between Des Moines River water quality to Beaver Creek flow at the DMWW intake (r^2=0.02, Table 1). This may be due to the relatively low percentage contribution of Beaver Creek to total flow throughout this period, i.e. elevated flow from Beaver Creek occurred during elevated discharge from Saylorville. However, counts spiked several times in mid-July though there was little change in turbidity.

Surface water runoff from the heavy August rainfall diluted chloride concentrations in the Des Moines River from 28.6 mg/l on August 21 to 7.6 mg/l on August 27 when 98% of the flow was from Saylorville Lake. There was little detention time in the reservoir during these high flows, yet counts remained under the water quality standard with one exception.

Table 1. Water Quality in the Des Moines River at the DMWW Intake

Sample Date	E.coli_QT	Turb	Cl	NO3-N	NO2-N	BC flow	DMR flow	% BC flow
07/02/07	34	13.6	23.2	9.8	0.3	334	5,310	5.9
07/03/07		19.5	22.8	9.6	0.3	306	5,240	5.5
07/05/07	36	18.8	23.9	9.5	0.2	264	2,580	9.3
07/06/07	18	17.8	22.9	9.3	0.3	239	5,060	4.5
07/09/07	11	12.0	23.0	8.8	0.3	187	4,910	3.7
07/10/07	7	12.3	23.3	8.9	0.2	178	4,820	3.6
07/11/07	12	12.3	23.3	8.6	0.2	166	4,740	3.4
07/12/07	7	19.8	23.4	8.4	0.2	146	4,530	3.1
07/13/07	16	14.8	23.7	8.3	0.2	137	3,930	3.4
07/16/07	9768	30.3	23.5	6.6	0.2	121	1,370	8.1
07/17/07	108	18.8	24.6	6.5	0.3	114	1,440	7.3
07/18/07	96	16.1	25.6	5.7	0.3	101	598	14.4
07/19/07	1046	20.0	25.7	5.3	0.3	111	630	15.0
07/20/07	53	14.0	29.6	5.9	0.3	109	967	10.1
07/23/07	579	23.9	24.8	5.4	0.4	80	769	9.4
07/24/07	228	28.6	25.9	5.1	0.4	73	749	8.9
07/25/07	83	24.1	27.5	4.0	0.4	73	749	8.9
07/26/07	46	34.6	28.1	3.7	0.5	73	650	10.1
07/27/07	461	32.3	28.1	3.6	0.4	71	663	9.7
07/30/07	51	17.0	27.2	3.7	0.4	57	572	9.1
07/31/07	80	15.6	26.9	3.8	0.4	52	566	8.4
08/01/07	46	28.5				47	566	7.7
08/02/07	38	14.7	28.3	3.7	0.4	41	566	6.8
08/03/07	53	15.1	27.2	3.5	0.4	13	386	3.3
08/06/07	325	15.1	27.5	2.9	0.1	72	247	22.6
08/07/07	308	19.6	26.7	3.2	0.2	64	1,310	4.7
08/08/07	34	10.7	27.2	3.4	0.2	50	1,600	3.0
08/09/07	1203	22.1	26.7	2.9	0.1	51	1,020	4.8
08/10/07	34	13.7	74.8	3.4	0.2	25	1,010	2.4
08/13/07	13	16.0	29.5	2.5	0.1	14	769	1.8

Table 1. Water Quality in the Des Moines River at the DMWW Intake cont.

08/14/07	26	13.8	29.1	2.6	0.1	13	552	2.3
08/15/07	12	13.7	28.9	2.8	0.1	12	552	2.1
08/16/07	15	13.2	29.1	2.4	0.1	12	404	2.9
08/17/07	13	57.0	28.8	2.4	0.1	12	398	2.9
08/20/07	16	15.6	28.4	2.4	0.2	12	1,180	1.0
08/21/07	133	21.0	28.6	2.2	0.3	22	4,020	0.5
08/22/07	127	61.8				642	7,340	8.0
08/23/07	172	111.0	13.3	2.0	0.1	842	11,300	6.9
08/24/07	158	68.1	11.4	2.6	0.1	631	15,000	4.0
08/27/07	108	51.9	7.6	3.6	0.1	319	16,000	2.0
08/28/07	41	37.5	8.6	3.9	0.1	268	15,600	1.7
08/29/07	272	33.5				317	12,800	2.4
08/30/07	22	33.0	9.7	3.7	0.1	260	15,900	1.6
08/31/07	23	25.1	9.3	4.1	0.1	297	16,500	1.8
09/04/07	10	17.6	15.4	4.9	0.1	138	11,000	1.2
09/05/07	4	15.3				120	9,990	1.2
09/06/07	9	15.5				105	8,750	1.2
09/07/07	1990	77.3	12.8	3.9	0.1	372	8,620	4.1
09/10/07	100	13.7	12.5	4.0	0.1	167	6,770	2.4
09/11/07	29	11.8	12.7	3.9	0.1	136	6,710	2.0
09/12/07	23	13.7				108	6,330	1.7
09/13/07	23	13.0	18.5	3.8		93	6,270	1.5
09/14/07	12	17.5	14.6	3.8	0.2	81	6,210	1.3
09/17/07	62	19.3	16.2	3.4	0.3	60	5,610	1.1
09/18/07	15	22.4	17.6	2.5	0.3	56	5,570	1.0
09/19/07	99	19.0				64	5,540	1.1
09/20/07	15	12.0	17.2	3.4	0.4	73	5,450	1.3
09/21/07	6	14.0	17.9	3.4	0.4	70	5,420	1.3
09/24/07	6	15.6	18.3	3.3	0.3	59	5,290	1.1
09/25/07	7	17.0	19.1	3.9	0.3	57	4,650	1.2
09/26/07	7	17.9				55	3,600	1.5
09/27/07	5	17.4	19.3	3.8	0.3	54	3,090	1.7
09/28/07	5	15.7	20.6	4.2	0.3	51	3,600	1.4

