

# Blue-Green Algae (Cyanobacteria) and Microcystin Monitoring Results in the Vicinity of the Klamath Hydroelectric Project: April, May, and June 2008

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## Introduction

This technical memorandum summarizes the latest results of monitoring during 2008 of blue-green algae (BGA) species and the associated toxin microcystin above, below, and in the vicinity of PacifiCorp's Klamath Hydroelectric Project (Project). This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE), a BGA species with a recent history of summertime blooms in Copco and Iron Gate reservoirs that is known to produce microcystin. This monitoring also estimates the presence of other potentially-toxigenic BGA species, including *Anabaena spp.* and *Planktothrix (Oscillatoria) spp.* This monitoring is one of several water quality studies being conducted by PacifiCorp in the vicinity of the Project in 2008 in support of on-going assessment of water quality conditions and potential management actions (PacifiCorp 2008a and 2008b).

The results specifically addressed in this memorandum are for samples collected on April, May, and June 2008. PacifiCorp plans to prepare subsequent memoranda such as this on a rolling basis to summarize the results to date of BGA species and microcystin sample analysis. PacifiCorp plans to prepare a final report of the results and interpretation of the complete set of collected data after the conclusion of the sampling effort in winter 2008-09.

## Methods

Phytoplankton sampling for laboratory analysis of potentially-toxigenic BGA species, notably MSAE, and microcystin is occurring at 22 sites in the vicinity of the Project listed in Table 1, including:

- Seven river sites upstream, within, and downstream of the Project area that were sampled during PacifiCorp's 2008 water quality monitoring study (as further described in PacifiCorp 2008c and 2008d).
- Two open-water reservoir sites in the lower ends of Iron Gate and Copco reservoirs (near the log booms) that are associated with PacifiCorp's 2008 water quality monitoring study (as further described in PacifiCorp 2008c and 2008d).

- Four shoreline sites in coves in Copco and Iron Gate reservoir (i.e., two cove sites in each reservoir). These are similar to sites as monitored in previous years by the Karuk Tribe.
- Four shoreline sample locations in the lower basin of Upper Klamath Lake.
- Five open-water sample locations in the vicinity of solar-powered circulators deployed in the upper end of Copco reservoir during 2008 (in conjunction with PacifiCorp's testing of circulators in Copco reservoir).

Sampling is to occur at the seven river and two open-water monitoring sites once per month in April, May, November, and December, and twice per month in June through October. Samples are to be taken at the shoreline locations in the reservoirs once per month in April, May, October, and November and twice per month in June through September. Samples from the four shoreline locations in UKL will be obtained once in June and twice per month in July through September. Samples at the sites in the vicinity of solar-powered circulators in Copco reservoir are to be obtained once in May and twice per month from June through October.

Phytoplankton samples from the river sites are taken as grab samples offshore in the current at approximately 0.5 meters (m) below the surface. At the open-water reservoir sites (i.e., near the log booms), two types of phytoplankton samples are taken: (1) a surface grab sample over the top 30 cm depth; and (2) an integrated vertical sample from the surface to a depth of 8 m (approximately the depth of the reservoir's photic zone). At shallow reservoir shoreline sites (e.g., cove sites), phytoplankton samples are taken as a surface grab sample over the top 30 cm depth.

Samples for phytoplankton speciation, density, and biovolume are preserved in Lugol's solution and sent to Aquatic Analysts in White Salmon, Washington for analysis. The laboratory analysis of phytoplankton speciation and density is done on prepared microscope slides of filtered samples using phase contrast microscopy. Species are counted as algal units of cell, filament, or colony depending on the natural growth form of the species. BGA species are enumerated as individual cells. Algal forms are identified to species or otherwise to the lowest practicable taxonomic level. Biovolumes are estimated by multiplying the cell counts by the average geometric dimensions of the cells for a given phytoplankton taxa.

