APPENDICES

APPENDIX A -- POTENTIAL SURVEY DATA, mV vs. Cu/$CuSO_4$ REFERENCE ELECTRODE

APPENDIX A -- Potential Survey Data, mV vs $Cu/CuSO_4$ Reference Electrode

EAST Side (Sections 1 and 2 combined)

Grid ID				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	in			3	9	15	21	27	33	39	45	51	57	63	69	75	81	87	93	99	105	111	117
		ft		0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75
			m	0.076	0.229	0.381	0.533	0.686	0.838	0.991	1.143	1.295	1.448	1.600	1.753	1.905	2.057	2.210	2.362	2.515	2.667	2.819	2.972
A	3	0.25	0.076	-355	-351	-372	-410	-373	-324	-295	-440	-403	-405	-428	-376	-376	-378	-488	-388	-375	-388	-396	-392
B	9	0.75	0.229	-256	-398	-474	-488	-489	-437	-411	-415	-411	-396	-396	-366	-355	-348	-342	-332	-366	-372	-383	-380
C	15	1.25	0.381	-411	-436	-479	-480	-470	-427	-372	-382	-369	-364	-350	-347	-319	-319	-346	-329	-326	-325	-319	-329
D	21	1.75	0.533	-427	-431	-440	-437	-433	-396	-373	-371	-389	-393	-354	-348	-324	-332	-349	-348	-331	-324	-304	-303
E	27	2.25	0.686	999	-430	-411	-424	-432	-408	-371	-375	-384	-374	-347	-394	-405	-432	-419	-411	-394	-363	-330	-325
F	33	2.75	0.838	999	-384	-413	-426	-428	-431	-422	-473	-419	-389	-354	-434	-461	-479	-461	-456	-476	-444	-408	-414
G	39	3.25	0.991	999	999	-420	-450	-431	-435	-432	-466	-442	-382	-356	-394	-418	-468	-478	-493	-518	-485	-462	-429

Grid ID				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
	in			123	129	135	141	147	153	159	165	171	177	183	189	195	201	207	213	219	225	231	237
		ft		10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	19.25	19.75
			m	3.124	3.277	3.429	3.581	3.734	3.886	4.039	4.191	4.343	4.496	4.648	4.801	4.953	5.105	5.258	5.410	5.563	5.715	5.867	6.020
A	3	0.25	0.076	-398	-403	-424	-403	-385	-377	-373	-370	-366	-386	-411	-424	-417	-379	-371	-355	-354	-356	-359	-385
B	9	0.75	0.229	-392	-407	-416	-392	-379	-371	-360	-368	-359	-374	-417	-421	-406	-390	-373	-362	-359	-356	-375	-386
C	15	1.25	0.381	-335	-369	-377	-330	-330	-324	-315	-345	-344	-347	-405	-382	-374	-370	-319	-341	-349	-352	-356	-368
D	21	1.75	0.533	-310	-319	-310	-302	-299	-305	-285	-287	-308	-298	-361	-337	-317	-316	-309	-310	-319	-300	-298	-296
E	27	2.25	0.686	-310	-337	-358	-308	-312	-298	-292	-310	-305	-310	-403	-340	-307	-322	-302	-336	-378	-369	-337	-308
F	33	2.75	0.838	-357	-354	-388	-348	-342	-321	-312	-325	-340	-336	-371	-371	-324	-335	-340	-382	-472	-438	-368	-335
G	39	3.25	0.991	-405	-388	-425	-390	-383	-352	-339	-380	-459	-394	-380	-390	-402	-378	-385	-407	-480	-461	-391	-386

Grid ID				41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
	in			243	249	255	261	267	273	279							321	327	333	339	345	351	357
		ft		20.25	20.75	21.25	21.75	22.25	22.75	23.25							26.75	27.25	27.75	28.25	28.75	29.25	29.75
			m	6.172	6.325	6.477	6.629	6.782	6.934	7.087							8.153	8.306	8.458	8.611	8.763	8.916	9.068
A	3	0.25	0.076	-390	-401	-414	-393	-390	-398	-399							-317	-285	-298	-309	-278	-294	-272
B	9	0.75	0.229	-386	-410	-429	-372	-388	-387	-387							-315	-314	-310	-314	-308	-311	-289
C	15	1.25	0.381	-385	-407	-342	-347	-379	-379	-380							-311	-312	-310	-310	-305	-315	-300
D	21	1.75	0.533	-317	-313	-327	-353	-353	-364	-389							-290	-290	-306	-310	-310	-319	-302
E	27	2.25	0.686	-335	-336	-337	-351	-351	-349	-373							-320	-332	-339	-318	-330	-329	-333
F	33	2.75	0.838	-350	-334	-355	-395	-410	-375	-376							-339	-352	-359	-334	-362	-366	-364
G	39	3.25	0.991	-355	-354	-362	-417	-447	-397	-389							-428	-418	-392	-407	-404	-425	-435

Grid ID				61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	in			363	369	375	381	387	393	399	405	411	417	423	429	435	441	447	453	459	465	471	477
		ft		30.25	30.75	31.25	31.75	32.25	32.75	33.25	33.75	34.25	34.75	35.25	35.75	36.25	36.75	37.25	37.75	38.25	38.75	39.25	39.75
			m	9.220	9.373	9.525	9.678	9.830	9.982	10.135	10.287	10.440	10.592	10.744	10.897	11.049	11.202	11.354	11.506	11.659	11.811	11.964	12.116
A	3	0.25	0.076	-268	-277	-308	-310	-317	-318	-330	-344	-355	-346	-351	-354	-341	-328	-331	-301	-318	-331	-331	-343
B	9	0.75	0.229	-294	-294	-306	-320	-323	-318	-331	-345	-350	-345	-341	-346	-341	-343	-356	-329	-339	-334	-338	-347
C	15	1.25	0.381	-290	-313	-321	-321	-320	-319	-322	-338	-341	-341	-345	-349	-350	-355	-349	-350	-367	-328	-338	-345
D	21	1.75	0.533	-296	-298	-309	-320	-323	-330	-310	-324	-339	-339	-346	-376	-358	-373	-352	-373	-377	-356	-342	-324
E	27	2.25	0.686	-318	-313	-328	-340	-333	-334	-302	-326	-330	-343	-355	-351	-352	-391	-378	-374	-387	-372	-353	-343
F	33	2.75	0.838	-350	-328	-356	-362	-350	-344	-331	-343	-338	-352	-362	-356	-362	-336	-349	-374	-388	-396	-377	-369
G	39	3.25	0.991	-407	-401	-397	-380	-369	-369	-366	-364	-358	-380	-394	-395	-390	-366	-384	-409	-415	-433	-389	-395

Grid ID				81	82	83	84	85	86	87	88	89	90	91	92	93	94
	in			483	489	495	501	507	513	519	525	531	537	543	549	555	561
		ft		40.25	40.75	41.25	41.75	42.25	42.75	43.25	43.75	44.25	44.75	45.25	45.75	46.25	46.75
			m	12.268	12.421	12.573	12.726	12.878	13.030	13.183	13.335	13.488	13.640	13.792	13.945	14.097	14.250
A	3	0.25	0.076	-350	-354	-327	-324	-323	-334	-344	-314	-299	-304	-314	-315	-330	-307
B	9	0.75	0.229	-342	-340	-331	-326	-331	-329	-329	-308	-291	-298	-299	-310	-313	-312
C	15	1.25	0.381	-346	-351	-345	-331	-317	-308	-311	-302	-291	-296	-304	-325	-321	-312
D	21	1.75	0.533	-327	-335	-324	-326	-326	-312	-317	-330	-321	-321	-324	-342	-335	-313
E	27	2.25	0.686	-342	-350	-336	-339	-344	-333	-327	-324	-336	-345	-341	-340	-347	-327
F	33	2.75	0.838	-363	-363	-357	-359	-360	-372	-367	-340	-379	-406	-396	-389	-382	-371
G	39	3.25	0.991	-401	-389	-380	-393	-414	-423	-410	-387	-414	-458	-443	-463	-432	-395

WEST Side (Sections 1 and 2 combined)

Grid ID				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	in			3	9	15	21	27	33	39	45	51	57	63	69	75	81	87	93	99	105	111	117
		ft		0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75
			m	0.076	0.229	0.381	0.533	0.686	0.838	0.991	1.143	1.295	1.448	1.600	1.753	1.905	2.057	2.210	2.362	2.515	2.667	2.819	2.972
A	3	0.25	0.076	-342	-314	-341	-288	-277	-281	-260	-245	-233	-260	-246	-253	-298	-274	-258	-320	-327	-346	-345	-329
B	9	0.75	0.229	-294	-338	-301	-290	-325	-291	-361	-310	-306	-291	-288	-283	-302	-288	-256	-349	-383	-325	-330	-293
C	15	1.25	0.381	-399	-391	-373	-430	-438	-413	-375	-359	-358	-347	-332	-338	-330	-325	-341	-364	-399	-356	-362	-325
D	21	1.75	0.533	-401	-358	-422	-463	-475	-440	-369	-340	-341	-334	-321	-334	-324	-343	-364	-369	-359	-355	-330	-312
E	27	2.25	0.686	-414	-372	-408	-468	-444	-429	-353	-361	-348	-342	-350	-352	-330	-331	-371	-400	-387	-356	-330	-322
F	33	2.75	0.838	-423	-420	-400	-464	-483	-457	-441	-394	-359	-345	-368	-359	-334	-341	-352	-380	-390	-383	-370	-364
G	39	3.25	0.991	-413	-428	-432	-467	-489	-478	-498	-406	-356	-345	-364	-358	-352	-356	-366	-358	-374	-394	-382	-378

Grid ID				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
	in			123	129	135	141	147	153	159	165	171	177	183	189	195	201	207	213	219	225	231	237
		ft		10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	19.25	19.75
			m	3.124	3.277	3.429	3.581	3.734	3.886	4.039	4.191	4.343	4.496	4.648	4.801	4.953	5.105	5.258	5.410	5.563	5.715	5.867	6.020
A	3	0.25	0.076	-306	-325	-357	-369	-382	-385	-393	-401	-387	-400	-391	-380	-398	-378	-365	-357	-360	-360	-356	-356
B	9	0.75	0.229	-342	-352	-367	-385	-361	-363	-395	-412	-393	-416	-407	-382	-368	-374	-366	-360	-366	-344	-351	-350
C	15	1.25	0.381	-321	-338	-349	-363	-379	-404	-376	-364	-348	-398	-395	-365	-344	-355	-330	-325	-320	-320	-316	-334
D	21	1.75	0.533	-300	-311	-336	-350	-359	-374	-343	-326	-309	-326	-352	-327	-337	-327	-323	-328	-340	-346	-342	-349
E	27	2.25	0.686	-325	-321	-330	-322	-317	-320	-313	-306	-325	-306	-210	-318	-326	-329	-321	-345	-361	-371	-362	-352
F	33	2.75	0.838	-374	-345	-356	-358	-360	-338	-320	-334	-336	-318	-174	-320	-337	-340	-340	-371	-392	-396	-369	-367
G	39	3.25	0.991	-435	-357	-338	-376	-418	-364	-350	-379	-409	-355	-242	-352	-361	-355	-370	-388	-426	-414	-382	-376

