Ground Penetrating Carbon, Inc.

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GPC FILTER PROCESS

The patented GPC Filter Process is an additional add-on treatment process that can be installed at small scale wastewater treatment facilities, usually less than 100,000 gallons per day. The GPC Filter Process is positioned after the denitrification step and can be placed in-line, or as a soil absorption system. This innovative technology ensures wastewater treatment systems discharge higher quality water, meeting not only traditional standards, but also reducing Contaminants of Emerging Concern. As far as traditional measurements of the quality of final effluent, when a GPC Filter Process is added to a wastewater treatment system, the final effluent will have concentrations of 5 Day Biochemical Oxygen Demand (BOD_5) and concentrations of Total Suspended Solids (TSS) near detection level. The GPC Filter Process will reduce already low dissolved concentrations of Total Nitrogen by about half for each time the water is dosed. Finally, the GPC Filter Process will reduce trace concentrations of most organic Contaminants of Emerging Concern, also called Pharmaceuticals and Personal Care Products. The reduction of most organic Contaminants of Emerging Concern through the GPC Filter Process is almost always better than the reduction seen in other traditional wastewater treatment systems.

This memorandum describes how the process works and presents an analysis of test data from samples of the final effluent of a wastewater treatment system with an installed GPC Filter Process. The GPC Filter is a specially modified and stratified sand filter that mimics natural soil formation. A special proprietary liquid carbon is mixed with the denitrified effluent and then dosed onto the GPC Filter. The GPC Filter Process relies on the enhanced population of soil bacteria and other soil micro-organisms to further treat the fluid.

The GPC Filter Process was developed at a wastewater treatment facility in Mill Pond Village in Yarmouth, Massachusetts. With the GPC Filter Process operational, composite samples of the final effluent were collected weekly by a wastewater treatment plant operator from a sampling point prior to discharge into the soil absorption system. The results from the tests for the time period of May 13, 2011 through October 31, 2014 (almost three and a half years) are as follows:

Mill Pond Village
Final Effluent (composite samples)

	BOD_5 (mg/L)		TSS (mg/L)		TN (mg/L)		NO_3 (mg/L)
Average	3.1		2.3		5.1		4.5
Total Tests	181		181		181		181
Non-Conformities	0		3		13		7
Total Over Detection	6		23		n/a		n/a
Detection Level	3		3				
Total Below Detection level	175		158				
Percent Compliant	100%		98%		92%		96%
Median	3.0		1.5		4.2		3.5
High	13.7		14.0		23.1		22.2
Low	3.0		1.5		0.8		0.4

TN DENOTES Total Nitrogen

There are only a few wastewater treatment systems that can consistently discharge final effluent

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with the concentrations of BOD_5 and TSS below detection level. The chart shows 13 non-conforming tests for Total Nitrogen and 7 non-conforming tests for Nitrate (NO_3), out of 181 sampling events. The non-conforming Total Nitrogen and NO_3 concentrations occurred when the upstream system discharged elevated concentrations of dissolved nitrogen. The raw influent entering the wastewater treatment system is sampled on a monthly basis. The difference between the Total Nitrogen concentrations of the raw wastewater compared to the Total Nitrogen concentrations of the final effluent indicates that the entire wastewater treatment system has removed about an average of 95% of the dissolved Total Nitrogen. The GPC Filter removed about half of the already reduced concentrations of Total Nitrogen in denitrified water that passed through the GPC Filter Process.

We tested the GPC Process at a second treatment system with a GPC Filter serving an assisted living facility in Falmouth, Massachusetts. The effluent is tested monthly. The results of the tests confirm the excellent removal of BOD_5 and TSS by the GPC Process. A chart of the test results is below:

Falmouth MA **From 09/23/13 to 11/20/14**
Final Effluent (composite sample)

	Daily Flow	BOD_5 (mg/L)	TSS (mg/L)	TN (mg/L)	NO_3 (mg/L)
Discharge Limit	39,750 gpd	30	30	10	10
Average	11,938 gpd	3.0	2.4	6.1	4.8
Median	11,704 gpd	3.0	1.5	5.8	4.6
Detection Level		3.0	1.5		0.05
Count		15	15	15	15
Non-Conformities	n/a	0	0	1	1
Conforming	n/a	100%	100%	93%	93%

TN denotes Total Nitrogen

This system also had final effluent with concentrations of BOD_5 and TSS approaching Detection Level. The non-conformity of Total Nitrogen at this facility was in the first month of operation.