Counts this quarter were below the water quality standard 85% of the time. The water quality standard was exceeded most frequently (seven times) between July 1 and August 10 when the probability of recreation contact was highest (fig 5). The source of this contamination cannot be readily explained on the basis of flow alone. Spikes occurred when flow from both sources were receding. Only one small rise in flow

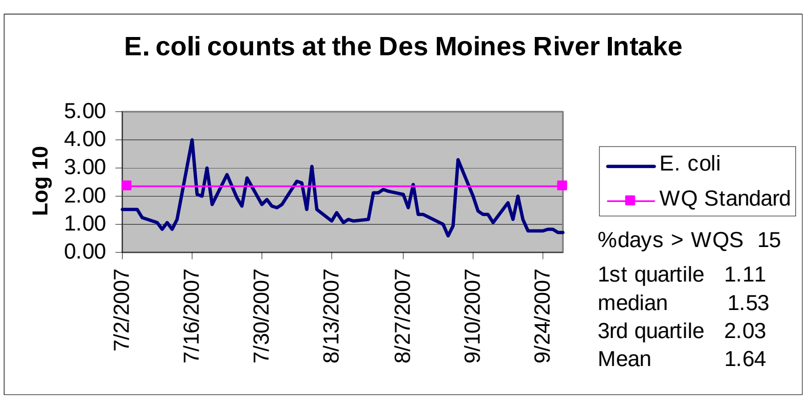

fig5. *E. coli* counts in the Des Moines River at the DMWW intake

(50 CFS) was observed in Beaver Creek during this time period on August 6. The highest counts (9768/100ml) occurred on July 16 when flow in both Beaver Creek and the Des Moines River were declining, indicating no runoff from upstream sources.

Rainfall maps show Des Moines either on the north edge of major cell or within a local shower during each of these spikes. Relatively little rain fell in the Beaver Creek and Des Moines River Watersheds upstream of Des Moines to produce elevated flow. On July 16, a strong local rain cell dumped 0.73 inches of rain in the Des Moines Metropolitan area (fig 6). On July 19 and 23, the Des Moines metro area recorded 0.61 and 0.26 inches of rain respectively. *E. coli* spikes in August also coincided with local rains where 0.64 inches of rain fell on August 4 and 5 and 1.6 inches of rain on August 7 and 8. Much of this rain fell on streets, parking lots and other impervious surfaces upstream of the DMWW intake where it was quickly diverted to storm sewers and discharged into local streams and rivers. The low counts the following day further support the hypothesis of a local source as the primary contributor to *E. coli* on these dates. The location of the collection point on one side of the river conceivably could bias counts. Several storm sewers discharge water into the Des Moines River on the intake side of the river within minutes travel time of the DMWW intake. The samples collected at the intake could be positively biased toward upstream storm sewer discharges on the intake side of the Des Moines River. However, since there was little change in chloride or nitrate concentration, the samples are considered well mixed and representative of Des Moines River water at time of sampling.