Samples for determination of microcystin toxin are placed in a cooler on ice and shipped to CH2M HILL Applied Sciences Laboratory in Corvallis, Oregon. The samples are analyzed using the competitive Enzyme-Linked ImmunoSorbent Assay (ELISA) method based on the EnviroLogix QuantiPlate Kit for Microcystins. The quantitation limit is 0.16 µg/L or parts per billion (ppb). This test method does not distinguish between the specific microcystin congeners, but detects their presence to differing degrees. That is, ELISA test results yield one value as the sum of all measurable microcystin variants.

**Table 1.** Sites of Blue-Green Algae (Cyanobacteria) and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project During 2008.

<b>Location</b>	<b>Approximate River Mile</b>	<b>River Sites</b>	<b>Reservoir Open Water Sites</b>	<b>Reservoir Shoreline Sites</b>	<b>UKL Shoreline Sites</b>	<b>Test Circulator Monitoring Sites</b>
Upper Klamath Lake near Eagle Ridge ramp	UKL				X	
Upper Klamath Lake near Hagelstein Park	UKL				X	
Upper Klamath Lake at Wocus Bay	UKL				X	
Upper Klamath Lake at Pelican Bay ramp	UKL				X	
Link River below Upper Klamath Lake	253.1	X				
Klamath R. below Keno dam	233.4	X				
Klamath R. above Copco reservoir	206.4	X				
Copco reservoir upper end at Copco Village (SB 1)	204.0					X
Copco reservoir upper end near "narrows" (SB 2)	203.0					X
Copco reservoir middle above Mallard Cove (SB 3)	202.0					X
Copco reservoir at Mallard Cove ramp	201.5			X		
Copco reservoir middle below Mallard Cove (SB 4)	201.0					X
Copco reservoir middle near Cpoco Cove (SB 5)	200.0					X
Copco reservoir at Copco Cove ramp	200.0			X		
Copco reservoir lower end at log boom	198.6		X			
Iron Gate reservoir at Camp Creek area	192.8			X		
Iron Gate reservoir at Williams boat ramp	192.4			X		
Iron Gate reservoir lower end above log boom	190.2		X			
Iron Gate powerhouse tailwaters	190.1	X				
Klamath R. at Iron Gate Hatchery bridge	189.7	X				
Klamath R. at I-5 Rest Area	176.7	X				
Klamath R. at Walker Bridge Road	159.0	X				

## Results

Sampling events conducted to-date occurred during April 28-29, May 22-24, June 4-6, and June 17-19, 2008. Results obtained to-date for these sampling events are summarized in Table 2.

### Samples of April 28-29, 2008

Results are not yet available for BGA speciation and cell count data for samples obtained during April 28-29. Samples were still being processed in the laboratory as of the date of this memorandum. Microcystin samples were not taken during April 28-29, 2008.

### Samples of May 22-24, 2008

Results are not yet available for BGA speciation and cell count data for samples obtained during May 22-24. Samples were still being processed in the laboratory as of the date of this memorandum.

Microcystin was below the quantitation limit (i.e., less than 0.16 µg/L) in all river and reservoir samples obtained during May 22-24. Samples for the Upper Klamath Lake shoreline sites were not taken during May 22-24, 2008.

### Samples of June 4-6, 2008

Results are not yet available for BGA speciation and cell count data for the sampling of June 4-6. Samples were still being processed in the laboratory as of the date of this memorandum.

Microcystin was detected at levels above the quantitation limit (i.e., 0.16 µg/L) in 15 of 19 samples obtained during June 4-6. However, detectable concentrations were all less than 0.27 µg/L, and therefore well below the WHO (2003) guideline value of 4 µg/L<sup>1</sup> for low health risk associated with recreational use of waters. Detectable concentrations also were well below the SWRCB (2007) and ODHS (2005) guideline value of 8 µg/L<sup>2</sup> for posting advisories in recreation waters.

