



Bakken VRUs and Treater Sampling

March 23, 2010



- **Multiwell pads and central batteries**
 - **Minimize footprint**
 - **Minimize truck traffic**
 - **Maximize gas recovery**
- **Minimize VOC emissions with VRUs**
 - **Installing VRUs and incinerators**
 - **Meters on VRUs for future measurement**

- Range of VOC emission estimates
 - VRU metering
 - Treater sampling
- VRU economics



**Flash
Factor
(scf/stb)**

**VOC
Density
(lb/scf)**

VRU Meter

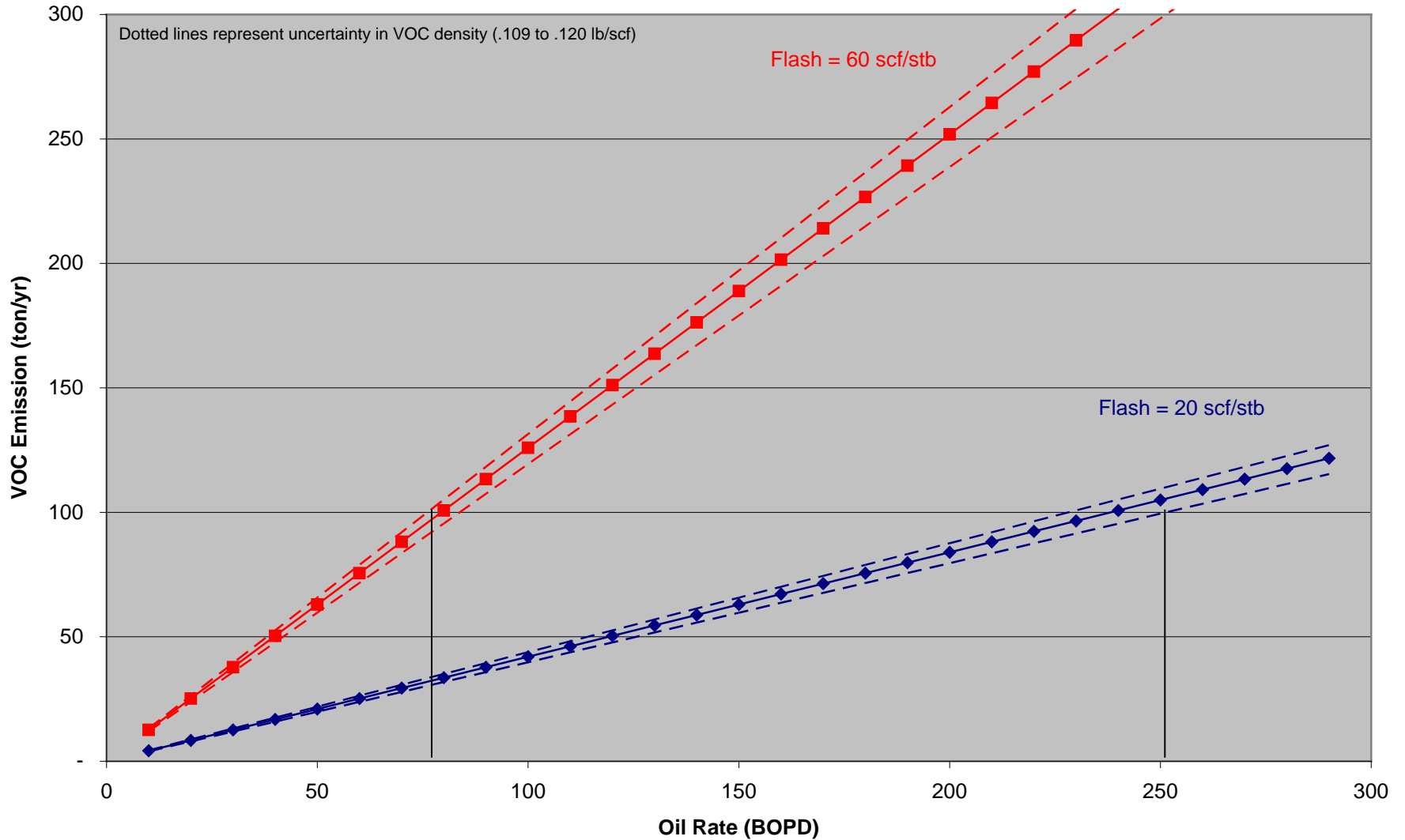
35-50

Treater Sampling

23-65

0.11-0.12

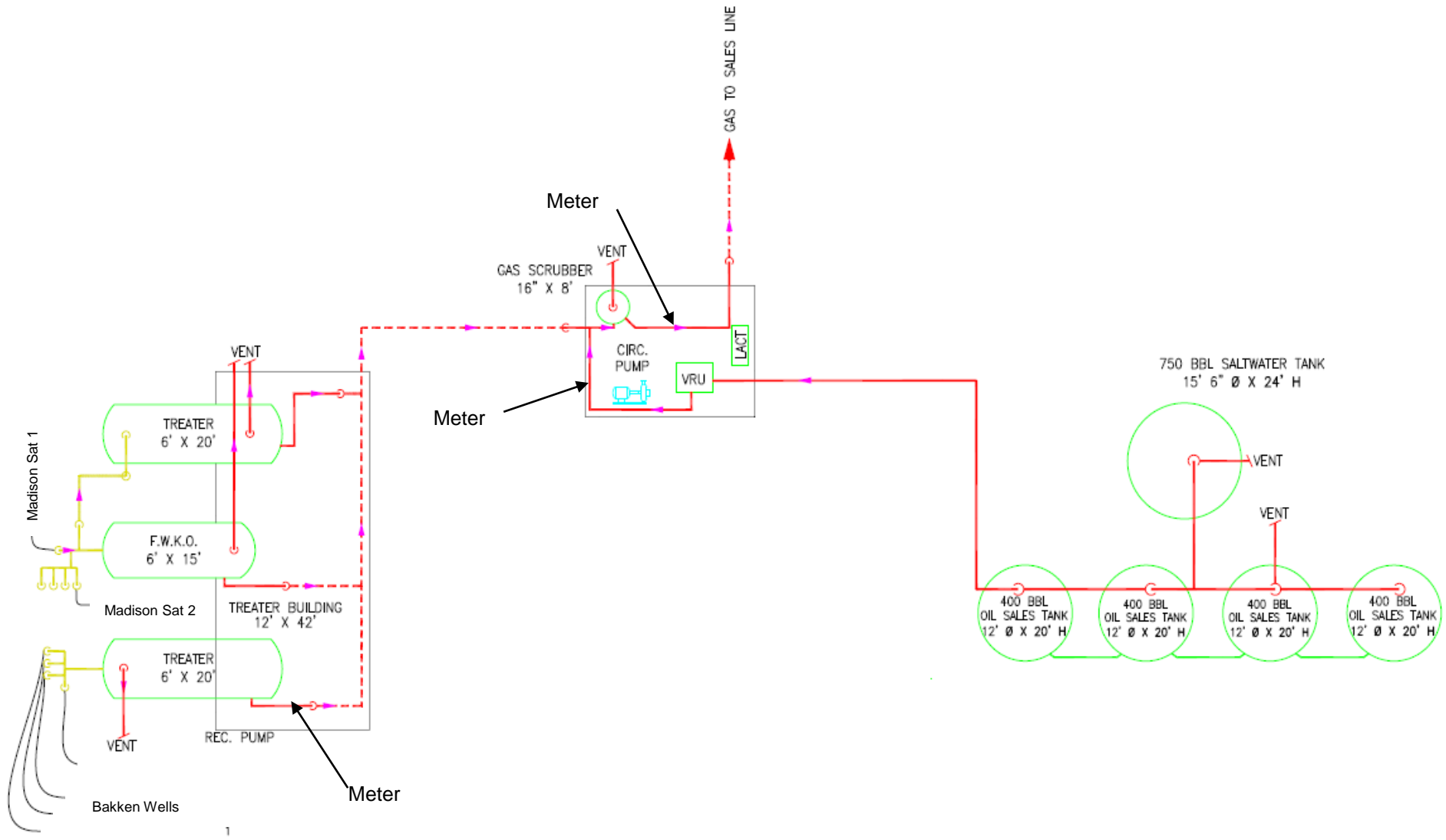
VOC Emissions vs. Oil Rate





- Central facility with emulsion from Bakken and Madison