Grid ID				41	42	43	44	45	46	47	54	55	56	57	58	59	60
	in			243	249	255	261	267	273	279	321	327	333	339	345	351	357
		ft		20.25	20.75	21.25	21.75	22.25	22.75	23.25	26.75	27.25	27.75	28.25	28.75	29.25	29.75
			m	6.172	6.325	6.477	6.629	6.782	6.934	7.087	8.153	8.306	8.458	8.611	8.763	8.916	9.068
A	3	0.25	0.076	-364	-355	-362	-370	-391	-404	-413	-318	-333	-367	-369	-295	-331	-261
B	9	0.75	0.229	-347	-342	-356	-368	-371	-397	-405	-308	-350	-366	-371	-349	-338	-329
C	15	1.25	0.381	-309	-326	-335	-344	-365	-379	-403	-327	-345	-373	-385	-363	-364	-325
D	21	1.75	0.533	-344	-331	-339	-344	-373	-381	-364	-329	-320	-377	-415	-368	-346	-327
E	27	2.25	0.686	-360	-360	-357	-356	-367	-377	-355	-304	-301	-333	-343	-339	-350	-351
F	33	2.75	0.838	-372	-354	-378	-374	-378	-360	-357	-330	-308	-323	-311	-342	-375	-352
G	39	3.25	0.991	-345	-298	-355	-404	-416	-392	-387	-373	-389	-349	-366	-376	-381	-385

Grid ID				61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	in			363	369	375	381	387	393	399	405	411	417	423	429	435	441	447	453	459	465	471	477
		ft		30.25	30.75	31.25	31.75	32.25	32.75	33.25	33.75	34.25	34.75	35.25	35.75	36.25	36.75	37.25	37.75	38.25	38.75	39.25	39.75
			m	9.220	9.373	9.525	9.678	9.830	9.982	10.135	10.287	10.440	10.592	10.744	10.897	11.049	11.202	11.354	11.506	11.659	11.811	11.964	12.116
A	3	0.25	0.076	-268	-291	-312	-316	-320	-333	-346	-336	-329	-335	-320	-337	-372	-348	-358	-314	-333	-361	-349	-334
B	9	0.75	0.229	-318	-310	-315	-306	-316	-333	-323	-331	-341	-333	-334	-337	-359	-393	-336	-304	-312	-313	-338	-311
C	15	1.25	0.381	-315	-330	-323	-320	-314	-332	-329	-351	-344	-328	-320	-282	-296	-401	-315	-268	-281	-294	-311	-312
D	21	1.75	0.533	-308	-334	-328	-323	-330	-324	-328	-333	-341	-323	-337	-324	-301	-349	-348	-319	-346	-325	-341	-342
E	27	2.25	0.686	-318	-318	-329	-382	-387	-340	-307	-320	-342	-344	-346	-338	-340	-349	-333	-346	-364	-347	-363	-366
F	33	2.75	0.838	-347	-371	-371	-401	-383	-359	-312	-339	-341	-336	-359	-362	-373	-375	-377	-394	-388	-379	-382	-408
G	39	3.25	0.991	-398	-372	-400	-399	-374	-381	-357	-357	-356	-376	-383	-418	-412	-399	-423	-454	-429	-417	-411	-438

Grid ID				81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
	in			483	489	495	501	507	513	519	525	531	537	543	549	555	561	567
		ft		40.25	40.75	41.25	41.75	42.25	42.75	43.25	43.75	44.25	44.75	45.25	45.75	46.25	46.75	47.25
			m	12.268	12.421	12.573	12.726	12.878	13.030	13.183	13.335	13.488	13.640	13.792	13.945	14.097	14.250	14.402
A	3	0.25	0.076	-329	-351	-344	-360	-341	-328	-327	-311	-317	-307	-255	-240	-233	-294	12.421 -270
B	9	0.75	0.229	-312	-334	-344	-334	-302	-280	-281	-281	-255	-224	-224	-203	-195	-194	-197
C	15	1.25	0.381	-302	-299	-334	-341	-328	-289	-284	-281	-263	-252	-238	-222	-224	-211	-184
D	21	1.75	0.533	-339	-328	-340	-330	-334	-317	-309	-305	-303	-313	-314	-264	-269	-304	-320
E	27	2.25	0.686	-347	-341	-330	-329	-315	-323	-327	-320	-313	-327	-349	-352	-335	-356	-349
F	33	2.75	0.838	-417	-394	-379	-349	-323	-334	-348	-350	-339	-354	-373	-364	-397	-401	-415
G	39	3.25	0.991	-439	-434	-407	-400	-365	-369	-371	-369	-386	-404	-384	-390	-432	-439	999

APPENDIX B -- CONCRETE PETROGRAPHY

APPENDIX B – Concrete Petrography: Component Definitions

B.1 FINE AGGREGATE DEFINITIONS

B.1.1 Rock fragments

Chert, cryptocrystalline or microcrystalline SiO_2, is a very abundant constituent of the fine aggregate. There is a continuous gradation of crystal sizes from too small to be resolved under a light microscope to distinguishable crystals. Larger crystals grade into quartzite. Some grains have iron oxide filling fractures or permeating the rock. Clay or micaceous inclusions and alignment of mica flakes in some grains indicates that some of the chert borders on being schist. This category includes agate, represented by a few fibrous microcrystalline quartz particles present in a thin section from core 69A/B.

Diorite and *andesite* consist primarily of plagioclase feldspar with ferromagnesian silicates, and small amounts of quartz. Diorite has larger mineral grains, and andesite finer ones.

Gneiss is a medium-grained metamorphic rock similar in mineralogy to schist, but having alternating layers of light and dark minerals. [**Note:** Many of the schist and gneiss fragments appear to have been derived from previously existing impure sandstones (graywacke); they contain similar mineral and rock fragments. Alignment of micaceous or acicular minerals is stronger in the metamorphic rocks.]

Granite consists primarily of coarse quartz and feldspar, with small amounts of ferromagnesian silicates. One fragment of rhyolite, the fine-grained equivalent of granite, was identified in a thin section from core 27F and is included in this category.

Graywacke is a sandstone that contains large proportions of minerals other than quartz. Mineral grains are usually quite angular, and the matrix is hematite and clay.

Mafic igneous and miscellaneous *metamorphic rocks* consist of pyroxene and other ferromagnesian silicate minerals, chromite and/or magnetite, olivine and/or serpentine. Iron oxide is generally abundant in these rock fragments.

Quartzite is similar to chert, with larger crystals of quartz intergrown with one another. Boundaries between crystals tend to be sutured, as is characteristic of metamorphic forms of quartz. Again, fracture fillings of iron oxide are common and there are some inclusions. Quartzite is another abundant constituent.

Sandstone contains grains of sub-angular to sub-rounded chert and quartz, with small amounts of feldspar and ferromagnesian silicates. Grains are bound together with hematite (iron oxide) and/or calcite.

Schist is a fine-grained metamorphic rock containing two or more of the following minerals (in order of abundance): quartz, mica, feldspar, iron oxides, ferromagnesian silicates, carbonate minerals, and opaque minerals (mostly pyrite and magnetite). In some cases, heavy iron oxide staining is present. Micaceous or acicular minerals are aligned, creating a direction of preferred breakage. Rock fragments

are frequently elongated in this direction. Schist grains tend to be larger than other fine aggregate constituents in the Rocky Point concrete.

Serpentinite is a metamorphic rock consisting predominantly of serpentine and residual olivine grains. Serpentine is a fibrous or micaceous silicate mineral that is a common product of the alteration of olivine-rich rocks.

Shale and *slate* are uncommon aggregate fragments; they are very fine grained and laminated. Their mineralogy includes clays and iron oxide.

Undifferentiated rock fragments were obscured by heavy iron oxide staining in some cases. Others apparently consist entirely of clay and iron oxide.

B.1.2 Mineral constituents

Carbonate includes fine-grained and coarse-grained calcite or dolomite ($(Ca,Mg)CO_3$). Fragments may be fine-grained limestone, coarse-grained vein carbonate, or portions of shells.

Feldspar is a group of silicate minerals; those in these cores are usually orthoclase (K feldspar), although some plagioclase (Ca-Na) feldspar is also present. Some are very altered and have clay minerals along cleavage planes or dispersed throughout the grain.

Ferromagnesian silicates are silicate minerals rich in iron, magnesium, and sometimes calcium. If exposed to weathering, they may deteriorate rapidly into iron oxide and clays.

Opaque minerals do not transmit light. It is not possible to determine optical properties for these minerals; however, examination of the sections under a binocular microscope shows that the dominant opaque species are pyrite and magnetite.

Quartz refers to individual crystals of SiO_2. Many of them demonstrate optical properties that are indicative of metamorphic quartz.

B.1.3 Other constituents

Holes fall into two categories: those that were present in the concrete before sample preparation, and those that were created during sample preparation by grain plucking. Only pores that were circular or nearly so were counted, in order that those created during sample preparation were not included. The concrete porosity may be underestimated by this method of determination.

Slag fragments occur only in the two sections prepared from patch concrete cores 30B and 36A. These are almost completely devitrified and have some angular edges, indicating that the fine aggregate was prepared by crushing coarser material.

Wood is a rare constituent.

B.2 COARSE AGGREGATE DEFINITIONS

B.2.1 Rock constituents

Chert and quartzite. (see Fine Aggregate, Rock Fragments)

Clay balls are the result of extreme alteration of fine-grained igneous rocks. They consist of clay, iron oxide, and sometimes quartz, and differ from shale and slate in that they are not laminated and are usually reddish or tan in color.

Granite, diorite, and andesite. (see Fine Aggregate, Rock Fragments)

Mafic igneous rocks. (see Fine Aggregate, Rock Fragments)

Sandstone and graywacke sandstone. In the coarse aggregate, some graywacke fragments contain large grains of metamorphic and igneous rock types, including schist, chert, and diorite, in addition to the mineral fragments named in the description of the fine aggregate. These sedimentary rocks are cemented with iron oxides and clays, but sometimes have micaceous minerals between the grains. They have been apparently affected by a degree of metamorphism in the geologic past.

Schist and gneiss. Close examination of the schist fragments show that there are two varieties of schist: a muscovite mica schist, in which the fabric of the schist is delineated by bands of white muscovite mica, and a chlorite schist, in which green chlorite is the micaceous mineral present. Some aggregate fragments consist of chlorite schist interlayered with quartzite. The dominant lithology was used to categorize the fragment in these cases.

Serpentinite. (see Fine Aggregate, Rock Fragments)

Shale and slate. (see Fine Aggregate, Rock Fragments)

B.2.2 Other constituents

Wood. (see Fine Aggregate, Other Constituents)

B.2.3 Key to coarse aggregate mineral identification

The key to the labels in Figures 4.16 through Figure 4.21 is as follows:

Ch - chert
G - granitic to dioritic igneous rocks (both fine and coarse grained)
F - rock of indeterminate type, permeated with iron oxide
H - hole
Q - quartz or quartzite
S - schist
S/Q - intermixed schist and quartz
Ss - sandstone or graywacke sandstone
Serp - serpentinite

W - wood

B.3 DETAILED PETROGRAPHY RESULTS

B.3.1 Fine aggregate

Most of the thin sections were made from original concrete cores. The two made from two-inch cores are known to be from patch concrete. The fine aggregate in a thin section from three-inch core 69A was significantly different in mineralogy from that of the original concrete or of the known patch concrete.

The following sections describe the mineral and rock fragments found in the fine aggregate fraction of the concrete. The mean abundance and standard deviation for each fine aggregate component were derived from grain counts and are shown in Table 4.2. Variation in the abundance of less common constituents resulted, in some instances, in standard deviations larger than the mean values.