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<sup>1</sup> The World Health Organization (WHO) has recommended guidelines for safe recreational water environments based on a low, moderate, or high probability of adverse health effects from exposure to concentrations of cyanobacterial cells and microcystin toxins in recreational waters (WHO 2003). The WHO guideline values for low and moderate probability of adverse health in recreational waters are 20,000 and 100,000 cyanobacterial cells/mL, respectively. WHO equates these cell count values to microcystin toxin concentrations of 4 µg/L and 20 µg/L, respectively (WHO 2003). The WHO guideline for high probability of adverse health effects is a narrative; i.e., "Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur". No specific cyanobacterial cell or microcystin concentrations are provided by WHO for high probability of adverse health effects. The WHO (2003) guidance values were derived from calculations based on a 20 kg child that would swim for up to two hours (in a day) and would accidentally ingest 0.05 L of water per hour.

<sup>2</sup> The California State Water Resources Control Board (SWRCB 2007) and Oregon Department of Health Services (ODHS 2005) provide guidelines for posting advisories in recreation waters. These guidelines were developed using information provided in WHO (2003). Both SWRCB (2007) and ODHS (2005) recommend posting advisories in recreation waters under three circumstances: (1) if "scum is present associated with toxigenic species"; (2) if scum is not present, but the density of *Microcystis* or *Planktothrix* is 40,000 cells/ml or greater; and (3) if scum is not present, but the density of all potentially toxigenic BGA is 100,000 cells/ml or greater. Based on WHO (2003) information, SWRCB (2007) and ODHS (2005) indicate that cell counts of 40,000 and 100,000 cells/ml equate to microcystin toxin concentrations of 8 µg/L and 20 µg/L, respectively.

## Samples of June 17-19, 2008

PacifiCorp began ordering expedited processing of phytoplankton samples from certain sites starting with the set of samples taken during June 17-19, 2008. The expedited processing was for samples from shoreline sites in Copco and Iron Gate reservoirs, and Klamath River sites below Iron Gate dam. BGA cells were not found in the expedited samples of June 17-19, with one exception: a small number of *Aphanizomenon flos-aquae* cells were counted in the sample from Iron Gate reservoir at Camp Creek. Results are not yet available for BGA speciation and cell count data for the other samples obtained during June 17-19.

Microcystin was below the quantitation limit (i.e., less than 0.16 µg/L) in samples obtained during June 17-19, 2008 at the river sites, with one exception: microcystin was detected at a concentration of 0.65 µg/L at the Link River site upstream of the Project area. Microcystin was below the quantitation limit in samples obtained on June 18, 2008 at the two open-water sites in the lower ends of Iron Gate and Copco reservoirs (near the log booms). However, microcystin was detected at concentrations of 0.32 to 0.46 µg/L at the four shoreline sites in coves in Copco and Iron Gate reservoirs (i.e., two cove sites in each reservoir). Microcystin also was detected at concentrations of 0.22 to 0.42 µg/L in the three shoreline samples obtained in the lower basin of Upper Klamath Lake. The detectable microcystin concentrations in samples obtained during June 17-19 were each well below the guideline value of 4 µg/L for low health risk associated with recreational use of waters, and also well below the SWRCB (2007) and ODHS (2005) guideline value of 8 µg/L for posting advisories in recreation waters.

## References

- ODHS. 2005. Public Health Advisory Guidance for Toxigenic Cyanobacteria in Recreational Waters. Oregon Department of Human Services, Environmental Toxicology Program.
- PacifiCorp. 2008a. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2008.
- PacifiCorp. 2008b. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board, Division of Water Quality, Water Quality Certification Unit, Sacramento. Prepared by: PacifiCorp, Portland, Oregon. February 2008.
- PacifiCorp. 2008c. Water Quality Studies for Year 2008 for the Klamath Hydroelectric Project. April 22, 2008. Attachment to a letter from Linda Prendergast (PacifiCorp) to Chris Stine (Oregon Department of Environmental Quality) and Jennifer Watts (California State Water Resources Control Board).

PacifiCorp. 2008d. 2008 Water Quality Monitoring: Sampling Plan. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared by: PacifiCorp Energy, Portland, Oregon. Version: June 30, 2008.

SWRCB. 2007. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. June 2007. Document provided as part of Blue-green Algae Work Group of State Water Resources Control Board (SWRCB) and Office of Environmental Health and Hazard Assessment (OEHHA).