 - 4 Bakken wells → 6x20 treater → 400 bbl oil tanks (3)
 - 2 Madison sats → 6x15 FWKO → 400 bbl oil tank (1)
- Tank flash gas metered at outlet of VRU

Example 1 – Gas Process Flow



Ex. 1 - Flash Factor Assuming VRU Gas is Bakken



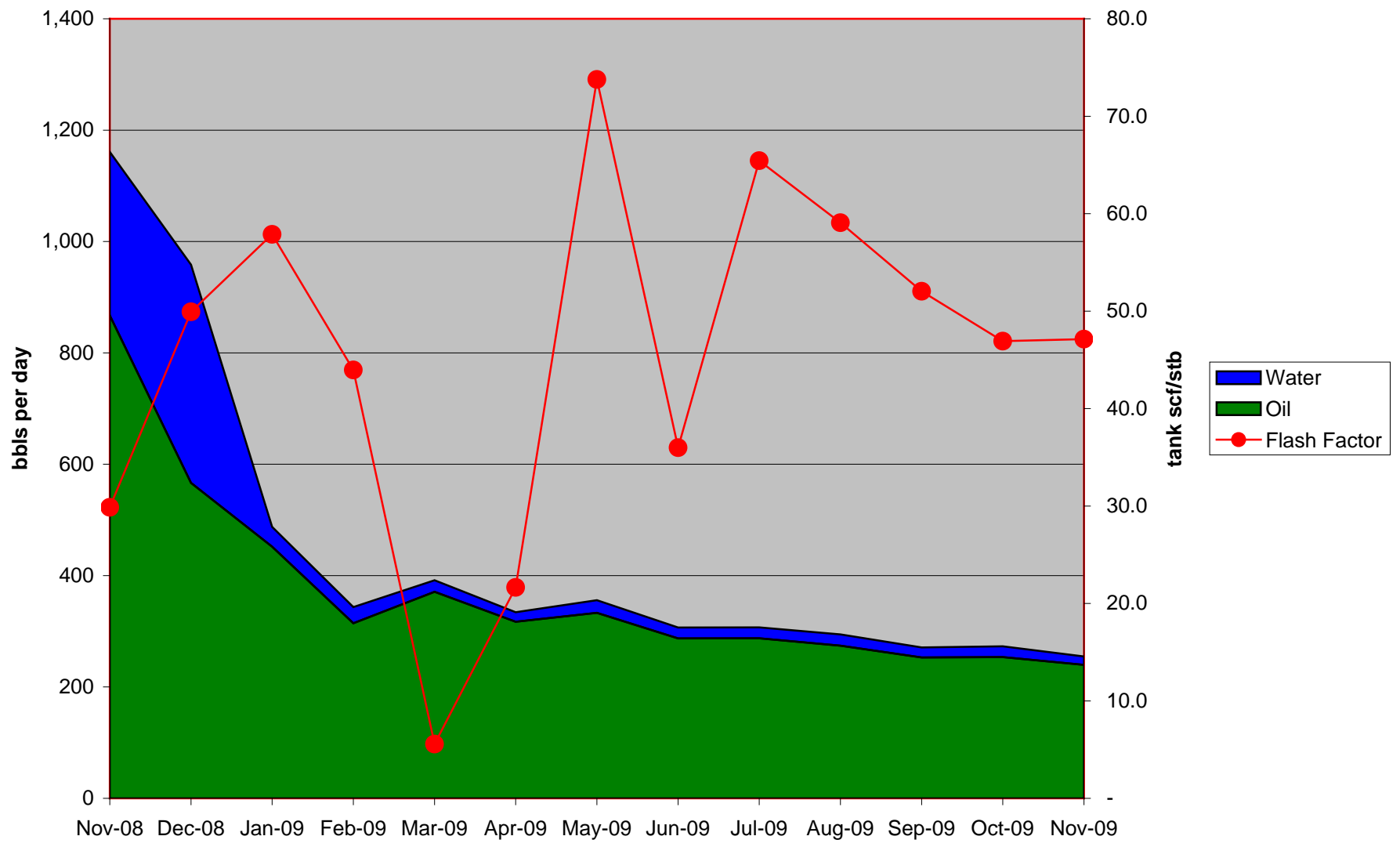
Date	Bakken Oil (BOPD)	Bakken Water (BWPD)	Bakken Gas (MCFD)	VRU Gas (MCFD)	Flash Factor
Nov-08	867	294	1,374	26	29.9
Dec-08	567	392	1,090	28	49.9
Jan-09	452	35	933	26	57.9
Feb-09	314	29	713	14	44.0
Mar-09	371	21	639	2	5.6
Apr-09	317	17	557	7	21.7
May-09	333	23	694	25	73.8
Jun-09	287	20	652	10	36.0
Jul-09	287	20	609	19	65.4
Aug-09	274	20	607	16	59.1
Sep-09	253	18	539	13	52.0
Oct-09	254	19	519	12	46.9
Nov-09	240	15	536	11	47.1
Average:					45.3