An immediately obvious difference between the fine aggregate components of the original and patch concretes, from a petrographic viewpoint, was the presence of devitrified slag particles in the known patch material (Patch 1 in Table 4.2). In comparison with the original concrete, the fine aggregate of the Patch 1 concrete contained more grains in the following categories: serpentinite, quartz, and feldspar. It contained fewer grains in the categories of chert and quartzite (silica); granite, diorite, and andesite; and fewer holes.

The average grain size of the patch concrete fine aggregate appeared somewhat coarser than the original concrete fine aggregate, although no quantitative size measurements were made. The aggregate-to-cement ratio was higher in the patch concrete, and much of the aggregate was iron-stained. Patch 1 concrete had relatively few holes in the cementitious matrix, and large areas of anisotropic matrix, i.e., the matrix had different optical properties in different coordinate directions.

The thin section from 3-inch core 69A/B (section ME3646A) was suspected to represent a different patch concrete mix than the known patch concrete, and was quite different from the original concrete. This different patch concrete mix was labeled Patch 2 in Table 4.2. Percentages of grains in the five categories that were most populated in Patch 2 material were greater than one standard deviation from the mean values for the same categories of the original concrete. Not enough grains were counted in the known patch concrete (Patch 1) thin sections to draw conclusions about the statistical likelihood that the two patch concrete mixtures were different. However, there were no slag fragments in the thin section of Patch 2. In addition, schist and gneiss were much more abundant and quartz much less common in Patch 2 than in the Patch 1 sections. Thus, it is suspected that the thin section of Patch 2 represents another patch concrete mix, perhaps used in a repair at a different time, or in a repair at the same time but from a different contractor or a different batch or concrete.

B.3.2 Coarse aggregate

The lithology of coarse aggregate fragments (greater than 2 mm) was determined in ten cores of original concrete and three cores of known patch concrete. A statistically significant number of aggregate particles was counted for the original concrete only.

Many constituents of the coarse aggregate fraction of the concrete are the same as those in the fine aggregate. Results of grain counts are shown in Table 4.3. Color photographs of the three-inch cores are paired with matching black-and-white versions, Figures 4.16 through 4.21. The coarse aggregate grains are visible in both photographs and are identified on the black-and-white version using the key given in Appendix B.2.3.

The differences between coarse aggregate constituents of the original and patch concretes are less obvious than they are for the fine aggregate. The apparent differences in abundance of chert/quartzite and granite/diorite are not statistically significant. In a qualitative visual comparison of the concrete cores, the coarse aggregate of the patch concrete was determined to have a smaller maximum size than that of the original concrete. No examination was made of the coarse aggregate in core 69A/B (Patch 2 in the discussion of fine aggregate).

B.3.3 Reaction products

When deterioration reactions occur in concrete, the reaction products fill cracks, pores, and voids and cross-cut pre-existing structures, occasionally pushing aggregate aside or splitting it along weak planes. Very few areas of the thin sections studied microscopically produced evidence of significant reaction products. However, traces of reaction products were observed in both the original concrete and the patch concrete cores.

Deteriorated areas of the Viaduct concrete, including areas under loosened aggregate grains, were examined macroscopically by ultra-violet light using a standard uranyl acetate application to reveal the presence of significant ASR products. None of the concrete exhibited the yellow-green fluorescence distinctive of ASR products.

No sodium-rich gel products or reaction rims were found by microscopic study that would indicate either ASR or ACR reactions had occurred in either the original concrete or in the patch areas studied. However, in all of the samples, fine aggregate materials in the cement include abundant quantities of cryptocrystalline quartz (some of which is of metamorphic origin), quartz-rich rocks, and plagioclase feldspar. These types of materials are considered to be important components of known ASR occurrences.

Another reaction mechanism that is known to cause damage to concrete is the formation of gypsum or ettringite through the sulfation reaction of calcium and aluminum. The reaction can result in the formation of relatively large crystals which results in expansive forces causing the concrete to crack. No sulfate minerals were detected in the concrete samples, although small pyrite crystals, a ready source of sulfur, were observed in some of the larger aggregate rock.

A thin section of concrete from near a corroded portion of the rebar showed significant hydrated iron oxide infusion of local areas of the concrete. The iron oxide stained the cement in its vicinity, forced its way into cracks in nearby aggregate materials, and caused nearby aggregate to shift position slightly within the concrete.

Sparse areas in a thin section from the original concrete and a thin section from Patch 2 had cross-

cutting veins of calcium carbonate material that indicate some reaction with carbonic, hydrochloric, or other acid. Both of these areas also contained fragments of shell material that were in the process of being solubilized and recrystallized into the carbonate veins. The carbonate veins were mixed with residual calcium oxide and calcium silicate hydrate cement material. The presence of shells suggests the source for some of the fine aggregate was beach sand. This fact would suggest the opportunity existed for contamination of the concrete by sea salt from the use of unwashed beach sand in the concrete mix.

Reactions within the aggregate materials themselves that occurred prior to incorporation into the concrete mixture were confined to individual grains. These veins and fracture fillings of such materials as quartz, opal, calcite, clays, and iron oxide minerals are common in aggregate materials, as are reaction rims, and are not part of the concrete deterioration process. They are formed from reactions between the original rock and altering solutions such as mineralized or acidic waters, either in their original depositional environments or under weathering or transport conditions.

In summary, the composition of the original concrete included a high amount of cryptocrystalline silica, sources of sodium in plagioclase feldspar and sea salt, and a source of sulfur in pyrite. These constituents are known to contribute to the formation of significant reaction products in hardened concrete. However, the petrographic results suggested that deterioration of the Rocky Point Viaduct was not due to their presence. The petrographic results indicated that chloride incorporation (from probable sea salt introduced with sand components), chloride penetration (from salt spray and fogs), and possibly some carbonation resulting in liberation of bound chlorides, caused corrosion of the rebar and deterioration of the original concrete.

Spot analysis indicated that the patch cement had an average composition higher in reactive Al_2O_3 and MgO than the original concrete. Elevated amounts of chloride penetrated both the original and patch concrete near the outside surface of the beam. Since chloride penetration rates depend primarily upon cement paste composition and type, the higher Al_2O_3 and MgO in the patch concrete may explain the higher amount of penetrated chloride in weathered surfaces of the patch concrete compare to the original concrete.

APPENDIX C -- SURFACE AIR PERMEABILITY, SCCC

APPENDIX C -- Surface Air Permeability, standard cubic centimeter/minute (mL/min)
EAST Side (Section 1)

Grid ID				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	in			3	9	15	21	27	33	39	45	51	57	63	69	75	81	87	93	99	105	111	117
		ft		0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75
			m	0.08	0.23	0.38	0.53	0.69	0.84	0.99	1.14	1.30	1.45	1.60	1.75	1.91	2.06	2.21	2.36	2.51	2.67	2.82	2.97
A	3	0.25	0.076	999	999	999	999	999	999	999	999	999	999	999	999	999	40.6	999	999	62.2	999	59	58
B	9	0.75	0.229	999	999	999	999	999	999	37	54.3	999	27.4	999	999	999	999	999	999	999	999	47	999
C	15	1.25	0.381	999	999	999	47.6	999	31.9	999	999	37.6	46.9	999	999	42.6	15.7	999	53.2	17.5	999	999	24.1
D	21	1.75	0.533	999	30.2	999	52.9	59.8	999	999	999	999	999	999	999	999	999	999	999	999	49.6	999	999
E	27	2.25	0.686	999	999	999	999	999	38.6	999	49.9	999	54.3	999	999	999	999	52.6	999	999	61.9	999	999
F	33	2.75	0.838	999	999	999	999	62.8	32	999	36	54.7	999	999	999	999	999	999	57.9	999	999	999	999
G	39	3.25	0.991	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	65.2	999	999	999	999

Grid ID				21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
	in			123	129	135	141	147	153	159	165	171	177	183	189	195	201	207	213	219	225	231	237
		ft		10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	19.25	19.75
			m	3.12	3.28	3.43	3.58	3.73	3.89	4.04	4.19	4.34	4.50	4.65	4.80	4.95	5.11	5.26	5.41	5.56	5.72	5.87	6.02
A	3	0.25	0.076	999	999	999	999	55.2	999	999	999	999	999	999	53.8	999	57.2	999	48.7	999	999	64.9	999
B	9	0.75	0.229	999	999	50.6	999	999	999	999	29.6	999	999	999	999	999	37.7	999	57.4	999	57.4	999	999
C	15	1.25	0.381	999	999	999	999	43.9	999	999	999	999	62.4	999	999	999	999	35.9	999	999	999	999	999
D	21	1.75	0.533	999	999	999	52.4	999	999	999	999	999	999	58.3	999	999	35	999	999	999	999	36	999
E	27	2.25	0.686	53.9	999	57.1	999	999	999	999	61.4	999	999	999	37.6	999	999	999	28.5	39.4	999	999	39.3
F	33	2.75	0.838	999	26.8	999	57.2	999	42.4	999	999	999	999	999	999	999	999	999	999	999	999	999	999
G	39	3.25	0.991	999	999	999	999	999	999	999	999	999	999	999	52.3	999	999	999	18.4	999	999	35.6	999

Grid ID				41	42	43	44	45	46	47
	in			243	249	255	261	267	273	279
		ft		20.25	20.75	21.25	21.75	22.25	22.75	23.25
			m	6.17	6.32	6.48	6.63	6.78	6.93	7.09
A	3	0.25	0.076	999	55.4	999	999	999	999	999
B	9	0.75	0.229	999	999	999	999	999	999	999
C	15	1.25	0.381	999	999	999	999	999	32.8	999
D	21	1.75	0.533	53.6	999	999	999	999	999	999
E	27	2.25	0.686	999	999	999	999	999	999	999
F	33	2.75	0.838	999	999	999	999	999	999	999
G	39	3.25	0.991	29.5	999	999	999	999	32	999

999 = missing data; no measurement.

APPENDIX D -- CHLORIDE PROFILE DATA AND ANALYSIS

APPENDIX D -- Chloride Profile Data and Analysis

D.1 ODOT POWDER SAMPLING APPARATUS FOR DETERMINING CHLORIDE ION CONCENTRATION IN CONCRETE

D1.1 Vacuum Collection Apparatus -- This system is designed to collect pulverized concrete powder from the hole produced by a rotary hammer in concrete. The powder is drawn though a 5/8-inch dia hollow bit by vacuum and collected in a #6 size cone coffee filter apparatus. See Figure 3.2.

Rotary hammer (large) -- For example, Bosch 11232EVS, Model 0-611-232-739, 8.8 amp, 950 watt; 450 RPM at 3750 BPM (beats per minute); a drill that produces powder more rapidly may plug the air hole in the drill bit.

Anchor Bore Air Bit -- Part No. AA62518, 5/8-inch dia., 16 1/2 inch usable length, 18 1/2 inch overall length rotary hammer drill bit; a conical secondary cutting head contains a vacuum hole at the tip for drawing powdered concrete out of the hole.
Anchor Bore Air System Adapter -- Part No. AA71368
Vacuum Cleaner Connector -- Part No. AA82543
(All manufactured by Heller Anchor Bore, Fraser MI 48026 (313-294-6066))

Wet/Dry Vacuum -- Shop Vac; use the standard vacuum hose end (1 1/4 inch dia.)