In October and November of 2014, at the Mill Pond Village wastewater treatment system, grab samples were taken to test for the presence of Contaminants of Emerging Concern from sample ports placed before and after the GPC Filter. These samples were taken and shipped to Eurofins Eaton Analytical Laboratories (Eurofins) for analysis of a Broad Spectrum Sweep of Pharmaceuticals and Personal Care Products. The ultraviolet light was disabled when the samples were drawn, so only the reduction capability of the GPC Filter Process was analyzed. Eurofins performed a suite of testing for 95 Pharmaceuticals and Personal Care Products. However, the wastewater generated at Mill Pond Village only serves 60 houses. As such, the presence of the Pharmaceuticals and Personal Care Products will vary in time as the people in the houses ingest and excrete certain pharmaceuticals. In larger flows of wastewater, such as in the wastewater at a municipal system, there will most likely be more consistent and higher loading of pharmaceuticals and indeed, most likely, different pharmaceuticals than in the Mill Pond Village wastewater.

The analysis by Eurofins of these Contaminants of Emerging Concern are reported in one parts per trillion. Since this concentration value is so low, there may be times when the reported result of a test of a

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particular chemical or analyte will vary from sample to sample, even from the same water. The rate of reduction for the different chemicals or analytes cannot be assessed until there are a multitude of tests.

Rather than discuss the reduction results on all 95 Contaminants of Emerging Concern tested, we will focus on the reduction observed for certain Contaminants of Emerging Concern always found in the first three rounds of testing in the influent of the GPC Filter Process. However, there are now five rounds of tests of Contaminants of Emerging Concern. There were six pharmaceuticals and seven household chemicals always found in the influent of the GPC Filter Process in the first three rounds of tests. For this selected list, we will report an average reduction rate for each Contaminant of Emerging Concern found in the five rounds as the average difference between the average concentrations of the influent concentration values compared to the average concentration of the effluent concentration values. The reduction rate for a particular Contaminant of Emerging Concern in a single sample event will vary because the Minimum Reporting Level for some Contaminants of Emerging Concern is a significant portion of the concentration reported.

The Chart of Contaminants of Emerging Concern Chemicals Reduced through the GPC Filter Process

All analytes concentration in ng/l

	Samples taken	9-Oct 2014		11 Nov 2014		9-Sep 2015		23-Dec 2015		21-Jan 2016		
	Pharmaceuticals											
1	Amoxicillin (semi-quantitative)	4000	ND	1200	ND	20000	ND	3200	ND	ND	ND	>99%
2	Atenolol	130	9.6	120	17	120	8.8	78	ND	88	22	88%
3	Lidocaine	220	150	94	97	200	130	240	ND	260	52	57%
4	Butalbital	6.7	11	18	15	24	15	11	7.3	8.9	5.5	22%
5	Ibuprofen	90	ND	25	ND	190	ND	ND	ND	6100	430	variable
6	Naproxen	120	ND	11	ND	23	ND	ND	ND	ND	43	variable
	Household Chemicals											
1	Cotinine	19	ND	ND	ND	31	ND	ND	ND	470	170	variable
2	DEET	130	25	33	ND	960	14	88	12	520	62	93%
3	TCEP	170	110	54	41	120	93	84	47	ND	ND	30%
4	TCPP	1100	290	290	ND	670	100	750	ND	1000	280	80%
5	TDCPP	630	320	220	ND	380	240	360	ND	1200	240	68%
6	Acesulfame-K	24000	750	14000	350	21000	54	16000	100	14000	4700	93%
7	Sucralose	37000	28000	11000	16000	26000	21000	24000	21000	24000	21000	12%

In the chart above, if the concentration is shown in red, the concentration in the final effluent is higher than the concentration of the influent concentration. The letters ND denote No Detect. The concentration of Amoxicillin (semi-quantitative) was always No Detect, so the reduction rate is over 99%. When the value of the concentration of Ibuprofen increased from less than 190 ng/l over four events and then jumped in the fifth event to 6100 ng/l, the reduction rate was considered to be variable. The reduction rate for Naproxen was labelled variable since there were four tests of the effluent with a No Detect concentration followed by a test with a concentration of 43 ng/l in the fifth effluent test, which was an

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increase over the influent concentration of No Detect. The reduction rate of the flame retardants (TCEP, TCPP and TDCPP) is impressive given that these chemicals are normally considered resistant to microbial attack.