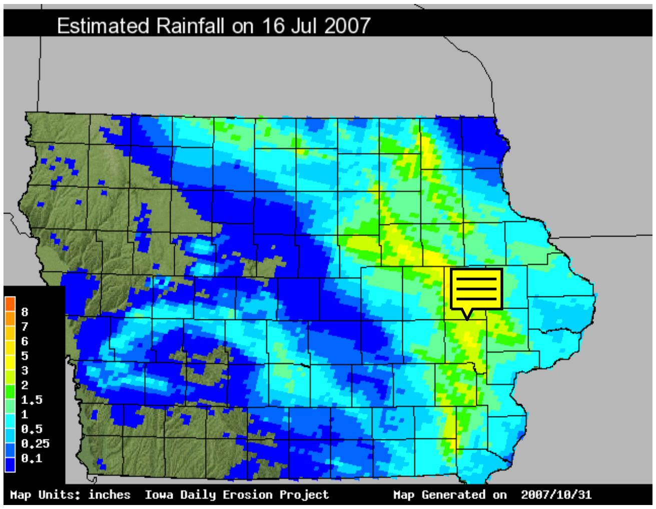

fig 6. Rainfall distribution July 16, 2007

WATER QUALITY AT THE RACCOON RIVER INTAKE

Water quality at the Raccoon River intake is primarily a function of land use and hydrologic contributions in the North and South Raccoon in response to weather conditions in their respective watersheds. Land use determines to a considerable extent the quantity of fecal material deposited on the surface of the landscape while landform and hydrology affect transport of fecal material into streams and continued discharge downstream. The North Raccoon Watershed lies entirely within the glaciated Des Moines Lobe landform. The relatively flat landscape is highly suited to row crop agriculture. There are fewer animal livestock units (141) per square mile than in the South Raccoon Watershed (165) and livestock operations tend toward confinement operations and swine production to maximize production of valuable farm ground. Management requirements for these operations include incorporation which further reduces the amount of fecal material left on the surface while the flat terrain decreases the energy of transport during a rain event. Furthermore, some of the overland flow is trapped in the numerous prairie potholes and subsequently drained by extensive tile systems.

Approximately 50% of the South Raccoon Watershed is located in the Southern Iowa Drift Plain landform which is not recently glaciated. It is highly dissected with relatively steep slopes. A much higher percentage of the land is uncultivated (36.2 % in grasses and woodlands vs. 14.2% for the North Raccoon). Cattle operations are more common which include open feedlots and grazing. Six (6) percent of the land is in permanent pasture compared to 2.9% in the North Raccoon. The landscape is much more subject to runoff and transport of exposed fecal material to streams than in the North Raccoon Watershed. Though unusually heavy rain fell in the North Raccoon Watershed leading to local flooding this quarter while the South Raccoon remained relatively dry, counts in the Raccoon River at the DMWW intake correlated much closer to South Raccoon River flow than North Raccoon River flow ($r^2 = 0.59$ vs. 0.18 respectively). The greatest spike in counts occurred September 7 when flow from the South Raccoon was nearly twice that of the North Raccoon and flow from Walnut Creek nearly equaled the North Raccoon.

A careful examination of flow in Walnut Creek and the 63rd street gauging station just upstream of Walnut Creek in Des Moines show a sharp rise in flow on the same dates as the apparent anomalies at the Des Moines River intake (July 16, Aug 7, 9, 29, Sept 7, 19) (Table 2). These exceptions can be attributed to the same rain events as seen on the rainfall distribution maps (July 19, 23, 26). These showers would produce runoff from impervious surfaces but contribute little to flow at the gauging stations (e.g. July 23, 2007). Every rise in counts occurred during a rain event somewhere within the watershed. Flow from local rainfall events are best evidenced by increased flow in Walnut Creek. Runoff from local rain is not necessarily observed at Raccoon River gauging stations upstream (e.g. July 23, 2007).

Table 2. Raccoon River and Tributary Flow to Water Quality at the DMWW Intake

	CFS	**CFS**	**CFS**	**CFS**	**CFS**	***E. coli***	**Cl**
Date	**NR**	**SR**	**VM**	**63rd St**	**WC**	**DMWW**	**DMWW**
07/01/07	593	765	1,270	2,210	66		
07/02/07	550	765	1,190	2,110	61	86	22.5
07/03/07	495	720	1,110	2,040	62	0	22.4
07/04/07	474	739	1,090	1,990	66		
07/05/07	455	720	1,060	1,910	55	119	22.0
07/06/07	442	612	973	1,770	50	266	22.1
07/07/07	420	578	932	1,690	49		
07/08/07	387	552	891	1,580	45		
07/09/07	330	525	825	1,460	43	37	23.2
07/10/07	322	635	825	1,280	39	55	24.2
07/11/07	287	520	761	1,210	37	59	22.2
07/12/07	267	440	670	999	39	28	21.1
07/14/07	211	399	602	797	33		

Table 2. Raccoon River and Tributary Flow to Water Quality at the DMWW Intake cont.