Ex. 1 - Flash Factor Assuming VRU Gas is Bakken+Madison

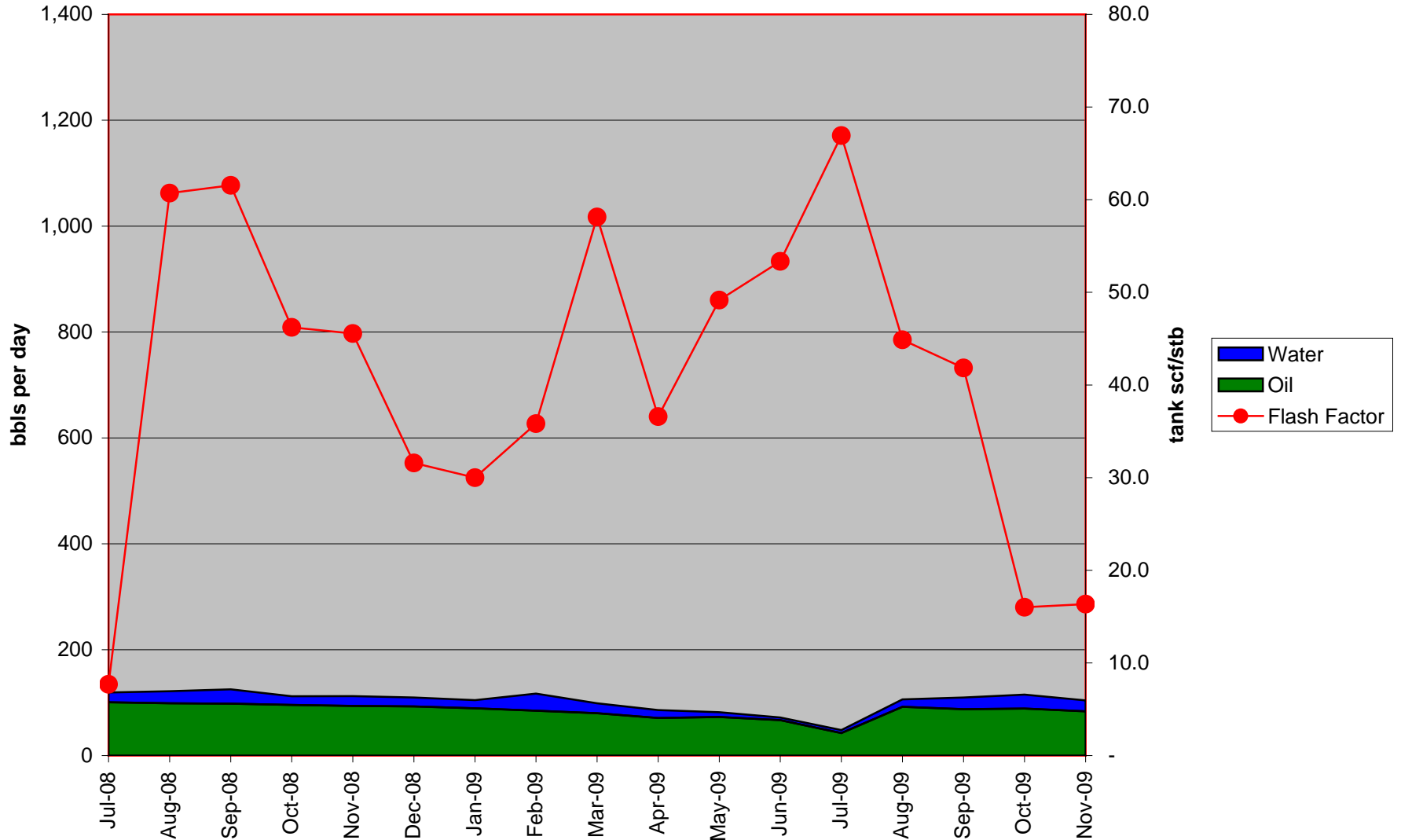


Date	Total Oil (BOPD)	Total Water (BWPD)	Total Gas (MCFD)	VRU Gas (MCFD)	Flash Factor
Nov-08	955	575	1,546	26	27.1
Dec-08	663	751	1,312	28	42.7
Jan-09	545	749	1,168	26	48.0
Feb-09	394	603	898	14	35.1
Mar-09	464	753	844	2	4.5
Apr-09	409	728	763	7	16.8
May-09	410	659	881	25	59.9
Jun-09	349	536	822	10	29.6
Jul-09	387	708	837	19	48.6
Aug-09	367	676	832	16	44.1
Sep-09	328	602	725	13	40.1
Oct-09	322	714	690	12	36.9
Nov-09	299	593	697	11	37.8
				Average:	36.2

Ex. 1 – No Relationship Between Rate and Flash Factor



Ex. 2 – Average Flash Factor 38 scf/stb



Treater Sampling Summary



- **Samples from 3 facilities**

- **Geographically dispersed** 30 miles
- **Little variation in rate** 500 to 800 BLPD

- **Pressurized Samples**

- **Treater pressure** 25-50 psi
- **Treater temperature** 45-66 deg F
- **Sampled from treater oil dump**