The upstream wastewater treatment system is a RUCK System where settled wastewater passes through a three layer stratified sand filter. The water leaving the filters pass through a denitrification tank. There will be some reductions of Contaminants of Emerging Concern as the water passes through the upstream RUCK System. Treated wastewater from other wastewater treatment technologies may have different Contaminants of Emerging Concern present and at higher concentrations than at Mill Pond Village.

We did not expect that the GPC Filter Process would reduce Contaminants of Emerging Concern. It appears that the soil bacteria in the filter attack the organic compounds, even at trace levels, and use the carbons in the organic chemicals for metabolism. This is superior to other accepted methods of removing these pollutants. Most other technologies remove these dissolved chemicals through either membranes, reverse osmosis or by chemical separation. Some of these other methods generate a brine from the influent side of the membranes. The brine then has to be treated, destroyed or stored in a hazardous waste landfill and becomes an additional concern for our environment. Unlike these other pollutant removing technologies, the discovery that the GPC Filter Process reduces many trace concentrations of organic pollutants from water, by metabolism, is a significant find.

While there are many unknowns concerning the hazard and risk to both human health and the environment caused by the presence of these Contaminants of Emerging Concern in water, the GPC Filter Process does reduce even some recalcitrant or resistant to decomposition chemicals even at very low trace concentrations. The discharge of final effluent passing through the GPC Filter Process into the environment poses very little real risk or hazard to human health or to the environment.

A GPC Filter Process can be easily permitted and added to wastewater treatment facilities over 10,000 gpd. For systems under 10,000 gpd, the construction requires a permit under the piloting program of Title-5. The GPC Filter Process can be designed to be constructed in-line after denitrification at a wastewater treatment system, or the effluent from the GPC Filter Process can be recycled or alternately, the GPC Filter System can be installed as a soil absorption system in a bottomless configuration.

Since Massachusetts usually requires disinfection for wastewater treatment systems over 10,000 gallon per day discharging into soils, there has to be filtering and reduction of Total Suspend Solids in every wastewater treatment system prior to exposure by Ultraviolet Light, a common disinfection process. The cost of a GPC Filter Process, then is partially offset in that the GPC Filter Process can substitute for a traditional sand filter or membrane needed to reduce Total Suspend Solids prior to the Ultraviolet Light stage.

Please contact us so we may answer your questions about working with your Engineer to incorporate a GPC Filter Process with your wastewater treatment system.

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PPCP TEST: GPC FILTER PROCESS

SAMPLING EVENT #1

Sampled 10/09/14

	ANALYTE	INFLUENT (ng/l)	EFFLUENT (ng/l)	DIFFERENCE*[1] (ng/l)	MRL (ng/l)	AVERAGE*[2] REMOVAL RATE %
1	1,7-Dimethylxanthine	40	ND	40	10	88%
2	Acesulfame-K	24000	750	23250	200*[3]	97%
3	Acetaminophen	140	ND	140	5	98%
4	Amoxicillin (semi-quantitative)	4000	ND	4000	20	>99%
5	Atenolol	130	9.6	120.4	5	93%
6	Azithromycin	ND	49	49	20	Increase
7	Butalbital	6.7	11	4.3	5	Increase
8	Caffeine	230	25	205	5	89%
9	Carbamazepine	12	6.8	5.2	5	43%
10	Cotinine	19	ND	19	10	74%
11	DEET	130	25	105	10	81%
12	Diltiazem	11	ND	11	5	77%
13	Diuron	16	ND	16	5	84%
14	Ibuprofen	90	ND	90	10	94%
15	Lidocaine	220	150	70	5	32%
16	Lopressor	260	31	229	20	88%
17	Naproxen	120	ND	120	10	96%
18	Pentoxifylline	40	ND	40	5	94%
19	Propylparaben	5.2	ND	5.2	5	52%
20	Sucralose	37000	28000	9000	1000	24%
21	TCEP	170	110	60	10	35%
22	TCPP	1100	290	810	1000*[4]	74%
23	TDCPP	630	320	310	100	49%
24	Theobromine	97	69	28	10	29%
25	Theophylline	81	ND	81	20	88%
26	Trimethoprim	52	ND	52	5	95%
27	Warfarin	9.1	ND	9.1	5	73%

*[1] The difference is based on the reported concentrations of the Influent and Effluent, and ignores the deltas caused by the Minimum Reporting Level.

