

APPENDIX E

Travel Time Calculations and Comparisons

This appendix contains the reduced data for calculated travel times from the formalin monitoring data and USGS water speed data. The following are included:

- 1 - description of travel time calculations
- 2 - travel time calculations from regressed water speed data
- 3 - travel time calculations from fit-by-eye water speed data
- 4 - travel time calculations from June, 1987 measured speeds
- 5 - travel time comparisons - formalin monitoring data
USGS water speed data
USACOE flood crest estimates

TRAVEL TIME CALCULATIONS AS FOLLOWS:

- HOPLAND Distance from the Forks of the Russian River to Hopland divided by the speed at Largo.
Tv.Tm = 19.2 mi./S.(Largo)
- CLOVERDALE Distance from Hopland to half-way point between Largo and Cumiskey
divided by the speed at Largo, plus half-distance between gauges divided by
speed at Cumiskey, plus distance from Cumiskey to Cloverdale divided
by the speed at Cumiskey.
Tv.Tm. = 1.7 mi./S.(Largo) + (6.6 mi.+6.7 mi.)/S.(Cumiskey)
- HEALDSBURG Distance from Cloverdale to half-way point between Cumiskey and Healdsburg gauges
divided by the speed at Cumiskey, plus half-distance between gauges divided
by the speed at Healdsburg, plus the distance between Healdsburg gauge and 101
bridge divided by the speed at Healdsburg.
Tv.Tm. = 10.8 mi./ S.(Cumiskey) + (17.5 mi.+ 2.2 mi.)/S.(Healdsburg)
- WOHLER Distance from Healdsburg 101 bridge to half-way point between Healdsburg and
Hacienda Bridge gauges divided by the speed at Healdsburg gauge, plus the distance
from the half-way point to Wohler bridge divided by the speed at Hacienda.
Tv.Tm. = 4.5 mi./S(Hacienda) + 3.4 mi./S.(Hacienda)
- GUERNEVILLE Distance from Wohler bridge to Hacienda Bridge gauge divided by the speed at Hacienda
plus the distance from Hacienda to Guerneville divided by the speed at Hacienda.
Tv.Tm. = 3.3 mi./S.(Hacienda) + 6.2 mi.)/S.(Hacienda)

Table E.1. Summary of cumulative travel times calculated by various methods for the Russian River between Hopland and Guerneville.

Discharge	Cumulative time from Hopland to:			
	Clovd1.	Hldsbg.	Wohler	Grnvl.
218-313				
Measured	17.8	58.2	63.8	71.2
400				
Flood	11.7	31.9		78.6
Regressed	11.3	39.2	48.0	60.2
1000				
Flood	8.4	22.6		56.3
Eye Fit	7.5	27.0	35.9	51.7
Regressed	8.1	27.7	34.0	43.0
2000				
Flood	6.6	18		46.3
Eye Fit	5.6	19.9	25.7	35.2
Regressed	6.4	21.3	26.2	33.3
Form.1	8.0	21.2	24.2	
Form.2	8.0	21.4	24.4	
Travel times using velocities for discharges during HCHO spill *				
Picked	6.8	22.1	27.0	34.3
Regress.	6.8	22.0	26.6	32.8
4000				
Flood	5.2	15.5		38.4
Regressed	5.0	16.4	20.2	25.8
6000				
Flood	4.7	14.0		34.6
Eye Fit	3.9	13.4	16.7	21.4
Regressed	4.3	14.1	17.4	22.3
8000				
Flood	4.2	12.9		33.5
Regressed	3.9	12.6	15.6	20.0
10,000				
Flood	3.8	11.9		30.9
Eye Fit	3.5	11.5	14.2	18.0
Regressed	3.6	11.6	14.3	18.5
15,000				
Eye Fit	3.4	10.4	12.6	15.8
Regressed	3.2	10.0	12.4	16.0
20,000				
Flood	2.8	9.9		29.9
Eye Fit	3.3	9.7	11.7	14.7
Regressed	2.9	9.0	11.2	14.4
40,000				
Flood	2.3	8.9		23.0
Regressed	2.3	7.1	8.7	11.3

Flood - U.S. Army Corps of Engineers' data

Eye Fit - best curve fit-by-eye through raw velocity data

Regressed - Root function curve obtained by least squares regression

* Travel times calculated using velocity rates corresponding to various discharges during formalin spill. (Discharges averaged over time of two peaks.)