#6 Size Cone Coffee Filter Apparatus -- The powder filter apparatus connects the vacuum source to the Plastic Air Vacuum Head (included on Anchor Bore Air System Adapter, but ordered separately as Part No. AA10256) on the rotary hammer and collects the powder sample in a #6 standard cone-type coffee filter. The length of the 1/2 inch dia. hose should be as short as practical; this facilitates cleaning of the hose between samples and improves the performance of the vacuum system.

The powder filter requires the following items: 12 to 18 inches of 1/2 inch ID reinforced Tygon hose, one nylon 1/2 inch hose to 1/2 inch pipe adapter, one 1/2 inch SS hose clamp, two 1/2 inch O-rings (1/8 inch thick), two 1/2 inch conduit lock nuts, two 1 inch x 1/2 inch conduit reducing washers.

The filter container should have a top lip of 16 to 20 inches in circumference. This is the vacuum seal for the #6 cone-type coffee filter. A snap seal will facilitate removal of the filter containing the sample. Use a 1 to 1.6 quart Rubbermaid Servin' Saver Canister. Make a 13/16 inch hole in the center of the snap top and a 1 5/8 inch hole in the center of the container bottom for hose connectors.

Connection from the filter container to the vacuum hose requires the following items: one 1 1/2 x 1/4 NFS-dwv adapter (plastic drain pipe), one sink overflow washer, one 2 inch x 1 1/4 inch conduit reducing washer. A standard Shop Vac vacuum cleaner hose will fit into the drain pipe adapter. Place the threaded adapter end with the compression nut

inside the container and washers outside, and tighten the nut to form a vacuum seal.

Spacers -- Spacers for drilling concrete to incremental depths are **NOT** made using PVC pipe (PVC contains chloride and abraded fragments can contaminate the powder sample). Use instead 3/4-inch dia. polypropylene pipe (it contains no halogens). This type of pipe is made by Simtek PolyPro, SI 34PP150, and is available from Familian Northwest, Industrial Plastics Div., Washougal WA, (360-835-2129). A graduated series of spacers consists of polypropylene pipe sections each shorter in length from the previous spacer by ½ inch. Spacers go over the drill bit during concrete powder sampling. The impact hammer is allowed to drill into the concrete until the spacer snugly fits between the hammer and the concrete. At this point the ½ inch deep sample has been taken. The next sample will use the next shorter spacer.

Dust removal snoot -- This is a 24 inch long piece of 1/4-inch dia SS tube attached by duct tape (and possibly a tubing fitting to give a better fit to the vacuum line) to a Shop Vac vacuum cleaner. It is used to suck out any debris remaining in the drill hole between samples to prevent cross-contamination of samples.

D.1.2 Sampling and Analytical Procedures

Sample collection -- The powder filter apparatus/rotary hammer/hollow drill apparatus is used in conjunction with spacers to incrementally removed pulverized concrete samples from the concrete. Take samples at 1/2 inch deep increments using the graduated series of spacers the positions the drill bit from 0 to 15 inches into concrete structures. Typically, pulverized concrete powder samples are collected from 3 side-by-side holes to increase the volume of the sample for chemical analysis. The powder samples are collected on the #6 size coffee filters. Using a powder funnel, the samples in the coffee filters are emptied into clear vials with thumb tab caps (for example, U.S. Plastics Part No. 81006, 1.24 inch dia x 2 7/8 inch long) for submission to the chemistry laboratory for analysis.

The last sample or two at the bottom of a hole, as the hole breaks through the backside of the beam, can result in incomplete sample collection. Typically, as the concrete breaks away, only a small sample is collected . Because of this, a series of samples is taken from the opposite (back) side of the beam, overlapping the original hole by 1 1/2 inches (3 to 6 samples). In this way, the frontside and backside sample results can be pieced together into a seamless chloride profile with good sampling practice for all samples collected. <u>All samples designated as backside samples are drilled in a direction counter to that of the frontside samples.</u>

Elimination of sample cross-contamination -- Cross contamination between successive samples is eliminated by cleaning the vacuum line, the hollow drill, the powder filter apparatus, and the drill hole between samples to remove any powder remaining form the prior sample. This is done by tapping the drill to shake dust out of the hollow tube, tapping the vacuum line to the powder filter apparatus and the powder filter apparatus (while open after removing the prior sample) to shake out dust or powder. The dust

removal snoot is inserted into each drilled hole between sampling and the hole is vacuumed out to remove any remaining powder before the next sample is collected (drilled).

Sample analysis -- The powder sample is analyzed for water soluble (Cl_w) and acid soluble (total Cl_t) chloride and for calcium (Ca). The techniques for Cl and Ca analysis are given in AASHTO T 260-94, "Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials," (*AASHTO, 1995b*). Calcium concentrations are also determined for each powder sample and used to correct the Cl values for the amount of aggregate contained in the powder sample. The chloride ion detection limits were 0.12 kg/m^3 (0.2 lb/yd^3) for total chloride content and 0.06 kg/m^3 (0.1 lb/yd^3) for the water-soluble chloride content.

Correction of Cl values for the aggregate in powder samples – Concrete powder samples contain varying amounts of pulverized aggregate that dilute the cement paste in the sample. Chlorides in the concrete are contained only in the cement paste. Therefore, in converting the amount of chloride in a specific powder sample to its concentration in a cubic meter (or yard) of concrete, it is necessary to adjust the chloride value for the dilution resulting from the powdered aggregate. Normally this is done using the value of soluble calcium in the concrete and present only in the cement paste as a reference. [Type 1 Portland contains approximately 22 weight pct soluble Si and 46.5 weight pct soluble Ca.] An alternative procedure when the concrete contains limestone aggregate is to use the soluble silica (expressed as Si) also present only in the cement paste.

The adjustment of the chloride values using soluble Ca is made in the following way. The soluble Ca values for all of the powder samples taken from the original concrete are averaged. This gives a fairly good estimate of the weight fraction of soluble Ca in the concrete. All of the chloride values are then adjusted to a concrete containing this weight fraction of soluble Ca. This is done by multiplying the measured chloride concentration in a specific sample by the ratio of the average soluble Ca weight fraction to the weight fraction of soluble Ca in the specific sample, i.e., (avg soluble Ca/soluble Ca in the specific sample). This then is the adjusted weight fraction of chloride in the concrete. Multiply this number by the density of concrete (2380 kg/m^3 or 4005 lb/yd^3) to get the concentration of chloride (in kg/m^3 or lb/yd^3) in the concrete.

D.2 CHLORIDE PROFILE DATA – "As-received" Beam.

Patch Concrete, concentration in weight pct in powder sample

Sample	Location	54A(west to east)			56A(west to east)			Average values(west to east)		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	5.18	0.216	0.220	5.08	0.264	0.262	5.13	0.24	0.24
0.5-1.0	0.75	5.22	0.281	0.285	5.37	0.444	0.414	5.30	0.36	0.35
1.0-1.5	1.25	7.68	0.504	0.504	4.95	0.341	0.357	6.32	0.42	0.43
1.5-2.0	1.75	8.20	0.479	0.468	6.30	0.382	0.393	7.25	0.43	0.43
2.0-2.5	2.25	11.30	0.205	0.205	6.21	0.329	0.327	8.76	0.27	0.27
2.5-3.0	2.75	3.19	0.192	0.183	7.06	0.262	0.260	5.13	0.23	0.22
3.0-3.5	3.25	4.91	0.138	0.139	7.61	0.212	0.212	6.26	0.18	0.18
3.5-4.0	3.75	6.20	0.098	0.107	5.91	0.125	0.116	6.06	0.11	0.11
4.0-4.5	4.25	3.06	0.048	0.051	5.27	0.067	0.067	4.17	0.06	0.06
4.5-5.0	4.75	4.25	0.040	0.033	5.23	0.032	0.035	4.74	0.04	0.03
5.0-5.5	5.25	5.70	0.029	0.035	4.68	0.015	0.013	5.19	0.02	0.02
5.5-6.0	5.75	2.35	0.011	0.011	4.75	0.003	0.011	3.55	0.01	0.01
6.0-6.5	6.25	5.90	0.014	0.019	5.79	0.003	0.006	5.85	0.01	0.01
6.5-7.0	6.75	7.07	0.015	0.016	4.82	0.003	0.005	5.95	0.01	0.01
7.0-7.5	7.25	7.36	0.006	0.005	6.89	0.003	0.005	7.13	0.00	0.01
7.5-8.0	7.75	5.84	0.003	0.005	3.78	0.016	0.015	4.81	0.01	0.01
8.0-8.5	8.25	6.55	0.014	0.012	7.18	0.010	0.008	6.87	0.01	0.01
8.5-9.0	8.75	5.89	0.005	0.005	4.87	0.035	0.035	5.38	0.02	0.02
9.0-9.5	9.25	5.80	0.010	0.006	2.97	0.010	0.007	4.39	0.01	0.01
9.5-10.0	9.75	6.35	0.011	0.005	2.89	0.015	0.016	4.62	0.01	0.01
10.0-10.5	10.25	7.21	0.022	0.008	4.30	0.010	0.007	5.76	0.02	0.01
10.5-11.0	10.75	5.43	0.037	0.035	6.01	0.020	0.019	5.72	0.03	0.03
11.0-11.5	11.25	4.75	0.062	0.060	7.89	0.052	0.052	6.32	0.06	0.06
11.5-12.0	11.75	7.65	0.167	0.158	4.89	0.050	0.053	6.27	0.11	0.11
12.0-12.5	12.25	7.75	0.163	0.175	5.32	0.080	0.078	6.54	0.12	0.13
12.5-13.0	12.75	7.00	0.218	0.214	5.43	0.075	0.083	6.22	0.15	0.15
13.0-13.5	13.25	4.66	0.178	0.175	6.25	0.182	0.180	5.46	0.18	0.18
13.5-14.0	13.75	4.51	0.230	0.234	5.70	0.190	0.196	5.11	0.21	0.22
14.0-14.5	14.25	5.58	0.318	0.327	9.82	0.212	0.207	7.70	0.27	0.27
14.5-15.0	14.75	4.22	0.257	0.264	6.39	0.040	0.020	5.31	0.15	0.14
15.0-15.5	15.25	5.25	0.104	0.104						
Average:		5.87	0.131	0.131	5.65	0.116	0.115	5.77	0.124	0.124