*[2] Removal Rates will vary due to MRLs. The Effluent was assumed to be 1/2 the MRL for Analytes with a No Detect (ND) in their Effluent Column

*[3] The MRL for this analyte is 200ng/l in the Influent and 20ng/l in the Effluent due to a dilution factor of 10

*[4] The Influent MRL for this analyte is 1000ng/l where the MRL for the Effluent was 100ng/l due to the sample being diluted by a factor of 10

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SAMPLING EVENT #2

Sampled 11/25/14

	ANALYTE	INFLUENT (ng/l)	EFFLUENT (ng/l)	DIFFERENCE*[1] (ng/l)	MRL (ng/l)	AVERAGE*[2] REMOVAL RATE %
1	4-nonylphenol-semi quantitative	ND	300	300	100	Increase
2	4-tert-Octylphenol	ND	140	140	50	Increase
3	Acesulfame-K	14000	350	13650	20	98%
4	Amoxicillin (Semi-quantitative)	1200	ND	1200	20	>99%
5	Atenolol	120	17	103	5	86%
6	Butalbital	18	15	3	5	17%
7	Caffeine	58	9.6	48.4	5	83%
8	Cyanazine	11	5.9	5.1	5	46%
9	DEET	33	ND	33	10	85%
10	Dilantin	23	ND	23	20	57%
11	Gemfibrozil	240	ND	240	5	99%
12	Ibuprofen	25	ND	25	10	80%
13	Iohexal	11	ND	11	10	55%
14	Isobutylparaben	5.6	ND	5.6	5	55%
15	Lidocaine	94	97	3	5	Increase
16	Lopressor	150	21	129	20	86%
17	Meprobamate	31	42	11	5	Increase
18	Naproxen	11	ND	11	10	55%
19	Sucralose	11000	16000	5000	100	Increase
20	TCEP	54	41	13	10	24%
21	TCPP	290	ND	290	100	83%
22	TDCPP	220	ND	220	100	77%
23	Triclocarban	18	ND	18	5	86%
*[1]	The Difference is based on the reported concentrations of the Influent and Effluent, and ignores the deltas caused by the Minimum Reporting Level.					
*[2]	Removal Rates will vary due to MRLs. The Effluent was assumed to be 1/2 the MRL for Analytes with a No Detect in their Effluent Column.					

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SAMPLING EVENT #3

Sampled 09/17/15

	ANALYTE	INFLUENT (ng/l)	EFFLUENT (ng/l)	DIFFERENCE*[1] (ng/l)	MRL (ng/l)	AVERAGE*[2] REMOVAL RATE %
1	4-nonylphenol-semi quantitative	280	ND	280	100	82%
2	4-tert-Octylphenol	100	ND	100	50	75%
3	Acesulfame-K	21000	54	20946	200*[3]	>99%
4	Albuterol	86	ND	86	5	97%
5	Amoxicillin (semi-quantitative)	20000	ND	20000	200	>99%
6	Atenolol	120	8.8	111.2	5	93%
7	Bendroflumethiazide	ND	6.5	6.5	5	Increase
8	BPA	52	ND	52	10	90%
9	Butalbital	24	15	9	5	38%
10	Cotinine	31	ND	31	10	84%
11	DEET	960	14	946	100*[4]	99%
12	Diltiazem	11	ND	11	5	77%
13	Gemfibrozil	330	ND	330	5	>99%
14	Ibuprofen	190	ND	190	10	97%
15	Iohexal	220	ND	220	10	98%
16	Iopromide	43	ND	43	5	94%
17	Lidocaine	200	130	70	5	35%
18	Naproxen	23	ND	23	10	78%
19	Sucralose	26000	21000	5000	1000	19%
20	Sulfamethoxazole	260	ND	260	5	>99%
21	TCEP	120	93	27	10	23%
22	TCPP	670	100	570	100	85%
23	TDCPP	380	240	140	100	37%
24	Triclocarban	28	ND	28	5	91%
25	Triclosan	11	ND	11	10	55%
26	Trimethoprim	52	ND	52	5	95%
*[1]	The difference is based on the reported concentrations of the Influent and Effluent, and ignores the deltas caused by the Minimum Reporting Level.					
*[2]	Removal Rates will vary due to MRLs. The Effluent was assumed to be 1/2 the MRL for Analytes with a No Detect (ND) in their Effluent Column					
*[3]	The MRL for this analyte is 200ng/l in the Influent and 20ng/l in the Effluent due to a dilution factor of 10					
*[4]	The MRL for this analyte is 100ng/l in the Influent and 10ng/l in the Effluent due to a dilution factor of 10					