Hopland: discharge rate = 1200; speed = 2.2

Cloverdale: discharge rate = 1700; speed = 2.2

Healdsburg: discharge rate = 2000; speed = 1.9

Guerneville: discharge rate = 3000; speed = 1.3

Travel times calculated from regression curve speeds.
 Speeds are from fractional exponent curve forced through 0,0.

	1000			2000			6000			300 cfs	
	Mi.Fks. (Miles)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)		Cum.Hrs. (Hours)
Forks	0		0	0		0		0		0.0	0
Vichy Spgs.	3										2.7
Rus.Rv.Est.	11.9										10.8
Largo Gauge	14.3	1.9			2.37			3.37			12.5
Hopland	19.2		10.1	10.1		8.1	8.1		5.7	5.7	16.1
Cumiskey	27.5	1.84			2.36			3.51			24.2
Cloverdale	34.2		8.1	18.2		6.4	14.5		4.3	10.0	33.9
Asti	38.35										42.4
Geyserville	44.1										54.6
Soda Rock Ln	50.3										62.3
Rio Lindo	58.4										69.3
Healdbg. Gg.	62.5	1.44			1.90			2.94			
Heald.101 Br	64.7		19.6	37.8		14.9	29.4		9.8	19.8	74.3
Foreman Ln	65.6										74.8
Wohler Br.	72.6		6.3	44.1		4.9	34.3		3.3	23.1	79.8
Mirabel Pk.	73.85										81
Cooks Bch.	74.8										81.7
Hacienda Br.	75.9	1.06			1.34			1.93			
Guerneville	82.1		9.0	53.1		7.1	41.4		4.9	28.0	87.3

	10000			15000			20000			
	Mi.Fks. (Miles)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)
Forks	0		0	0		0		0		0
Vichy Spgs.	3									
Rus.Rv.Est.	11.9									
Largo Gauge	14.3	3.97			3.99			3.97		
Hopland	19.2		4.8	4.8		4.8	4.8		4.8	4.8
Cumiskey	27.5	4.22			4.88			5.42		
Cloverdale	34.2		3.6	8.4		3.2	8.0		2.9	7.7
Asti	38.35									
Geyserville	44.1									
Soda Rock Ln	50.3									
Rio Lindo	58.4									
Healdbg. Gg.	62.5	3.6			4.23			4.74		
Heald.101 Br	64.7		8.0	16.4		6.9	14.8		6.1	13.9
Foreman Ln	65.6									
Wohler Br.	72.6		2.7	19.2		2.4	17.2		2.1	16.0
Mirabel Pk.	73.85									
Cooks Bch.	74.8									
Hacienda Br.	75.9	2.29			2.62			2.89		
Guerneville	82.1		4.1	23.3		3.6	20.8		3.3	19.3

Additional travel time calculations from regression curves

SITE	Mi.Fks. (Miles)	400			4000		
		Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)
Forks	0		0	0		0	0
Vichy Spgs.	3						
Rus.Rv.Est.	11.9						
Largo Gauge	14.3	1.42			2.96		
Hopland	19.2		13.5	13.5		6.5	6.5
Cummiskey	27.5	1.32			3.03		
Cloverdale	34.2		11.3	24.8		5.0	11.5
Asti	38.35						
Geyserville	44.1						
Soda Rock Ln	50.3						
Rio Lindo	58.4						
Healdbg. Gg.	62.5	1			2.5		
Heald.101 Br	64.7		27.9	52.7		11.4	22.9
Foreman Ln.	65.6						
Wohler Br.	72.6		8.9	61.5		3.8	26.7
Mirabel Pk	73.85						
Cooks Bch	74.8						
Hacienda Br.	75.9	0.78			1.69		
Guerneville	82.1		12.2	73.7		5.6	32.3

SITE	Mi.Fks. (Miles)	8000			40000		
		Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)
Forks	0		0	0		0	0
Vichy Spgs.	3						
Rus.Rv.Est.	11.9						
Largo Gauge	14.3	3.69			3.97		
Hopland	19.2		5.2	5.2		4.8	4.8
Cummiskey	27.5	3.89			6.95		
Cloverdale	34.2		3.9	9.1		2.3	7.2
Asti	38.35						
Geyserville	44.1						
Soda Rock Ln	50.3						
Rio Lindo	58.4						
Healdbg. Gg.	62.5	3.3			6.24		
Heald.101 Br	64.7		8.7	17.8		4.7	11.9
Foreman Ln.	65.6						
Wohler Br.	72.6		3.0	20.8		1.7	13.5
Mirabel Pk	73.85						
Cooks Bch	74.8						
Hacienda Br.	75.9	2.13			3.64		
Guerneville	82.1		4.5	25.2		2.6	16.2

Travel times calculated using speeds from best eye-fitted curve.