Patch Concrete, concentration in pounds per cubic yard of concrete

Sample	Location	54A(west to east)			56A(west to east)			Average values(west to east)		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	231.2	9.6	9.8	231.2	12.0	11.9	231.2	10.8	10.9
0.5-1.0	0.75	231.2	12.4	12.6	231.2	19.1	17.8	231.2	15.8	15.2
1.0-1.5	1.25	231.2	15.2	15.2	231.2	15.9	16.7	231.2	15.5	15.9
1.5-2.0	1.75	231.2	13.5	13.2	231.2	14.0	14.4	231.2	13.8	13.8
2.0-2.5	2.25	231.2	4.2	4.2	231.2	12.2	12.2	231.2	12.2	12.2
2.5-3.0	2.75	231.2	13.9	13.3	231.2	8.6	8.5	231.2	11.2	10.9
3.0-3.5	3.25	231.2	6.5	6.5	231.2	6.4	6.4	231.2	6.5	6.5
3.5-4.0	3.75	231.2	3.7	4.0	231.2	4.9	4.5	231.2	4.3	4.3
4.0-4.5	4.25	231.2	3.6	3.9	231.2	2.9	2.9	231.2	3.3	3.4
4.5-5.0	4.75	231.2	2.2	1.8	231.2	1.4	1.5	231.2	1.8	1.7
5.0-5.5	5.25	231.2	1.2	1.4	231.2	0.7	0.6	231.2	1.0	1.0
5.5-6.0	5.75	231.2	1.1	1.1	231.2	0.1	0.5	231.2	0.6	0.8
6.0-6.5	6.25	231.2	0.5	0.7	231.2	0.1	0.2	231.2	0.3	0.5
6.5-7.0	6.75	231.2	0.5	0.5	231.2	0.1	0.2	231.2	0.3	0.4
7.0-7.5	7.25	231.2	0.2	0.2	231.2	0.1	0.2	231.2	0.1	0.2
7.5-8.0	7.75	231.2	0.1	0.2	231.2	0.1	0.2	231.2	0.1	0.2
8.0-8.5	8.25	231.2	0.5	0.4	231.2	1.0	0.9	231.2	0.7	0.7
8.5-9.0	8.75	231.2	0.2	0.2	231.2	0.3	0.3	231.2	0.3	0.2
9.0-9.5	9.25	231.2	0.4	0.2	231.2	1.7	1.7	231.2	1.0	1.0
9.5-10.0	9.75	231.2	0.4	0.2	231.2	0.8	0.5	231.2	0.6	0.4
10.0-10.5	10.25	231.2	0.7	0.3	231.2	1.2	1.3	231.2	1.0	0.8
10.5-11.0	10.75	231.2	1.6	1.5	231.2	0.5	0.4	231.2	1.1	0.9
11.0-11.5	11.25	231.2	3.0	2.9	231.2	0.8	0.7	231.2	1.9	1.8
11.5-12.0	11.75	231.2	5.0	4.8	231.2	1.5	1.5	231.2	3.3	3.1
12.0-12.5	12.25	231.2	4.9	5.2	231.2	2.4	2.5	231.2	3.6	3.9
12.5-13.0	12.75	231.2	7.2	7.1	231.2	3.5	3.4	231.2	5.3	5.2
13.0-13.5	13.25	231.2	8.8	8.7	231.2	3.2	3.5	231.2	6.0	6.1
13.5-14.0	13.75	231.2	11.8	12.0	231.2	6.7	6.7	231.2	9.3	9.3
14.0-14.5	14.25	231.2	13.2	13.5	231.2	7.7	8.0	231.2	10.4	10.7
14.5-15.0	14.75	231.2	14.1	14.5	231.2	5.0	4.9	231.2	9.5	9.7
15.0-15.5	15.25	231.2	4.6	4.6	231.2	1.4	0.7	231.2	3.0	2.7

Original Concrete, concentration in weight pct in powder sample

Sample	Location	54F(west to east)			55F(west to east)			Average value(west to east)		
range in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	11.70	0.259	0.255	12.50	0.356	0.322	12.10	0.31	0.29
0.5-1.0	0.75	12.10	0.233	0.232	5.55	0.136	0.124	8.83	0.18	0.18
1.0-1.5	1.25	9.85	0.165	0.166	9.01	0.146	0.082	9.43	0.16	0.12
1.5-2.0	1.75	11.20	0.138	0.138	8.79	0.099	0.085	10.00	0.12	0.11
2.0-2.5	2.25	11.00	0.091	0.095	7.67	0.056	0.049	9.34	0.07	0.07
2.5-3.0	2.75	7.10	0.002	0.002	6.57	0.023	0.016	6.84	0.01	0.01
3.0-3.5	3.25	7.99	0.002	0.002	7.11	0.016	0.010	7.55	0.01	0.01
3.5-4.0	3.75	7.84	0.020	0.016	9.61	0.017	0.008	8.73	0.02	0.01
4.0-4.5	4.25	6.99	0.007	0.006	8.28	0.013	0.008	7.64	0.01	0.01
4.5-5.0	4.75	4.41	0.005	0.005	7.93	0.012	0.006	6.17	0.01	0.01
5.0-5.5	5.25	6.92	0.015	0.011	8.84	0.013	0.007	7.88	0.01	0.01
5.5-6.0	5.75	9.40	0.015	0.010	8.70	0.013	0.007	9.05	0.01	0.01
6.0-6.5	6.25	8.85	0.017	0.009	8.26	0.012	0.007	8.56	0.01	0.01
6.5-7.0	6.75	6.88	0.017	0.008	5.70	0.012	0.007	6.29	0.01	0.01
7.0-7.5	7.25	5.21	0.014	0.007	7.22	0.015	0.009	6.22	0.01	0.01
7.5-8.0	7.75	5.54	0.011	0.007	5.15	0.012	0.007	5.35	0.01	0.01
8.0-8.5	8.25	3.79	0.010	0.005	8.90	0.013	0.008	6.35	0.01	0.01
8.5-9.0	8.75	5.11	0.014	0.005	4.53	0.009	0.007	4.82	0.01	0.01
9.0-9.5	9.25	6.94	0.014	0.006	5.27	0.008	0.007	6.11	0.01	0.01
9.5-10.0	9.75	7.53	0.015	0.007	8.55	0.013	0.007	8.04	0.01	0.01
10.0-10.5	10.25	5.83	0.011	0.006	5.68	0.011	0.006	5.76	0.01	0.01
10.5-11.0	10.75	2.45	0.010	0.006	8.83	0.013	0.007	5.64	0.01	0.01
11.0-11.5	11.25	1.63	0.010	0.004	8.61	0.024	0.016	5.12	0.02	0.01
11.5-12.0	11.75	2.70	0.022	0.017	9.13	0.050	0.038	5.92	0.04	0.03
12.0-12.5	12.25	6.56	0.070	0.054	4.28	0.042	0.039	5.42	0.06	0.05
12.5-13.0	12.75	7.98	0.123	0.105	7.87	0.167	0.108	7.93	0.15	0.11
13.0-13.5	13.25	8.41	0.154	0.139	4.72	0.175	0.089	6.57	0.16	0.11
13.5-14.0	13.75	3.26	0.054	0.047	6.67	0.218	0.206	4.97	0.14	0.13
14.0-14.5	14.25	5.78	0.259	0.250	10.10	0.395	0.371	7.94	0.33	0.31
14.5-15.0	14.75	12.40	0.532	0.507	11.50	0.453	0.432	11.95	0.49	0.47
Average:		7.11	0.077	0.071	7.72	0.085	0.070	7.41	0.081	0.070

Original Concrete, concentration in pounds per cubic yard of concrete

Sample	Location	54F(west to east)			55F(west to east)			Average value(west to east)		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	297.0	6.6	6.5	297.0	8.5	7.6	297.0	7.5	7.1
0.5-1.0	0.75	297.0	5.7	5.7	297.0	7.3	6.6	297.0	6.5	6.2
1.0-1.5	1.25	297.0	5.0	5.0	297.0	4.8	2.7	297.0	4.9	3.9
1.5-2.0	1.75	297.0	3.7	3.7	297.0	3.3	2.9	297.0	3.5	3.3
2.0-2.5	2.25	297.0	2.5	2.6	297.0	2.2	1.9	297.0	2.3	2.2
2.5-3.0	2.75	297.0	0.1	0.1	297.0	1.0	0.7	297.0	0.6	0.4
3.0-3.5	3.25	297.0	0.1	0.1	297.0	0.7	0.4	297.0	0.4	0.2
3.5-4.0	3.75	297.0	0.8	0.6	297.0	0.5	0.2	297.0	0.6	0.4
4.0-4.5	4.25	297.0	0.3	0.3	297.0	0.5	0.3	297.0	0.4	0.3
4.5-5.0	4.75	297.0	0.3	0.3	297.0	0.4	0.2	297.0	0.4	0.3
5.0-5.5	5.25	297.0	0.6	0.5	297.0	0.4	0.2	297.0	0.5	0.4
5.5-6.0	5.75	297.0	0.5	0.3	297.0	0.4	0.2	297.0	0.5	0.3
6.0-6.5	6.25	297.0	0.6	0.3	297.0	0.4	0.3	297.0	0.5	0.3
6.5-7.0	6.75	297.0	0.7	0.3	297.0	0.6	0.4	297.0	0.7	0.4
7.0-7.5	7.25	297.0	0.8	0.4	297.0	0.6	0.4	297.0	0.7	0.4
7.5-8.0	7.75	297.0	0.6	0.4	297.0	0.7	0.4	297.0	0.6	0.4
8.0-8.5	8.25	297.0	0.8	0.4	297.0	0.4	0.3	297.0	0.6	0.3
8.5-9.0	8.75	297.0	0.8	0.3	297.0	0.6	0.5	297.0	0.7	0.4
9.0-9.5	9.25	297.0	0.6	0.3	297.0	0.5	0.4	297.0	0.5	0.3
9.5-10.0	9.75	297.0	0.6	0.3	297.0	0.5	0.2	297.0	0.5	0.3
10.0-10.5	10.25	297.0	0.6	0.3	297.0	0.6	0.3	297.0	0.6	0.3
10.5-11.0	10.75	297.0	1.2	0.7	297.0	0.4	0.2	297.0	0.8	0.5
11.0-11.5	11.25	297.0	1.8	0.7	297.0	0.8	0.6	297.0	1.3	0.6
11.5-12.0	11.75	297.0	2.4	1.9	297.0	1.6	1.2	297.0	2.0	1.6
12.0-12.5	12.25	297.0	3.2	2.4	297.0	2.9	2.7	297.0	3.0	2.6
12.5-13.0	12.75	297.0	4.6	3.9	297.0	6.3	4.1	297.0	5.4	4.0
13.0-13.5	13.25	297.0	5.4	4.9	297.0	11.0	5.6	297.0	8.2	5.3
13.5-14.0	13.75	297.0	4.9	4.3	297.0	9.7	9.2	297.0	7.3	6.7
14.0-14.5	14.25	297.0	13.3	12.8	297.0	11.6	10.9	297.0	12.5	11.9
14.5-15.0	14.75	297.0	12.7	12.1	297.0	11.7	11.2	297.0	12.2	11.6

D.3 FITTING CHLORIDE PROFILE DATA TO COMPUTE C_o AND D

The determination of chloride concentration at various depths in reinforced concrete structures has been performed in the field for many years. These data have shown that the near-surface chloride concentration can vary widely due to washing effects of precipitation. However, the chloride concentration at greater depths changes slowly in accordance with Fick's second law of diffusion, Equation 4.1, and the one-dimensional solution for concrete, with either a background chloride ion concentration or initially free of chloride ion, exposed to a constant surface concentration of chloride ion, C_o , at time zero, Equation 4.2. The effective diffusion constant for chloride ion in concrete in this equation is D. Values of these parameters are given in Table 4.7.

Since the chloride concentration below the near-surface region is well behaved, and sufficient data points are often available from field measurements, it is possible to estimate values for C_o and D from the chloride ion profile and the age of the structure. C_o and D are "effective" values since many factors affect the values of these parameters that are not considered in equation D.2. As noted, the actual C_o at any time is affected by precipitation washing of the concrete surface and the leaching of Cl ions from the near-surface region. In addition, during periods of dryness when there is not intervening precipitation washing, Cl ions can concentrate on the concrete surface as the result of prolonged dry deposition of salt. D values are affected by the porosity of the concrete, the size distribution of the aggregate, and reactions with aggregate and other minerals.