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SAMPLING EVENT #4

Sampled 12/23/15

	ANALYTE	INFLUENT (ng/l)	EFFLUENT (ng/l)	DIFFERENCE*[1] (ng/l)	MRL (ng/l)	AVERAGE*[2] REMOVAL RATE %
1	Acesulfame-K	16000	100	15900	200*[3]	>99%
2	Amoxicillin (semi-quantitative)	3200	ND	3200	20	>99%
3	Atenolol	78	ND	78	5	97%
4	BPA	25	ND	25	10	80%
5	Butalbital	11	7.3	3.7	5	34%
6	Caffeine	200	ND	200	5	99%
7	Cyanazine	21	9.7	11.3	5	54%
8	DEET	88	12	76	10	86%
9	Diltiazem	8.3	ND	8.3	5	70%
10	Gemfibrozil	59	ND	59	5	96%
11	Iohexal	46	29	17	10	37%
12	Iopromide	26	ND	26	5	90%
13	Lidocaine	240	120	120	5	50%
14	Quinoline	24	ND	24	5	90%
15	Sucralose	24000	21000	3000	1000	13%
16	Sulfamethoxazole	7.7	ND	7.7	5	68%
17	TCEP	84	47	37	10	44%
18	TCPP	750	ND	750	100	93%
19	TDCPP	360	ND	360	100	86%
20	Trimethoprim	35	ND	35	5	93%
*[1]	The Difference is based on the reported concentrations on the Influent and Effluent, and ignores the deltas caused by the MRL					
*[2]	Removal Rates will vary due to MRLs. The Effluent was assumed to be 1/2 the MRL for Analytes with a No Detect (ND) in their Effluent Column					
*[3]	The Influent MRL for this particular analyte is 200ng/l where the MRL for the Effluent was 20ng/l due to the sample being diluted by a factor of 10					

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PPCP TEST: GPC FILTER PROCESS

SAMPLING EVENT #5
Sampled 01/21/16

	ANALYTE	INFLUENT (ng/l)	EFFLUENT (ng/l)	DIFFERENCE*[1] (ng/l)	MRL (ng/l)	AVERAGE*[2] REMOVAL RATE %
1	4-nonylphenol-semi quantitative	140	ND	140	100	64%
2	Acesulfame-K	14000	4700	9300	200	66%
3	Albuterol	100	82	18	5	18%
4	Atenolol	88	22	66	5	75%
5	Butalbital	8.9	5.5	3.4	5	38%
6	Caffeine	1800	ND	1800	50	99%
7	Carbamazepine	7.5	5.8	1.7	5	23%
8	Cotinine	470	170	300	10	64%
9	DEET	520	62	458	100*[3]	88%
10	Diazepam	7.3	ND	7.3	5	66%
11	Diltiazem	6.8	ND	6.8	5	63%
12	Erythromycin	15	ND	15	10	67%
13	Gemfibrozil	120	62	58	5	48%
14	Ibuprofen	6100	430	5670	100*[4]	93%
15	Iopromide	11	ND	11	5	77%
16	Ketorolac	14	ND	14	5	82%
17	Lidocaine	260	52	208	5	80%
18	Lopressor	ND	43	43	20	Increase
19	Naproxen	ND	43	43	10	Increase
20	Progesterone	10	ND	10	5	75%
21	Propazine	18	ND	18	5	86%
22	Sucralose	24000	21000	3000	1000	13%
23	TCPP	1000	280	720	100	72%
24	TDCPP	1200	240	960	100	80%
25	Theobromine	1200	260	940	10	78%
26	Theophylline	610	100	510	20	84%

*[1]	The Difference is based on the reported concentrations on the Influent and Effluent, and ignores the deltas caused by the MRL
*[2]	Removal Rates will vary due to MRLs. The Effluent was assumed to be 1/2 the MRL for Analytes with a No Detect (ND) in their Effluent Column
*[3]	The MRL for this analyte is 100ng/l in the Influent and 10ng/l in the Effluent due to a dilution factor of 10
*[4]	The MRL for this analyte is 100ng/l in the Influent and 10ng/l in the Effluent due to a dilution factor of 10