	1000			2000			6000			
	*****			*****			*****			
	Mi.Fks. (Miles)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)
Forks of River	0			0			0			0
Rus.Rv.Ests.	11.9									
Largo Gauge	14.3	2			2.7			3.6		
Hopland Br.	19.2		9.6	9.6		7.1	7.1		5.3	5.3
Pieta Creek	24.2									
Cummiskey Sta.	27.5	2			2.7			3.9		
Cloverdale	34.2		7.5	17.1		5.6	12.7		3.9	9.2
Asti Rv.Rd.Br.	38.35									
Geyserville	44.1									
Soda Rock Ln.	50.3									
Rio Lindo	58.4									
Healdbg. Gauge	62.5	1.4			1.9			2.9		
Heald.101 Br.	64.7		19.5	36.6		14.4	27.0		9.6	18.8
Wohler Br.	72.6		8.9	45.5		5.8	32.8		3.3	22.0
Mirabel Pk.	73.85									
Hacienda Br.	75.9	0.6			1			2		
Odd Fel.Br.	78.6									
Guerneville	82.1		15.8	61.3		9.5	42.3		4.8	26.8

	10000			15000			20000			
	*****			*****			*****			
	Mi.Fks. (Miles)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)	Speed (MPH)	Tv.Tm. (Hours)	Cum.Hrs. (Hours)
Forks of River	0			0			0			0
Rus.Rv.Ests.	7.4									
Largo Gauge	14.3	3.6			3.6			3.6		
Hopland Br.	19.2		5.3	5.3		5.3	5.3		5.3	5.3
Pieta Creek	24.2									
Cummiskey Sta.	27.5	4.3			4.6			4.7		
Cloverdale	34.2		3.6	8.9		3.4	8.7		3.3	8.6
Asti Rv.Rd.Br.	38.35									
Geyserville	44.1									
Soda Rock Ln.	50.3									
Rio Lindo	58.4									
Healdbg. Gauge	62.5	3.6			4.2			4.8		
Heald.101 Br.	64.7		8.0	16.9		7.0	15.7		6.4	15.0
Wohler Br.	72.6		2.6	19.5		2.2	17.9		2.0	17.0
Mirabel Pk.	73.85									
Hacienda Br.	75.9	2.5			3			3.2		
Odd Fel.Br.	78.6									
Guerneville	82.1		3.8	23.3		3.2	21.1		3.0	20.0

SPEEDS MEASURED AT DISCHARGE RATES OF 210 TO 313 CFS AT HEALDSBURG.
 JUNE, 1987

SITE	Mi.Fks.*	DIST. (Miles)	DIST/2 (Miles)	SPEED (MPH)	TRV.TM. (Hours)	FORKS	HOPLAND
						CUMM.TM. (Hours)	CUMM.TM. (Hours)
FORKS OF RIVER	0			1.49	0.0	0.0	
VICHY SPGS. RD.	3	3	1.5	0.873	2.72	2.7	
RUS. RIV. ESTS	11.9	8.9	4.45	1.48	8.10	10.8	
LARGO GAUGE	14.3	2.4	1.2	1.38	1.68	12.5	
HOPLAND BRIDGE	19.2	4.9			3.55	16.1	0.0
PIETA CREEK	24.2	5	4.95	1.11	4.50	20.6	4.5
CUMMISKEY STATION	27.5	3.3	1.65	0.773	3.62	24.2	8.1
CLOVDL. BRIDGE	34.2	6.7	3.35	0.626	9.69	33.9	17.8
ASTI-RIV.RD.BRG.	38.35	4.15	2.075	0.394	8.58	42.4	26.4
GEYSERVL. BRG.	44.1	5.75	2.875	0.586	12.20	54.6	38.6
SODA ROCK LANE	50.3	6.2	3.1	1.29	7.69	62.3	46.3
RIO LINDO ACAD.	58.4	8.1	4.05	1.05	7.00	69.3	53.3
HEALDSBG.GAUGE	62.5						
HLDSBG.101 BRG.	64.7	6.3			4.96	74.3	58.2
FOREMAN LANE	65.6	0.9	3.6	1.76	0.51	74.8	58.8
WOHLER BRIDGE	72.6	7			5.03	79.8	63.8
MIRABEL PARK	73.85	1.25	4.125	1.07	1.17	81.0	64.9
COOKS BEACH	74.8	0.95	0.475	1.63	0.74	81.7	65.7
HACIENDA BRIGDE	75.9						
ODD FELLOWS PK.	77.5	2.7	1.35	1.83	1.57	83.3	67.3
ODD FELLOWS BRG.	78.6	1.1	0.55	1.1	0.80	84.1	68.1
GUERNVL. BRIDGE	82.1	3.5			3.18	87.3	71.2