07/15/07	197	390	568	747	31		
07/16/07	199	395	568	1,020	434	5500	15.4
07/17/07	180	408	613	706	59	256	23.4
07/18/07	161	377	553	675	39	108	23.2
07/19/07	163	382	527	660	M	1986	22.1
07/20/07	180	431	527	595	M	49	22.1
07/21/07	189	386	516	638	34		
07/22/07	170	352	506	588	33		
07/23/07	148	340	486	555	54	2310	21.8
07/24/07	246	450	491	581	40	105	24.1
07/25/07	146	422	591	691	33	102	22.4
07/26/07	131	356	481	574	28	53	21.5
07/27/07	121	382	476	541	M	1733	22.1
07/28/07	100	552	542	515	M		
07/29/07	103	373	476	595	M		
07/30/07	97	316	418	455	M	30	21.1
07/31/07	91	305	373	402	24	26	22.9
08/01/07	89	293	364	382	23		
08/02/07	85	297	364	365	22	22	23.8
08/03/07	127	272	335	356	22	6	24.1
08/04/07	121	265	322	318	21		
08/05/07	265	386	373	337	43		
08/06/07	505	791	1,310	1,200	62	816	23.2
08/07/07	509	1,360	1,430	1,920	285	2750	15.5
08/08/07	1,033	758	1,680	2,320	71	2200	13.0
08/09/07	933	561	1,650	2,060	171	6131	17.1
08/10/07	689	418	1,350	1,860	54	1139	23.4
08/11/07	519	356	1,120	1,390	39		
08/12/07	426	328	959	1,070	35		
08/13/07	347	328	857	902	77	2092	20.4
08/14/07	300	320	857	912	44	104	21.5
08/15/07	262	258	688	699	40	249	20.2
08/16/07	244	272	647	574	34	89	22.0
08/17/07	211	272	624	541	34	63	22.7
08/18/07	204	265	591	502	31		
08/19/07	204	265	586	465	30		
08/20/07	211	279	575	465	28	41	23.6
08/21/07	199	290	630	554	M	2920	22.3
08/22/07	4,292	373	743	490	37	132	
08/23/07	7,220	395	6,140	5,020	M	116	13.8
08/24/07	8,383	677	7,750	7,380	M	693	6.9
08/25/07	9,216	459	8,780	8,780	90		
08/26/07	10,393	328	9,250	9,410	53		
08/27/07	11,047	244	10,100	10,201	42	345	9.1
08/28/07	6,430	203	10,101	11,100	38	387	10.9

Table 2. Raccoon River and Tributary Flow to Water Quality at the DMWW Intake cont.

08/29/07	4,606	618	6,140	7,240	407	1281	
08/30/07	6,430	677	6,280	6,720	70	8164	11.2
08/31/07	8,266	530	7,730	7,490	49	4352	11.8
09/01/07	8,924	348	8,520	8,760	41		
09/02/07	4,853	275	7,130	8,900	38		
09/03/07	3,671	251	4,660	5,360	34		
09/04/07	2,943	244	3,600	4,370	33	199	14.9
09/05/07	2,440	215	2,960	3,780	31	249	
09/06/07	2,081	209	2,590	3,280	30	204	
09/07/07	1,859	3,440	3,710	4,530	1,160	8650	15.1
09/08/07	1,653	937	3,590	6,550	123		
09/09/07	1,459	455	2,170	3,800	71		
09/10/07	1,314	356	1,740	3,160	57	520	15.5
09/11/07	1,226	356	1,560	2,850	66	261	16.5
09/12/07	1,253	290	1,380	2,660	50	150	
09/13/07	1,465	328	1,470	2,500	24	116	13.5
09/14/07	1,337	308	1,470	2,590	21	65	19.2
09/15/07	1,204	290	1,300	2,430	18		
09/16/07	1,081	279	1,220	2,300	19		
09/17/07	1,010	290	1,160	2,190	18	62	21.2
09/18/07	946	297	1,120	2,090	17	62	20.8
09/19/07	941	408	1,160	2,130	70	1986	
09/20/07	916	408	1,270	2,370	26	548	19.9
09/21/07	2,293	336	1,400	2,150	21	2419	20.1
09/22/07	2,047	336	2,220	3,260	20		
09/23/07	1,742	312	1,910	3,080	18		
09/24/07	1,520	305	1,680	2,780	16	1120	18.1
09/25/07	1,325	297	1,490	2,560	17	731	19.7
09/26/07	1,286	305	1,350	2,390	17	334	
09/27/07	2,236	286	1,410	2,310	16	141	20.8
09/28/07	2,373	297	2,330	3,130	15	548	21.1
09/29/07	1,972	290	2,090	3,260	13		
09/30/07	1,691	282	1,780	2,960	13		

Load contribution of these sources to *E. coli* in the Des Moines and Raccoon River is difficult to quantify. It is virtually impossible to establish any grab sample as representative of the stream during a rain event since counts vary considerably across the flow hydrograph as evidenced by automated ISCO samplers. Nonetheless, grab samples and event-triggered automated ISCO samplers supported observations based on flow and rainfall distribution data.