World Health Organization (WHO). 2003. Guidelines for safe recreational waters, Volume 1 - Coastal and fresh waters, Chapter 8: Algae and cyanobacteria in fresh water. WHO Publishing, Geneva, pp. 136-158.

Table 2. Blue-green algae cell count (cells/mL) and microcystin concentration (ug/L) in sites sampled to date during 2008 by PacifiCorp in Iron Gate, Copco, and J.C. Boyle reservoirs and other sites in the Klamath River.

Codes:

- R Regular grab sample (at surface)
- INT Integrated grab sample (from surface to 8 m)
- NA Results not available to date
- NT Sample not taken

Date	Location	River Mile	Depth (m)	Sample Type	Microcystin (ug/L)	Est. Microcystin (ug/L)	<i>Microcystis</i> (cells/mL)	<i>Anabaena</i> (cells/mL)	<i>Planktothrix</i> (cells/mL)	<i>Aphanizomenon</i> (cells/mL)
NT	Upper Klamath Lake near Eagle Ridge ramp	UKL	0.5	R						
NT	Upper Klamath Lake near Hagelstein Park	UKL	0.5	R						
NT	Upper Klamath Lake at Wocus Bay	UKL	0.5	R						
NT	Upper Klamath Lake at Pelican Bay ramp	UKL	0.5	R						
24-May-08	Link River below Upper Klamath Lake	253.1	0.5	R	<0.16	0.054	NA	NA	NA	NA
24-May-08	Klamath R. below Keno dam	233.4	0.5	R	<0.16	0.070	NA	NA	NA	NA
23-May-08	Klamath R. above Copco reservoir	206.4	0.5	R	<0.16	0.085	NA	NA	NA	NA
22-May-08	Copco reservoir upper end at Copco Village (SB 1)	204.0	0.5	R	<0.16	0.068	NA	NA	NA	NA
22-May-08	Copco reservoir upper end at Copco Village (SB 1)	204.0	8.0	INT	<0.16	0.074	NA	NA	NA	NA
22-May-08	Copco reservoir upper end near "narrows" (SB 2)	203.0	0.5	R	<0.16	0.097	NA	NA	NA	NA
NT	Copco reservoir upper end near "narrows" (SB 2)	203.0	8.0	INT						
22-May-08	Copco reservoir middle above Mallard Cove (SB 3)	202.0	0.5	R	<0.16	0.025	NA	NA	NA	NA
22-May-08	Copco reservoir middle above Mallard Cove (SB 3)	202.0	8.0	INT	<0.16	0.086	NA	NA	NA	NA
22-May-08	Copco reservoir at Mallard Cove ramp	201.5	0.5	R	<0.16	0.081	NA	NA	NA	NA
22-May-08	Copco reservoir middle below Mallard Cove (SB 4)	201.0	0.5	R	<0.16	0.086	NA	NA	NA	NA
22-May-08	Copco reservoir middle below Mallard Cove (SB 4)	201.0	8.0	INT	<0.16	0.089	NA	NA	NA	NA
NT	Copco reservoir middle near Copco Cove (SB 5)	200.0	0.5	R						
NT	Copco reservoir middle near Copco Cove (SB 5)	200.0	8.0	INT						
22-May-08	Copco reservoir at Copco Cove ramp	200.0	0.5	R	<0.16	0.082	NA	NA	NA	NA
22-May-08	Copco reservoir lower end at log boom	198.6	0.5	R	<0.16	0.110	NA	NA	NA	NA
22-May-08	Copco reservoir lower end at log boom	198.6	8.0	INT	<0.16	0.096	NA	NA	NA	NA
23-May-08	Iron Gate reservoir at Camp Creek area	192.8	0.5	R	<0.16	0.067	NA	NA	NA	NA
23-May-08	Iron Gate reservoir at Williams boat ramp	192.4	0.5	R	<0.16	0.079	NA	NA	NA	NA
23-May-08	Iron Gate reservoir lower end above log boom	190.2	0.5	R	<0.16	0.107	NA	NA	NA	NA
23-May-08	Iron Gate reservoir lower end above log boom	190.2	8.0	INT	<0.16	0.081	NA	NA	NA	NA
24-May-08	Iron Gate powerhouse tailwaters	190.1	0.5	R	<0.16	0.074	NA	NA	NA	NA
23-May-08	Klamath R. at Iron Gate Hatchery bridge	189.7	0.5	R	<0.16	0.082	NA	NA	NA	NA
22-May-08	Klamath R. at I-5 Rest Area	176.7	0.5	R	<0.16	0.103	NA	NA	NA	NA
22-May-08	Klamath R. at Walker Bridge Road	159.0	0.5	R	<0.16	0.086	NA	NA	NA	NA