- **Analysis**

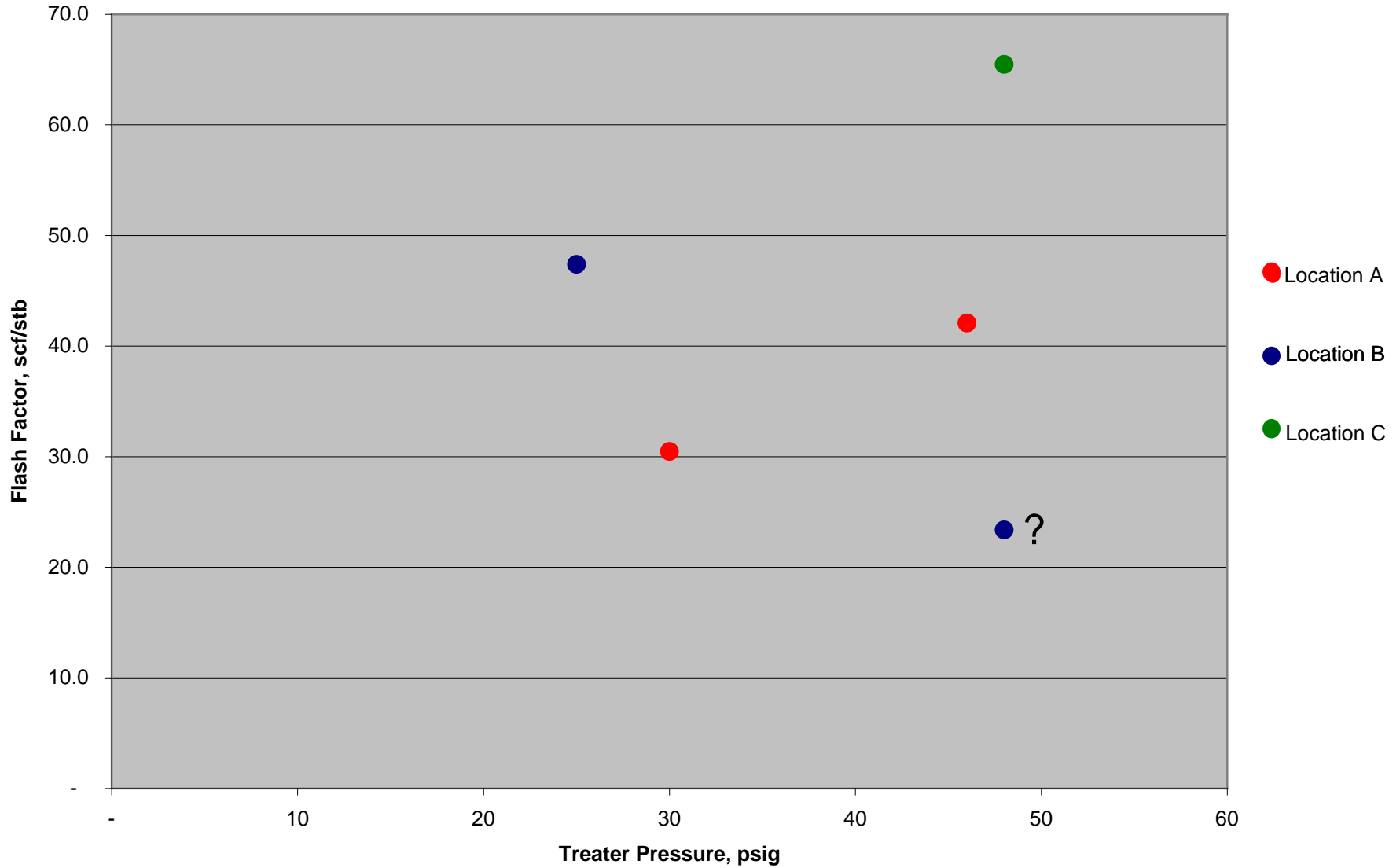
- **Flashed to standard pressure** 13.5 psia
- **Flash factor** 23-66 scf/stb

Treater Sampling Data



Location	Date	Production			Treater		Analysis	
		Oil BOPD	Gas MCFD	Water BWPD	Pressure psig	Temp deg F	Oil Gravity deg API	Flash cuft/bbl
A	11/17/2008	479	268	205	46	59	43.2	42.1
B	11/17/2008	482	185	157	48	66	43.8	23.4
C	11/17/2008	562	1,528	191	48	43	45.9	65.5
A	1/22/2009	436	227	74	30	45	44.0	30.5
B	1/22/2009	524	160	148	25	52	43.7	47.4

Treater Sampling Results



- Installing VRUs or incinerators
- VRU standard at central facilities
- Standard VRU design
 - 500 MCFD max rate at 60 psig discharge pressure
 - Sliding vane compressor
 - Flash gas metered at outlet of VRU

Capital Costs

• VRU	\$100M
• Installation	<u>\$100M</u>
• Total	\$200M

Operating Costs

• Electricity	\$0.30/mcf
• Maintenance	\$1000/month

Payout

• 1000 BOPD	2 yrs
• 500 BOPD	6 yrs



End