WATERSHED CONTRIBUTIONS

Beaver Creek:

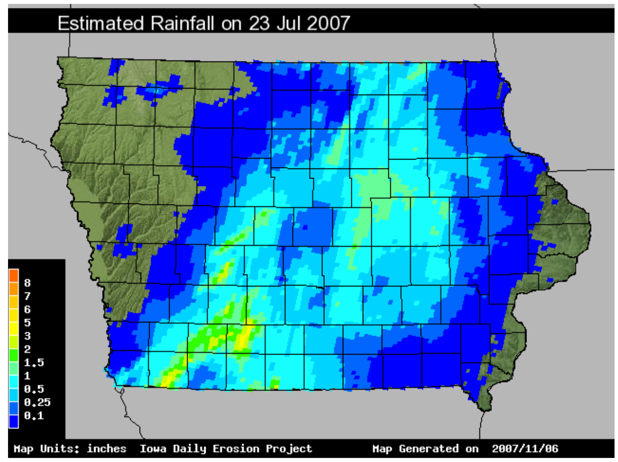

Fig 7. Rainfall distribution on July 23, 2007

High counts occurred throughout the Beaver Creek watershed on July 23. The rainfall distribution map (fig 7) shows light rain throughout the watershed but flow remained below normal and there was no increase in flow at the Beaver Creek gauging station. Contributions from two point sources are readily apparent from the elevated chloride and phosphorus concentrations at sites BC09 and BC11B, but otherwise flow and water chemistry is typical of rural non-point sources (Table 3). This suggests limited runoff from highly contaminated and impervious surfaces such as from open feedlots. Light rain on the dry vegetated fields would be retained and contribute little toward runoff or flow in Beaver Creek. Counts near the mouth of the stream, however, were much lower (970cfu/100ml). This may have been a function of when the sample was collected, i.e. before upstream contamination arrived. Light rain on August 6 produced only slightly elevated counts in Beaver Creek as determined by the automated ISCO sampler where the highest count was 630cfu/100ml. Count density higher in the watershed is unknown. Samples collected by the automated sampler during the late August rain event show unusual characteristics that do not match the usual pattern associated with surface runoff. Chloride concentrations dropped from 27.2 mg/l on August 9 to 5.5 mg/l on the leading edge of the hydrograph on August 22, indicating considerable dilution from surface runoff. Turbidity, however, was much lower than would be expected when surface runoff dominates stream flow. Turbidity values remained rather constant as did o-phosphorus. Counts, however, continued to rise on the descending limb of the hydrograph. This suggests a high count contribution from the upper part of the watershed with its greater time of travel to the sample site. More data is needed to determine whether this is a consistent pattern for this watershed or the result of unusual circumstances.

Table 3. Water Quality in the Beaver Creek Watershed

Sample Date	Client Id	Chloride	*E. coli*	Nitrate as N	Nitrite as N	Phosphorus-O as P	Turbidity
7/12/2007	BC04	22.30	197	9.99			15.1
7/23/2007	BC04	23.76	970	3.96	#VALUE!		17.1
	BC09	70.67	850	6.91	0.06	0.63	11.9
	BC10	23.22	100	4.59	0.05		10.9
	BC10A	17.79	740	7.11	0.06		8.48
	BC10B	16.73	740	7.32	0.10		10.4
	BC11	25.77	9330	3.88	0.10		21.7
	BC11A	23.49	7330	4.67	0.09		19.6

Table 3. Water Quality in the Beaver Creek Watershed cont.

	BC11B	69.13	3640	5.84	0.13	0.20	25
	BC11C	23.20	1460	2.07	0.07		24.5
	BC12	14.66	9880	1.58	0.08		22.2
	BC20	21.22	9090	8.81	0.08		29
	BC19	22.20	20140	6.86	0.10		62.6
	BC14	23.31	480	2.98	0.07		26.2
	BC13	20.38	11985	3.80	0.08		28.1
7/26/2007	BC04	23.64	300	2.75			12
8/6/2007	BC04-01	25.14	200	0.34			48.2
	BC04-02						39.1
	BC04-03	23.52	100	0.23			49.4
	BC04-04						36.7
	BC04-05						91.3
	BC04-06	21.75		0.80		0.16	32.1
	BC04-07						83
	BC04-08						32.4
	BC04-09	21.04	630	0.52			35.8
	BC04-10						90.4
	BC04-11		300				32.8
8/7/2007	BC04-12						36.7
	BC04-13	19.55	310	0.80			40.8
	BC04-14						32.4
	BC04-15						41.9
	BC04-16						38.3
	BC04-17	22.81	410	1.24		0.18	39.6
	BC04-18						29.5
	BC04-19						33.5
	BC04-20						33.1
	BC04-21	19.59		1.22		0.10	30.6
8/9/2007	BC04	27.20		2.51		0.21	45
8/22/2007	BC-01	5.51	310	1.70		0.19	110
8/23/2007	BC04	6.30	410	2.68		0.26	109
	BC-05	5.55	410	2.41		0.24	130
	BC-11	6.94	1190	2.52		0.27	111
8/24/2007	BC-17	7.68	1430	2.53		0.22	117
	BC-23	9.16	2560	2.72		0.22	119