However, the values of C_o and D obtained by fitting the Cl ion profiles can be considered representative of the structure and the environment to which the structure has been exposed. C_o can be considered a measure the severity of the environment and conditions at the concrete surface. D can be considered a measure of concrete durability since, in addition to its mechnical properties, the concrete must serve as an effect barrier to chloride diffusion to maintain the integrity of the structure. Furthermore, if detailed Cl profile data are taken before a structure shows visible distress due to chloride-induced corrosion of the rebar and are fitted to equation D.2 to give values of C_o and D, an estimate of the time to distress can be made and preventative measures taken before the structure is at risk to corrosion damage.

To obtain values for C_o and D from **equally-spaced chloride profile data**, a BASIC program was written to estimate the values based on the least-squares criteria for the residuals. The program works as follows:

- Input the duration of the concrete exposure to the chloride environment, in years; usually the structure age.
- Input depth spacing of the equally-spaced chloride samples, in **inches**. The program converts this value to cm. It then computes the location of each sample as the mid-point of the sample interval, i.e., half the sum of the maximum and minimum sample depth. The location of the first sample is computed as half the sample spacing.
- Input sequentially, from the first sample to the last sample taken, the concentration of chloride ion in each sample, in any units desired. The programs provides the opportunity to correct the input chloride ion concentrations. The series of input chloride ion concentration

data can be truncated later to limit the series to those values where the chloride ion concentration is changing significantly or to those values unaffected by near-surface washing effects.

- The initial point in the series of chloride ion concentrations to be fit can be selected. The program assumes the series is to begin with the first point. However, if washing or concentration effects are present in the near-surface region to distort the profile, a sampling point deeper in the concrete can be selected to begin the fitting algorithm by simply specifying the number of the point in the series, e.g., point 3 in a series of 12 values.
- The initial estimate of C_o is assumed by the program to correspond to the chloride ion concentration of the initial point in the series to be fit. However, the program allows this value to be changed to any desired value. The initial C_o could be estimated by inspection of the chloride ion concentration data. However, using the default initial value, the algorithm will converge to the least-squares best estimate fairly efficiently. The usual sumof the squares error (or residual) term measures the agreement between the input value of the measured chloride concentration, C_m , and the fitted value, C_f , i.e.,

$$^2 = (C_m - C_f)^2 \qquad \textbf{(D.3)}$$

- The program will execute the least-squares fitting algorithm, showing the changing values of C_o and D on the screen.
- The program will refine the estimate for D by incrementing for the current value of C_o. It will compare the magnitude of the sum of the square of the residuals for the current step, ^2_n , with that for the previous step, $^2_{n-1}$. Delta is the sum of the square of the residuals for the current step compared to the previous step. When delta ceases to converge for the current value of C_o , the value of C_o is incremented and D again found for the minimum in the sum of the square of the residuals. This two step process is continued until the sum of the square of the residuals is a minimum for both C_o and D within a specified error value selected by the program.
- At convergence to a solution, values of C_o and D will be printed on the screen. The units of C_o are those of the input chloride concentration data, and those for D are in cm^2/s.
- The option is then given to look at a plot of the fitted chloride profile computed using equation D.2 and the measured profile produced from the input data. The fitted values of C_o and D, along with a few statistics, are printed on the graph.
- The program stops if the operator is finished. Continuation will permit a complete new data set to be entered or the previous set to be reused for refinement of the data set by choice of the initial point in the input series or of the initial C_o.

The flow diagram for the computer program follows in Figure D.1.

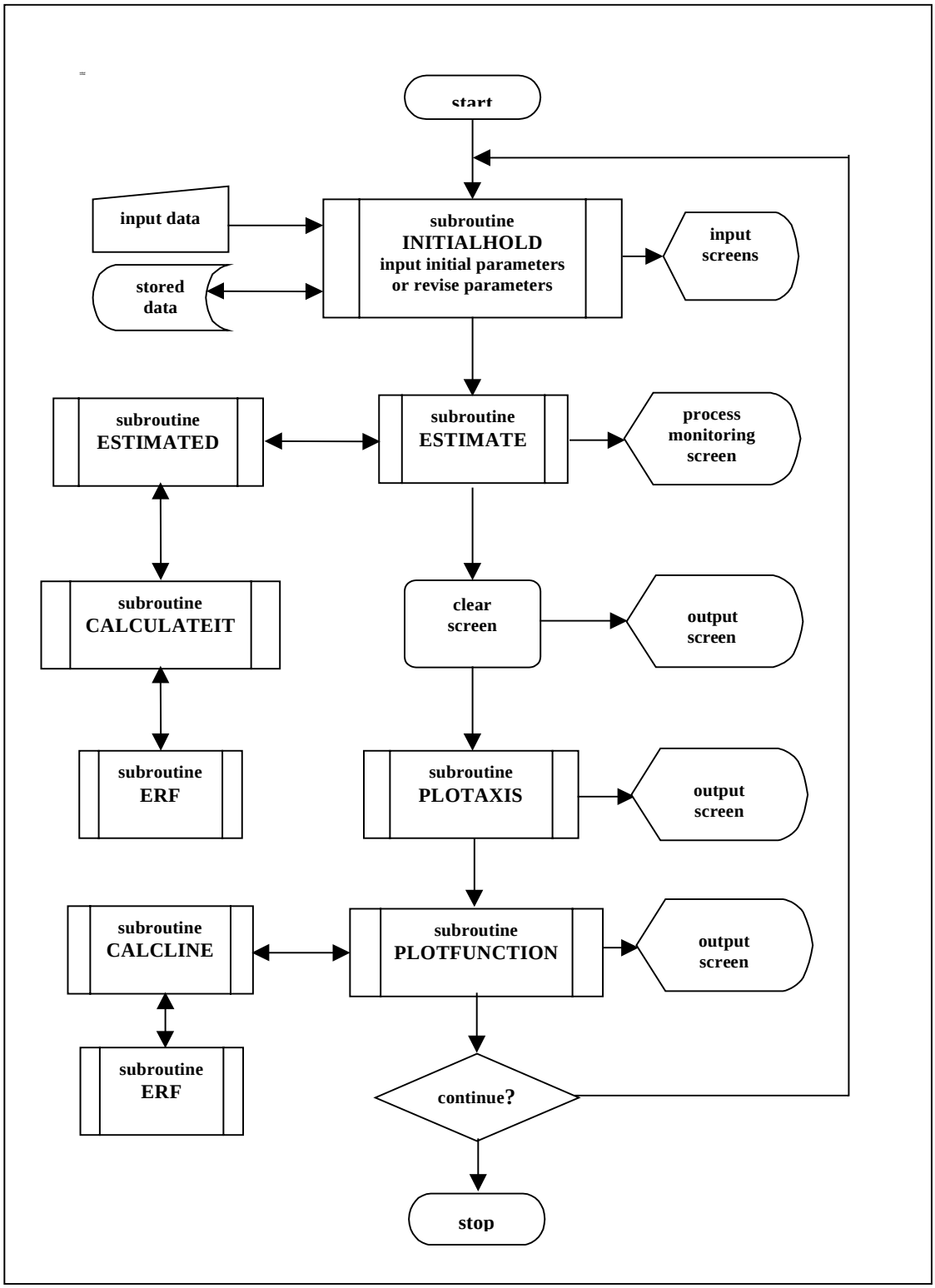

Figure D.1: Flow diagram for BASIC computer program to determine diffusion coefficient, *D*, and surface chloride ion concentration, C_0 , from chloride profile in concrete.

D.4 BASIC CODE FOR FITTING CHLORIDE PROFILE DATA AND COMPUTING C_o AND D

The code was written in a basic Microsoft (R) BASIC Professional Development System, Version 7.00,C) Copyright Microsoft Corporation, 1989. The code follows. An executable copy of this program is available from the Oregon Department of Transportation, Research Group, 200 Hawthorne Avenue SE, Salem, OR 97301-5192, telephone 503-986-2700. Refer to the "Evaluation of Rocky Point Viaduct Concrete Beam" final report, Project No. SPR 381.

REM FIND C_o AND D USING LEAST SQUARES FITTING

```
    DIM realc(25), calcc(110), delta(1000)
    CONST pi = 3.14159
    DECLARE SUB Initialhold (title$, t, depth, realc(), n, Co, nx)
    DECLARE SUB Esitmate (t, depth, realc(), n, Co, D, nx, calcc(), SSR, SST)
    DECLARE SUB EstimateD (t, depth, realc(), n, Co, nx, D, calcc())
    DECLARE SUB Calculateit (t, depth, n, Co, D, nx, calcc(), z, erfz)
    DECLARE SUB Erf (z, erfz)
    DECLARE SUB PLOTAXIS (title$, t, Co, D, SSR, SST)
    DECLARE SUB PLOTFUNCTION (t, depth, Co, D, calcc(), realc(), n)
    DECLARE SUB Calcline (t, Co, D, calcc(), z, erfz)
500 CLS
    SCREEN 8, 1
    CALL Initialhold(title$, t, depth, realc(), n, Co, nx)
    CALL Esitmate(t, depth, realc(), n, Co, D, nx, calcc(), SSR, SST)
    CLS
    CALL PLOTAXIS(title$, t, Co, D, SSR, SST)
    CALL PLOTFUNCTION(t, depth, Co, D, calcc(), realc(), n)
    PRINT "again? y/n  "
      y$ = INPUT$(1)
    IF y$ = "y" THEN GOTO 500
    CLOSE #1
END SUB
```

SUB Initialhold (title$, t, depth, realc(), n, Co, nx)

```
    VIEW
    WINDOW
    CLS
    COLOR 15, 1
    REM using cgs units
    IF t = 0 GOTO 91      REM coming from start t = 0,
    CLOSE #1
    LOCATE 3, 15
    PRINT "Reuse current data? y/n"
      data$ = INPUT$(1)
    IF data$ = "n" THEN GOTO 91
```

```
    CLS
    FOR i = 1 TO n
            ii = i + 2
            LOCATE ii, 15
            PRINT "sample # "; i, "concentration = "; realc(i)
    NEXT i
    LOCATE ii + 1, 20
    PRINT "is everything as you want it? y/n"
      ok1$ = INPUT$(1)
    IF ok1$ = "y" THEN GOTO 93
89  PRINT "Which sample # needs changing?"
    INPUT sno
    PRINT "Enter the new value"
    INPUT realc(sno)
    PRINT "change another? y/n"
      ok2$ = INPUT$(1)
    IF ok2$ = "y" GOTO 89
    GOTO 93
91  CLS
    LOCATE 1, 15
    INPUT "Data Identification?  ", title$
    LOCATE 2, 15
    INPUT "Enter the age of the structure in years  ", age
     day = 24 * 60 * 60#
      t = day * 365 * age
    LOCATE 3, 15
    INPUT "Enter the sampling increment in inches  ", depth
     depth = depth * 2.54
    LOCATE 4, 15
    PRINT "Enter the chloride concentration in descending order"
    LOCATE 5, 20
    PRINT "Hit enter to end   "
        nx = 1
          i = 1
92  LOCATE 5 + i, 20
    INPUT realc(i)
       n = i - 1
    IF realc(i) = 0 THEN GOTO 93
       i = i + 1
    GOTO 92
93  Co = realc(nx)
    CLS
    FOR i = 1 TO n
     ii = i + 3
         LOCATE ii, 15
```

```
        PRINT "sample # "; i, "concentration = "; realc(i)
    NEXT i
    LOCATE ii + 2, 20
    PRINT "is everything correct? y/n"
      ok1$ = INPUT$(1)
    IF ok1$ = "n" THEN GOTO 91
    CLS
94  LOCATE 4, 20
    PRINT "Co = "; Co
    LOCATE 6, 20
    PRINT "no. of points = "; n, "starting point = "; nx
    LOCATE 10, 15
    PRINT "Do you want to change the starting point?  y/n"
      ok2$ = INPUT$(1)
    IF ok2$ = "n" THEN GOTO 95
    LOCATE 12, 15
    INPUT "enter new starting point"; nx
      Co = realc(nx)
    LOCATE 14, 15
    PRINT "the new starting point is"; nx; ", new Co is"; Co
95  LOCATE 16, 20
    PRINT "Do you want to change Co?  y/n"
      ok3$ = INPUT$(1)
    IF ok3$ = "n" THEN GOTO 96
    LOCATE 19, 15
    INPUT "enter new Co"; Co
96  CLS
    'LOCATE 3, 15
    'PRINT "do you wish to adjust the sensitivity on Co? y/n"
    'LOCATE 4, 22
    'PRINT "the value to be input is in Co units"
    'LOCATE 5, 22
    'PRINT "for example, .05 "
    'LOCATE 7, 22
    'PRINT "Do you want hardcopy of the results? y/n"
      'x$ = INPUT$(1)
    'IF x$ = "n" THEN GOTO 98
    ‘OPEN "c:\chloride\fitdata.dat" FOR APPEND AS #1
98   END SUB
```