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Date	Location	River Mile	Depth (m)	Sample Type	Microcystin (ug/L)	Est. Microcystin (ug/L)	<i>Microcystis</i> (cells/mL)	<i>Anabaena</i> (cells/mL)	<i>Planktothrix</i> (cells/mL)	<i>Aphanizomenon</i> (cells/mL)
NT	Upper Klamath Lake near Eagle Ridge ramp	UKL	0.5	R						
NT	Upper Klamath Lake near Hagelstein Park	UKL	0.5	R						
NT	Upper Klamath Lake at Wocus Bay	UKL	0.5	R						
NT	Upper Klamath Lake at Pelican Bay ramp	UKL	0.5	R						
3-Jun-08	Link River below Upper Klamath Lake	253.1	0.5	R	0.18	0.18	NA	NA	NA	NA
3-Jun-08	Klamath R. below Keno dam	233.4	0.5	R	<0.16	0.096	NA	NA	NA	NA
5-Jun-08	Klamath R. above Copco reservoir	206.4	0.5	R	0.17	0.167	NA	NA	NA	NA
NT	Copco reservoir upper end at Copco Village (SB 1)	204.0	0.5	R						
NT	Copco reservoir upper end at Copco Village (SB 1)	204.0	8.0	INT						
NT	Copco reservoir upper end near "narrows" (SB 2)	203.0	0.5	R						
NT	Copco reservoir upper end near "narrows" (SB 2)	203.0	8.0	INT						
NT	Copco reservoir middle above Mallard Cove (SB 3)	202.0	0.5	R						
NT	Copco reservoir middle above Mallard Cove (SB 3)	202.0	8.0	INT						
4-Jun-08	Copco reservoir at Mallard Cove ramp	201.5	0.5	R	0.19	0.194	NA	NA	NA	NA
4-Jun-08	Copco reservoir middle below Mallard Cove (SB 4)	201.0	0.5	R	0.19	0.193	NA	NA	NA	NA
4-Jun-08	Copco reservoir middle below Mallard Cove (SB 4)	201.0	8.0	INT	0.26	0.258	NA	NA	NA	NA
4-Jun-08	Copco reservoir middle near Copco Cove (SB 5)	200.0	0.5	R	0.19	0.185	NA	NA	NA	NA
4-Jun-08	Copco reservoir middle near Copco Cove (SB 5)	200.0	8.0	INT	0.20	0.199	NA	NA	NA	NA
4-Jun-08	Copco reservoir at Copco Cove ramp	200.0	0.5	R	<0.16	0.155	NA	NA	NA	NA
4-Jun-08	Copco reservoir lower end at log boom	198.6	0.5	R	0.19	0.187	NA	NA	NA	NA
4-Jun-08	Copco reservoir lower end at log boom	198.6	8.0	INT	0.19	0.192	NA	NA	NA	NA
3-Jun-08	Iron Gate reservoir at Camp Creek area	192.8	0.5	R	0.20	0.199	NA	NA	NA	NA
3-Jun-08	Iron Gate reservoir at Williams boat ramp	192.4	0.5	R	0.23	0.231	NA	NA	NA	NA
4-Jun-08	Iron Gate reservoir lower end above log boom	190.2	0.5	R	0.18	0.183	NA	NA	NA	NA
4-Jun-08	Iron Gate reservoir lower end above log boom	190.2	8.0	INT	<0.16	0.149	NA	NA	NA	NA
5-Jun-08	Iron Gate powerhouse tailwaters	190.1	0.5	R	0.19	0.188	NA	NA	NA	NA
5-Jun-08	Klamath R. at Iron Gate Hatchery bridge	189.7	0.5	R	0.21	0.208	NA	NA	NA	NA
3-Jun-08	Klamath R. at I-5 Rest Area	176.7	0.5	R	0.17	0.173	NA	NA	NA	NA
3-Jun-08	Klamath R. at Walker Bridge Road	159.0	0.5	R	<0.16	0.154	NA	NA	NA	NA