Raccoon River and tributaries:

Walnut Creek

A storm sewer study was initiated this quarter at several points along Walnut Creek near its discharge to the Raccoon River. Samples were collected from storm sewers and receiving points on Walnut Creek either during or shortly following a rain event (Table 4). Storm sewer samples include an “SS” id in the site name.

Table 4. Walnut Creek Water Quality and Storm Sewer Discharges

Sample Date	Creek Name	Client Id	Chloride	*E. coli*	Nitrate as N	Total Coliform	Turbidity
07/12/07	Walnut Creek	70	18.98	2638	12.90		21.2
07/16/07	North Walnut Creek	WCr3	36.40	5470	2.80	241920	
		WCrSS6	36.60	5910	2.80	241920	
		WCrSS7	13.60	173290	0.50		
		WCr6	36.60	3790	2.80	241920	
07/23/07	North Walnut Creek	WCr3	14.40	11530	0.90		
		WCrSS6	39.40	7660	1.40		
		WCrSS7	21.50	46110	0.40		
		WCr6	39.10	3930	1.40		
		WCrSS6a	7.00	8570	0.64		
		WCrSS5	31.40	11980	1.20		
07/26/07	Walnut Creek	70	20.06	1080	3.52	34480	25
08/09/07	Walnut Creek	70	22.79	1220	1.36	43600	68.7
08/23/07	Walnut Creek	70	23.77	410	0.25	72700	49.8
09/24/07	North Walnut Creek	40A	81.98	1658	0.67	14136	1.66
		NWC2	78.20	256	1.07	24192	2.05
		NWC3	74.04	231	0.79	15531	3.16
		NWC1	64.55	472	0.73	19863	4.01

E. coli counts from the rural headwaters (Site 70) exceeded the water quality standard during each of the four sampling events. The August samples likely included limited runoff based on the rainfall distribution maps and slightly elevated turbidity that did not result in elevated counts. Samples from the urban North Walnut Creek collected 9/24/07 were slightly above the water quality standard even though turbidity was very low. During the July 16 and July 23 rain events, counts in the storm sewers were high, ranging from 5910 to 173290 counts/100ml, and consistently exceeded counts in the receiving stream. At least some of the elevated counts observed in urban streams can be attributed to storm sewer discharges during rain events. The source of the *E. coli* in the storm sewers is not known and is still under investigation. It should be noted however that fecal material deposited in storm sewers will not be trapped or retained by vegetation. Therefore higher counts may be a function of suspension and transport rather than higher density of fecal material.

<u>Main-stem tributaries</u>

E. coli counts at the mouth of the South Raccoon near Van Meter (site 37) are considerably higher than in the North Raccoon (site A) despite the heavy rain in the North Raccoon Watershed in late August (Table 5). Counts in the Middle Raccoon tributary are similar to the North Raccoon but without the high maximum values. Most of the Middle Raccoon watershed lies within the Des Moines lobe landform and therefore has similar hydrology as the North Raccoon. Lake Panorama stabilizes some of the upstream loading and attenuates spikes from upstream sources (note the consistently low turbidity). Counts in the South fork of the South Raccoon (site 32) are much higher than that of the Middle Raccoon (site 31). The elevated counts observed in the South Raccoon near Van Meter (site 37) can therefore be attributed to the South Fork of the South Raccoon.