SUB Esitmate (t, depth, realc(), n, Co, D, nx, calcc(), SSR, SST)

```
    DIM testsumdeltac(300)
    FOR i = 1 TO 300
          testsumdeltac(i) = 0
    NEXT i
```

```
      CLS
        j = nx - 1
110     j = j + 1
      CALL EstimateD(t, depth, realc(), n, Co, nx, D, calcc())
        sumdeltac = 0
      FOR i = nx TO n
            absdelta = (calcc(i) - realc(i)) ^ 2
            sumdeltac = sumdeltac + absdelta
      NEXT i
         testsumdeltac(j) = sumdeltac
         Co = Co + .1
      IF j = nx GOTO 110
      LOCATE 14, 33
      PRINT USING "D = ##.##^^^^"; D
      LOCATE 12, 33
      PRINT USING "Co = ##.## "; Co
      LOCATE 16, 33
      PRINT USING "Delta = ###.#### "; testsumdeltac(j)
            IF testsumdeltac(j - 1) < testsumdeltac(j) THEN GOTO 111
     GOTO 110
111     Co = Co - .25
      FOR i = 1 TO 300
            testsumdeltac(i) = 0
      NEXT i
      CLS
        j = nx - 1
112  j = j + 1
      CALL EstimateD(t, depth, realc(), n, Co, nx, D, calcc())
        sumdeltac = 0
      FOR i = nx TO n
            absdelta = (calcc(i) - realc(i)) ^ 2
            sumdeltac = sumdeltac + absdelta
      NEXT i
          testsumdeltac(j) = sumdeltac
         Co = Co + .01
      IF j = nx GOTO 112
      LOCATE 14, 33
      PRINT USING "D = ##.##^^^^"; D
      LOCATE 12, 33
      PRINT USING "Co = ##.## "; Co
      LOCATE 16, 33
      PRINT USING "Delta = ###.#### "; testsumdeltac(j)
            IF testsumdeltac(j - 1) < testsumdeltac(j) THEN GOTO 113
      GOTO 112
113  Co = Co - .01
```

```
    LOCATE 19, 26
    PRINT "hit any key to display the graph"
      x$ = INPUT$(1)
      SSR = 0
      SST = 0
    FOR i = 1 TO n
          delta = (calcc(i) - realc(i)) ^ 2
          SSR = SSR + delta
          totaldelta = realc(i) ^ 2
          SST = SST + totaldelta
    NEXT i
END SUB
```

SUB EstimateD (t, depth, realc(), n, Co, nx, D, calcc())

```
    DIM test1(20), test2(10000)

    FOR i = 1 TO 20
          test1 = 0
    NEXT i
    FOR i = 1 TO 1000
          test2 = 0
    NEXT i
      D = .0001
       j = nx - 1
100   j = j + 1
    CALL Calculateit(t, depth, n, Co, D, nx, calcc(), z, erfz)
      sumdelta = 0
    FOR i = nx TO n
          absdelta = ABS(calcc(i) - realc(i))
          sumdelta = sumdelta + absdelta
    NEXT i
      test1(j) = sumdelta
      D = .1 * D
    IF j = nx GOTO 100
    IF test1(j - 1) < test1(j) THEN GOTO 101
    GOTO 100
101 credit = .1 * D
      k = nx - 1
102  k = k + 1
    CALL Calculateit(t, depth, n, Co, D, nx, calcc(), z, erfz)
      sumdelta = 0
    FOR i = nx TO n
          absdelta = (calcc(i) - realc(i)) ^ 2
          sumdelta = sumdelta + absdelta
    NEXT i
```

```
        test2(k) = sumdelta
      IF k = nx GOTO 102
      IF test2(k - 1) < test2(k) THEN GOTO 103
        D = D + credit
      GOTO 102
103
         D = D - credit
END SUB
```

SUB Calculateit (t, depth, n, Co, D, nx, calcc(), z, erfz)

```
      FOR i = nx TO n
            x = (i - .5) * depth
            dt = D * t
            dt = 2 * ((D * t) ^ .5)
            z = x / dt
            CALL Erf(z, erfz)
            calcc(i) = Co * (1 - erfz)
      NEXT i
END SUB
```

SUB Erf (z, erfz)

```
      REM CALCULATE ERFZ FOR Z
      IF z >= 2 THEN GOSUB 10
      IF z < 2 AND z >= .1 THEN GOSUB 20
      IF z < .1 AND z > 0 THEN GOSUB 30
      IF z <= 0 THEN GOSUB 40
      GOTO 50
10     erfz = 1
      RETURN
20       A1 = .278393
         A2 = .230389
         A3 = .000972
         A4 = .078108
         xxx = 1 + A1 * z + A2 * z ^ 2 + A3 * z ^ 3 + A4 * z ^ 4
         erfz = 1 - (1 / (xxx ^ 4))
      RETURN
30    erfa = 0
      FOR i = 1 TO 10
            n = i - 1
            GOTO 32
31           k = ((2 * i) - 1)
             a = z ^ k
             IF NF <= 0 THEN NF = 1
             delta = ((-1) ^ (i - 1)) * (a / (NF * k))
             erfa = erfa + delta
```

```
        erfz = (2 / (pi ^ .5)) * erfa
        IF ABS(delta) < .00001 THEN RETURN
    NEXT i
    RETURN
32  REM CALCULATES THE FACTORIAL OF N AND RETURNS THE VALUE AS NF
        NF = n
33      n = n - 1
        IF n < 2 THEN GOTO 31
        NF = NF * n
    GOTO 33
40  CLS
    REM IF Z IS LESS THAN OR EQUAL TO ZERO, SET ERFZ = 0"
      erfz = 0
50  REM
END SUB
```

SUB PLOTAXIS (title$, t, Co, D, SSR, SST)

```
        xmin = 0
        xmax = 100
        ymin = 0
        ymax = 100
        ntick = 10
        dx = (xmax - xmin) / ntick
        dy = (ymax - ymin) / ntick
    VIEW (110, 5)-(529, 179), 2, 5
    WINDOW (xmin - dx, ymin - dy)-(xmax + dx, ymax + dy)
    LINE (xmin, ymin)-(xmax, ymin)
    FOR i = 1 TO 10
        LINE (xmin, 10 * i)-(xmax, 10 * i)
    NEXT i
    LINE (xmin, ymin)-(xmin, ymax)
    FOR i = 1 TO 10
        LINE (10 * i, ymin)-(10 * i, ymax)
    NEXT i
    LOCATE 2, 35
    PRINT title$
    WRITE #1,
    WRITE #1, "Title ", title$
    WRITE #1,
    LOCATE 3, 15
    PRINT "40"
    LOCATE 5, 15
    PRINT "wt/"
    LOCATE 6, 15
    PRINT "vol"
```

```
    LOCATE 12, 15
    PRINT "20"
    LOCATE 1, 50
    PRINT USING "  Co  = ##.##     "; Co
    WRITE #1, "  Co  = ", Co
    LOCATE 2, 50
    PRINT USING "  D   = ##.##^^^^ "; D
    WRITE #1, "  D   =  ", D
    LOCATE 3, 50
    PRINT USING "  SSR =###.####    "; SSR
    WRITE #1, "  SSresidual = ", SSR
    LOCATE 4, 50
    PRINT USING "  SST = #####      "; SST
    WRITE #1, "  SStotal = ", SST
      rsquared = ((SST - SSR) / SST) * 100
    LOCATE 5, 50
    PRINT USING "  Rsquared = ###.##% "; rsquared
    WRITE #1, "Rsquared = ", rsquared
      hour = 60 * 60
     day = hour * 24
     year = day * 365
     age = t / year
    LOCATE 6, 50
    PRINT USING "  Structure Age = ## years"; age
    WRITE #1, "Structure Age ", age, "years"
        Lx = .1 * dx
        Ly = .1 * dy
    FOR itick = 0 TO ntick
        concl = xmin + itick * dx
        row = ymin + itick * dy
        LINE (concl, ymin)-(concl, ymin + Lx)
        LINE (xmin, row)-(xmin + Ly, row)
    NEXT itick
        LOCATE 22, 18
        PRINT "0"
        LOCATE 22, 62
        PRINT "20cm"
END SUB

SUB PLOTFUNCTION (t, depth, Co, D, calcc(), realc(), n)
    FOR i = 1 TO 7
        IF realc(i) < .05 THEN calcc(i) = realc(i)
        test = (calcc(i) - realc(i)) ^ 2
        LOCATE i + 3, 2
        PRINT USING " ###.# "; calcc(i)
```

```
            LOCATE i + 11, 2
            PRINT USING " ##.## "; test
        NEXT i
        WRITE #1, "chloride values"
        WRITE #1, "   depth ", "   real  ", "calculated"
        FOR i = 1 TO n
            x = (i - .5) * depth
            WRITE #1, x, realc(i), calcc(i)
        NEXT i
        CALL Calcline(t, Co, D, calcc(), z, erfz)
        FOR i = 1 TO 100
            LINE (i - 1, 2.5 * calcc(i))-(i, 2.5 * calcc(i + 1)), 5
        NEXT i
          i = 1
200         x = (i - .5) * depth * 5
            y = 2.5 * realc(i)
        CIRCLE (x, y), .5, 0
        IF i = n THEN GOTO 201
          i = i + 1
       GOTO 200
201     END SUB
```

SUB Calcline (t, Co, D, calcc(), z, erfz)

```
        FOR i = 1 TO 100
            x = .2 * i
           dt = 2 * ((D * t) ^ .5)
            z = x / dt
            CALL Erf(z, erfz)
            calcc(i) = Co * (1 - erfz)
        NEXT i
END SUB
```

D5. SPREADSHEET FOR FITTING CHLORIDE PROFILE DATA AND COMPUTING C_o AND D

In addition to the BASIC program in Appendix D.4, C_o and D can be computed using available spreadsheet software and the equation solver that is included in the software. Both approaches are based on the least-square method for minimizing the square of the residuals between measured, C_m, and fitted, C_f, chloride ion concentration profiles.

The values that need to be entered at the beginning of the spreadsheet analysis are underlined in the example in Figure D.2 and are described below.