*Mi.Fks. = Miles downstream from Forks

General formula for calculation of travel times:

Half-distance between gauging sites divided by the velocity (mph) at the upstream gauge plus the half-distance divided by the velocity at the downstream gauge.

COMPARISON OF TRAVEL TIMES
FOR DISCHARGE RATES OF APPROXIMATELY 2000 cfs AT HEALDSBURG

SITE	MI.FKS. (Miles)	DIST. (Miles)	FORMALIN DATA PEAK 1			SPEED (MPH)	FORMALIN DATA PEAK 2			SPEED (MPH)
			TRV.TM. (Hours)	CUM PLUS (Hours)	TRV.TM. (Hours)		CUM.HRS. (Hours)			
FORKS	0	0	0			0				
LARGO	14.3	14.3								
HOPLND	19.2	4.9	0	0		19.2		0		
CUM.STA.	27.5	8.3								
CLOV	34.2	6.7	0	8		34.2	8	8	1.88	
HL.D.GAGE	62.5	28.3								
HEALD	64.7	2.2	13.2	21.2	2.31	64.7	13.36	21.36	2.28	
WOHLER	72.6	7.9	3	24.2	2.63	72.6	3	24.36	2.63	
HACIENDA	76.6	4								
GUERN	82.1	5.5				82.1				

SPEED AT FLOW RATES OF FORMALIN SPILL*
*****SPEEDS FROM EYE PICKED CURVE*****

SITE	MI.FKS. (Miles)	TRAVEL TIME		
		SPEED (MPH)	TRV.TM. (Hours)	CUM.T.T. (Hours)
FORKS			0.0	
LARGO		2.2		
HOPLND	19.2		8.7	0.0
CUM.STA.		2.2		
CLOV	34.2		6.8	6.8
HL.D.GAGE		1.9		
HEALD	64.7		15.3	22.1
WOHLER			4.9	27.0
HACIENDA		1.3		
GUERN	82.1		7.3	34.3

SPEEDS FROM REGRESSION CURVE
TRAVEL TIME

SITE	MI.FKS. (Miles)	TRAVEL TIME		
		SPEED (MPH)	TRV.TM. (Hours)	CUM.T.T. (Hours)
FORKS				
LARGO		2.01		
HOPLND	19.2		9.6	0.0
CUM.STA.		2.23		
CLOV	34.2		6.8	6.8
HL.D.GAGE		1.9		
HEALD	64.7		15.2	22.0
WOHLER			4.5	26.6
HACIENDA		1.53		
GUERN	82.1		6.2	32.8

* Discharges during formalin spill:
LARGO (Peak 2) - 1200 cfs
CUMMISKEY (Peak 1) - 2000 cfs
(Peak 2) - 1400 cfs
Average - 1700 cfs
HEALDSBURG (Peak 1) - 2100 cfs
(Peak 2) - 1950 cfs
Average - 2000 cfs
HACIENDA (Peak 1) - 3000 cfs

USACOE FLOOD CREST DATA AT 2000 CFS

SITE	MI.FKS. (Miles)	TRV.TM. (Hours)	CUM.HRS. (Hours)	SPEED (MPH)
FORKS				
LARGO				
HOPLND	19.2	0	0	
CUM.STA.				
CLOV	34.2	6.56	6.56	1.89
HL.D.GAGE				
HEALD	64.7	11.44	18	3.33
WOHLER				
HACIENDA				
GUERN	82.1	28.29	46.29	0.54

OCTOBER, 1973 ACCIDENTAL RELEASE

SITE	TV.TM. (Hours)	CUM.HRS. (Hours)	SPEED (MPH)*
FORKS			
LARGO			
HOPLND	1.75	0	(2.8)
CUM.STA.	3	3	
CLOV			(2.5)
HL.D.GAGE	14.25	17.25	
HEALD			
WOHLER			(2.7)
HACIENDA	5.25	22.5	
GUERN			

* Average MPH between gauges