Table 5. *E. coli* Counts and Turbidity in the Main-stem Tributaries

	E. coli				Turbidity			
Sample Date	A	37	32	31	A	37	32	31
07/12/07	41	146	419	173	28.3	45.2	61.6	28.4
07/17/07	200	100	100	100	35	24.3	43.5	27.6
07/26/07			1580		39.1	27.9	86	19.3
07/31/07	100	200	520	200	60.5	22.5	68.8	16.1
08/09/07	1080	8800	7030	630	118	274	190	30.3
08/15/07	85		1560	278	35.7		479	39.5
08/21/07	4220	9050	980	2920	48.1	26.2	17.3	19.7
08/23/07	2590	9600	5040	740	246	22.7	101	22.1
09/11/07	122	1067	1529	677	16.6	59.7	66.2	21.4
09/24/07	195	723			42.6	32		
first quartile	100	186.5	520	193	35.2	24.3	61.6	19.7
Median	161	1067	1529	454	39.1	27.1	68.8	22.1
third quartile	1458	8925	1580	693	60.5	48.8	101.0	28.4

Counts in the South Raccoon are generally higher than counts in the Middle and North Raccoon. Within the South Raccoon Watershed, Brushy Creek had the highest counts. It also had the lowest counts during low flow (April 18, 2007). Both high and low counts are consistent with streams which have more extremes in flow. During low flow, *E. coli* settles into the numerous sedimentation pools leaving lower counts downstream. This reservoir of *E. coli* slowly accumulates during low flow and is re-suspended during increased flow. *E. coli* counts in the sediments of sites 42A and 42B2 in October 2006 likely increased during the relatively extended dry period in October while the high flow in late April 2007 likely flushed much of the accumulated sediment downstream before the May, 2007 sediment sampling. The substrate in May had a gritty texture suggesting silt and fine sand compared to the mucoid, hydrophilic sediments during the November sampling. The organic content (loss on ignition) was also much lower in the 05/01/07 samples. The larger particle size is also less supportive of *E. coli* survival rates.

<u>Sub-watershed water quality</u>

Most of the sampling was conducted in the South fork of the South Raccoon Watershed. There are many small streams within this area (highly dissected landform) with high *E. coli* counts throughout this watershed. Brushy Creek is the largest tributary of this branch and therefore has a dominant impact on water quality in the South Raccoon at site 32. The South Raccoon just upstream of the Brushy Creek confluence was very similar to the discharge from Brushy Creek. Therefore, additional sites were sampled this quarter on the South Raccoon upstream of Brushy Creek to determine whether *E. coli* counts increased upstream on the South Raccoon as well (Table 6).

Table 6. *E. coli* Counts in Brushy Creek and the South Raccoon

Sample Date	Brushy Creek outlet (site 28)	South Raccoon (site 28A)	28A1	28A2	28AC
07/12/07	350	1019			
07/17/07	410	410			
07/26/07	2620	2030			
07/31/07	2880	1220			
08/09/07	2280	6200			
08/15/07	384	1014			
08/21/07	17890	30760			
08/23/07	41060	34480			
09/11/07	1281	1785	233	220	842
09/18/07	1017	985	336		

No specific sources for high fecal contamination in the South Raccoon were apparent from the single round of upstream sampling. Only one small open feedlot operation and approximately seven confinement operations are identified in the IDNR interactive mapping. Manure from confinement operations is to be incorporated, so if properly managed, these would not be contributing to high counts. The watershed terrain is typical for a Southern Iowa Drift Plain (SIDP). Samples collected from upstream tributaries were less than the outlet site. Additional sampling is being conducted to determine source(s) and cause of the high counts at the outlet. What should be considered normal or achievable in this landform is uncertain as there are very limited areas without anthropogenic sources of contamination. Sampling of streams in the White Rock Conservancy area along the Middle Raccoon may elucidate what to consider normal environmental background contamination.

Brushy Creek

Previous sampling showed exceptionally high counts in upper Brushy Creek during runoff events. Benthic analyses in the sedimentation basins indicated a large quantity of fecal contaminated sediments which may have contributed to high counts by re-suspension during accelerated flow during runoff. Several open feedlot operations within the area did not have adequate manure containment structures so that fecal material flowed into Brushy Creek during runoff events. This occurred in late December of 2005 which resulted in a fish kill that was investigated by the IDNR. It is probable that without the containment structures, manure runoff occurred during many previous rain events and contributed to high counts in the South Raccoon. Enforcement action included installation of manure containment structures to reduce manure runoff and loading to Brushy Creek. Most, if not all, required structures are now installed.

Counts this summer (table 7) were not as high as last summer when counts exceeded 241020 following a rain event. This could be due to the relatively dry conditions in this watershed during the summer, but there are multiple indicators of some improvement in this stream. The sites reported in this table are a subset of sites investigated. These were selected as they provide better comparative data, i.e. sampled on a more regular basis and on the same dates.