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19-Jun-08	Upper Klamath Lake near Eagle Ridge ramp	UKL	0.5	R	0.42	0.422	NA	NA	NA	NA
19-Jun-08	Upper Klamath Lake near Hagelstein Park	UKL	0.5	R	0.34	0.344	NA	NA	NA	NA
19-Jun-08	Upper Klamath Lake at Wocus Bay	UKL	0.5	R	0.22	0.216	NA	NA	NA	NA
NT	Upper Klamath Lake at Pelican Bay ramp	UKL	0.5	R						
19-Jun-08	Link River below Upper Klamath Lake	253.1	0.5	R	0.65	0.647	NA	NA	NA	NA
NT	Klamath R. below Keno dam	233.4	0.5	R						
17-Jun-08	Klamath R. above Copco reservoir	206.4	0.5	R	<0.16	0.096	NA	NA	NA	NA
NT	Copco reservoir upper end at Copco Village (SB 1)	204.0	0.5	R						
NT	Copco reservoir upper end at Copco Village (SB 1)	204.0	8.0	INT						
NT	Copco reservoir upper end near "narrows" (SB 2)	203.0	0.5	R						
NT	Copco reservoir upper end near "narrows" (SB 2)	203.0	8.0	INT						
NT	Copco reservoir middle above Mallard Cove (SB 3)	202.0	0.5	R						
NT	Copco reservoir middle above Mallard Cove (SB 3)	202.0	8.0	INT						
18-Jun-08	Copco reservoir at Mallard Cove ramp	201.5	0.5	R	0.45	0.451	0	0	0	0
NT	Copco reservoir middle below Mallard Cove (SB 4)	201.0	0.5	R						
NT	Copco reservoir middle below Mallard Cove (SB 4)	201.0	8.0	INT						
NT	Copco reservoir middle near Copco Cove (SB 5)	200.0	0.5	R						
NT	Copco reservoir middle near Copco Cove (SB 5)	200.0	8.0	INT						
18-Jun-08	Copco reservoir at Copco Cove ramp	200.0	0.5	R	0.46	0.458	0	0	0	0
18-Jun-08	Copco reservoir lower end at log boom	198.6	0.5	R	<0.16	0.107	0	0	0	0
18-Jun-08	Copco reservoir lower end at log boom	198.6	8.0	INT	<0.16	0.107	NA	NA	NA	NA
18-Jun-08	Iron Gate reservoir at Camp Creek area	192.8	0.5	R	0.42	0.423	0	0	0	271
18-Jun-08	Iron Gate reservoir at Williams boat ramp	192.4	0.5	R	0.32	0.315	0	0	0	0
18-Jun-08	Iron Gate reservoir lower end above log boom	190.2	0.5	R	<0.16	0.103	NA	NA	NA	NA
18-Jun-08	Iron Gate reservoir lower end above log boom	190.2	8.0	INT	<0.16	0.089	NA	NA	NA	NA
18-Jun-08	Iron Gate powerhouse tailwaters	190.1	0.5	R	<0.16	0.091	NA	NA	NA	NA
17-Jun-08	Klamath R. at Iron Gate Hatchery bridge	189.7	0.5	R	<0.16	0.089	0	0	0	0
17-Jun-08	Klamath R. at I-5 Rest Area	176.7	0.5	R	<0.16	0.103	0	0	0	0
17-Jun-08	Klamath R. at Walker Bridge Road	159.0	0.5	R	<0.16	0.100	0	0	0	0