Table 7. *E. coli* and Turbidity in the Brushy Creek Watershed

Sites	28	(Outlet)	43	Dedham	42BA	Halbur Creek	42B2.5	Upper Brushy
Sample Date	*E. coli*	Turbidity	*E. coli*	Turbidity	*E. coli*	Turbidity	*E. coli*	Turbidity
07/12/07	350	65.6	794	33.5				
07/17/07	410	66.7	1580	23.0	2230	5.9	2810	18.9
07/26/07	2620	51.4	1100	31.5				
07/31/07	2880	40.8	100	11.8	310	5.0	410	7.1
08/09/07	2280	47.1	8130	42.6				
08/15/07	384	18.0	862	7.9	2809	15.3	1223	7.6
08/21/07	17890	21.5	4960	16.3	13360	4.7	16740	4.4
08/23/07	41060	28.1	13330	61.2				
09/11/07	1281	22.7	269	4.2	2613	6.4	565	3.7
09/18/07	1017	13.8			19863	14.2	1782	5.0
Average	7017	37.6	3458	25.8	6864	8.6	3922	7.8

<u>Sediment analyses:</u>

Site 42B2 sediments again had the highest indicators of fecal contamination (*E. coli*, and ammonia) as well as volatile solids and total phosphorus (table 8). These numbers, however, are much lower than last fall when *E. coli* counts/100ml and % volatile solids (VS) were 11199000 and 9.2 respectively. Site 42A, also from pool sediments further downstream, had much lower indicators of fecal contamination than site 42B2 and much lower values than what was observed during Fall (2006), when *E. coli* counts and % VS were 4611000 and 9.5 respectively.

Table 8. South Raccoon Sediment Analyses

Sample Date	Site Id	Ammonia as N	*E. coli*	Total Solids	Turbidity	Volatile Solids	Phosphorus-T as P
09/18/07	28A1	47.1	261300	56.8	200000	4.6	545
	42A	3.19	123600	66.2	26000	3.6	128
	42B2	219.4	1413600	57.8	120000	7	557
	50	42.3	325500	70.8	45000	1.26	275

Sediments in the South Raccoon and Brushy Creek (sites 28A1 and 50) were similar in both *E. coli* abundance and ammonia content. The sediment texture at site 28A1, however, contained qualitatively higher clay content than Brushy Creek site 50. *E. coli* counts in site 50 sediments were much lower than last fall as well suggesting less transport downstream.

Both pool and stream sediments indicate a smaller reservoir of *E. coli* that can be re-suspended during elevated flow. The lower concentration of *E. coli* in the sediments also suggests a lower flux of *E. coli* from the stream to the sediments during low flow.

DISCUSSION AND SUMMARY

E. coli is ubiquitous in much of the Raccoon and Des Moines River watersheds, and its concentration within streams is the product of many factors. The study has been examining sources, transport, and fate of *E. coli* within watersheds to better understand the dynamics in *E. coli* counts observed in the Des Moines and Raccoon River at the Des Moines Water Works intake locations. The relative contribution of these factors is highly dynamic and differs according to landscape. In previous reports, an increase in *E. coli* could be linked to a runoff event as evidenced by increased flow from an upstream tributary. This linkage was not nearly as apparent during the Fall of 2007. However, rainfall distribution maps showed that every increase in *E. coli* counts occurred during a rainfall event within the local watershed where elevated *E. coli* was observed. This was especially true for urban streams that have a large percentage of impervious surfaces and their contributions to mainstem flow at gauging stations are often masked by the magnitude of flow in the mainstem rivers.

The South Raccoon continues to be the primary source of *E. coli* in the Raccoon River as evidenced by the relationship of South Raccoon flow to *E. coli* in the Raccoon River. This was somewhat unexpected as the North Raccoon Watershed received much more rain than did the South Raccoon. Differences in transport appear to be the primary reason for the differences observed in these two watersheds.

The decrease in *E. coli* and other fecal indicators in the stream and sediments of upper Brushy Creek indicate some reduction in fecal contributions. This is consistent with the manure containment structures that have been installed in this region of the watershed. Since the South Raccoon Watershed is more subject to runoff than the North Raccoon, containment structures will provide greater benefit to water quality in the South Raccoon watershed than in the North Raccoon.

<u>Activities next quarter:</u>

Variability in *E. coli* counts during base flow is difficult to interpret and raises several questions:

1. Are the samples representative?
2. How uniform is the distribution of E. coli within a stream?
3. How much does it vary through time?
4. What numeric resolution should be expected by the method?
5. Can fresh fecal matter deposited directly into a stream cause the variations observed in the stream?

ISCO samplers have been programmed to composite three samples every half hour over a 24 hour period during base flow at three different locations. This is designed to test the relationship between unrestricted access of cattle to streams and variability in E. coli counts associated with cattle activity. In conjunction with this, pats of bovine feces have been collected to determine the potential contribution of direct defecation into a stream and the influence of sediment particles on mortality rate and transport.