> **Exposure time** from when the material was placed in service to when the chloride concentration data were collected. The value is entered in years and the spreadsheet computes the time in seconds to use in the diffusion equation.
>
> **Background chloride concentration, C_b,** is determined by inspecting the graphed chloride profile data. That portion of the chloride profile in the center of the beam where diffusion has not yet affected the concrete composition and where the curve becomes flat is the background chloride concentration. A non-zero value indicates the concrete mix contained chloride at the time of construction.
>
> **Effective diffusion coefficient, D,** multiplied by 10^8, is entered as an initial guess. Typical values for cured and aged concrete with various water/cement ratios range from 0.9×10^{-8} to 52×10^{-8} cm^2/s. It was found that the spreadsheet used in this analysis (Microsoft Excel) produced erroneous results or error messages when untransformed D values were used. Evidently the equation solver becomes unstable when manipulating very small number. Consequently, D is multiplied by 10^8 (transformed) before entering the value into the spreadsheet. The spreadsheet later calculates the correct D in a separate cell by multiplying the entered value by 10^{-8}. As described below, the calculated D is used in the diffusion equation, Equation 4.2, and the transformed D is used by the optimization algorithm in the equation solver.
>
> **Surface chloride concentration, C_o,** is entered as an initial guess. A reasonable value can be determined by inspection of the chloride.

Measured chloride concentration and position data are entered into the spreadsheet and the chloride profile plotted for inspection. The data shown in the example, Figure D.2, have been truncated to save space. Based on inspection of the chloride profile, the first two measured C values were not incorporated into the analysis because the profile has been affected by precipitation washing in this part of the profile. They do not lie near the projection of the profile in the near-surface region of the beam. Position data in inches are changed to centimeters to accommodate the units used for D in the calculation. The spreadsheet calculates the $C(x,t)$ at each position (column labeled "Fitted C_f") using Equation 4.2 modified to include a background level of chloride, i.e., C_b, and the current values of C_o, D, and t. The error function ERF in Excel is incorporated into Equation 4.2. The residuals and the sum of the squares of the residuals are

listed in the last column. The sum of squares is not calculated beyond the location where the chloride profile becomes flat (towards the beam center).

CALCULATION OF EFFECTIVE DIFFUSION COEFFICIENT AND SURFACE CONCENTRATION FROM CHLORIDE ION PROFILE

Location: Patch concrete on west (ocean) side of beam A1
Values:

Exposure time: in years = 25 ; in seconds = 7.88E+08 s
Background chloride ion concentration in concrete (i.e., at time = 0 s), C_b = 0.0 lb/yd^3)

Initial C_o estimate = 22 lb Cl/yd^3

Initial D estimate x 10^8 = 1 cm^2/s

Initial D estimate = 1 E-8 cm^2/s

Data, Fitted Values and Residuals:

Position in beam measured from West face, inches	Measured C_m (lb/yd^3)	Fitted C_f (lb/yd^3)	Residual C_m - C_f
0.25	10.8	not used in fit	
0.75	15.8	not used in fit	
1.25	15.5	16.85	-1.35
1.75	13.8	13.83	-0.03
2.25	12.2	11.10	1.10
2.75	11.2	8.71	2.49
3.25	6.5	6.68	-0.18
3.75	4.3	5.00	-0.70
4.25	3.3	3.65	-0.35
4.75	1.8	2.60	-0.80
5.25	1	1.81	-0.81
5.75	0.6	1.22	-0.62
6.25	0.3	0.81	-0.51
6.75	0.3	0.52	-0.22
7.25	0.1	0.32	-0.22

Sum of squared residuals = 11.80

Calculated Fick's Law Parameters:

Effective chloride diffusion coefficient, D = 3.47 E-8 cm^2/s
Surface Cl concentration, C_o = 25.23 lb/yd^3

Figure D-2. Sample spreadsheet for calculating C_o and D.

The spreadsheet uses an iterative routine that minimizes the value in the sum of squared residuals cell by varying the values in the transformed *D* (*D* multiplied by 10^8) and C_o cells. The routine is called solver in Excel. Each iteration produces a new transformed *D* and/or C_o value, which is subsequently used by the spreadsheet to calculate a new *D*, new C_f values (column "Fitted C_f"), new residuals, and a new sum of squares. These new values replace the previous values for each iteration. The routine stops when the sum of squares converges to a minimum value resulting in final values for *D* and C_o, shown in Figure D.2 as "Calculated Fick's Law Parameters".

The BASIC program requires equally spaced data points and assigns the first chloride concentration in the profile to the mid-point of the first interval. All succeeding chloride data are assigned to the mid-points of succeeding intervals equally spaced from first mid-point. Unless the concentration data are first transformed to remove a background level of chloride ion, the program is intended for use where there is no background chloride level. However, small background chloride concentrations will not significantly affect the value of the parameters computed by the program. The program plots measured and calculated profiles. Points at the beginning or end of the data series are readily removed from consideration in the fitting procedure. The program runs in DOS.

The spreadsheet calculations do not require equally spaced data points, although that is the likely format for taking concrete powder samples from drill holes in bridges for measuring the chloride profile. The spreadsheet runs in WINDOWS. Table D.2 shows that there is excellent agreement between C_o values computed by the two procedures. There was less agreement between the *D* values, with up to a 15 percent difference between the two values. However, these differences are small compared to the variability typically encountered between values measured at different locations on bridges or between values measured for different bridges.

Table D-1. Comparison of C_o and *D* values calculated using the BASIC program (Appendix D.4) and the spreadsheet (Appendix D.5).

Concrete type and orientation	C_o kg Cl/m^3 (lb Cl/ft^3)		*D* cm^2/s	
	BASIC program	Spreadsheet	BASIC program	Spreadsheet
Original concrete, west face	5.21 (8.78)	5.25 (8.86)	9.48×10^{-9}	8.21×10^{-9}
Patch concrete, west face	15.00 (25.29)	14.97 (25.23)	3.25×10^{-8}	3.47×10^{-8}
Original concrete, east face	9.58 (16.15)	9.86 (16.61)	1.24×10^{-8}	1.05×10^{-8}
Patch concrete, east face	9.56 (16.12)	9.60 (16.18)	3.14×10^{-8}	3.15×10^{-8}

APPENDIX E -- CORROSION RATES, A/cm^2

APPENDIX E -- Corrosion Rates, µA/cm^2 (October 25)

Grid ID				1		2		3		4		5		6		7		8		9		10	
	in			3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
		ft		0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5	2.75	3	3.25	3.5	3.75	4	4.25	4.5	4.75	5
			m	0.076	0.152	0.229	0.305	0.381	0.457	0.533	0.610	0.686	0.762	0.838	0.914	0.991	1.067	1.143	1.219	1.295	1.372	1.448	1.524
A	3	0.25	0.076	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
	6	0.5	0.152	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
B	9	0.75	0.229	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
	12	1	0.305	999	999	999	999	999	999	999	999	999	999	999	999	0.102	999	999	0.1025	999	0.0365	999	999
C	15	1.25	0.381	999	999	999	999	0.310	999	999	999	999	0.076	0.076	999	0.069	999	999	999	999	0.1045	999	999
	18	1.5	0.457	999	999	0.023	999	999	999	999	0.357	999	999	0.042	999	0.067	999	999	999	999	999	999	999
D	21	1.75	0.533	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
	24	2	0.610	999	999	999	999	0.052	999	999	999	999	999	999	999	0.044	999	999	0.07	999	999	999	999
E	27	2.25	0.686	999	999	999	999	999	999	999	999	999	999	999	999	0.032	999	999	999	999	999	999	999
	30	2.5	0.762	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	0.0795	999	0.0275	999	999
F	33	2.75	0.838	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
	36	3	0.914	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
G	39	3.25	0.991	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999

rid ID				11		12		13		14	
	in			63	66	69	72	75	78	81	84
		ft		5.25	5.5	5.75	6	6.25	6.5	6.75	7
			m	1.600	1.676	1.753	1.829	1.905	1.981	2.057	2.134
A	3	0.25	0.076	999	999	999	999	999	999	999	999
	6	0.5	0.152	999	999	999	999	0.046	999	999	999
B	9	0.75	0.229	999	999	999	999	999	999	999	999
	12	1	0.305	999	999	999	999	999	999	999	999
C	15	1.25	0.381	999	999	999	999	0.021	999	999	999
	18	1.5	0.457	999	999	999	999	999	999	999	999
D	21	1.75	0.533	999	999	999	999	999	999	999	999
	24	2	0.610	999	999	999	999	999	999	999	999
E	27	2.25	0.686	999	999	999	999	999	999	999	999
	30	2.5	0.762	999	999	999	999	999	999	999	999
F	33	2.75	0.838	999	999	999	999	999	999	999	999
	36	3	0.914	999	999	999	999	999	999	999	999
G	39	3.25	0.991	999	999	999	999	999	999	999	999

999 = missing data; no measurement.

Conversion: µm/y = 11.63 * µA/cm^2.

APPENDIX F -- CHLORIDE PROFILE DATA AFTER ICCP

APPENDIX F – Chloride Profile Data after ICCP

F.1 CHLORIDE PROFILE DATA AFTER 0.5 year ICCP

Original Concrete, concentration in weight pct in powder sample

Sample	Location	Slice 48-49, 49F(east to west)			Slice 50-51, 50F(west to east)			Slice 52-53, 53E(east to west)		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	7.61	0.269	0.245	10.60	0.279	0.215	.94	0.386	0.302
0.5-1.0	0.75	13.40	0.342	0.302	8.94	0.210	0.167	7.35	0.289	0.215
1.0-1.5	1.25	8.90	0.262	0.255	11.10	0.216	0.171	6.29	0.172	0.120
1.5-2.0	1.75	8.28	0.189	0.169	8.82	0.129	0.098	7.22	0.208	0.153
2.0-2.5	2.25	7.69	0.128	0.109	7.19	0.070	0.057	4.99	0.137	0.091
2.5-3.0	2.75	9.85	0.117	0.105	6.43	0.056	0.041	7.22	0.178	0.125
3.0-3.5	3.25	8.36	0.099	0.072	8.39	0.039	0.027	4.08	0.080	0.050
3.5-4.0	3.75	8.17	0.041	0.038	10.80	0.031	0.023	4.68	0.061	0.039
4.0-4.5	4.25	8.10	0.023	0.020	10.60	0.019	0.011	7.66	0.070	0.048
4.5-5.0	4.75	9.35	0.012	0.011	7.28	0.012	0.008	4.76	0.030	0.017
5.0-5.5	5.25	7.29	0.007	0.006	6.68	0.010	0.005	7.11	0.029	0.015
5.5-6.0	5.75	4.04	0.007	0.006	8.51	0.013	0.007	8.35	0.021	0.011
6.0-6.5	6.25	6.06	0.008	0.006	10.50	0.013	0.012	7.33	0.012	0.006
6.5-7.0	6.75	5.88	0.008	0.006	10.40	0.012	0.007	9.12	0.014	0.005
7.0-7.5	7.25	7.37	0.007	0.006	11.20	0.012	0.011	9.26	0.003	0.004
7.5-8.0	7.75	7.51	0.011	0.009	8.12	0.012	0.010	9.58	0.016	0.009
8.0-8.5	8.25	7.64	0.007	0.006	7.29	0.016	0.015	7.72	0.010	0.011
8.5-9.0	8.75	7.66	0.007	0.005	10.20	0.028	0.026	7.09	0.035	0.007
9.0-9.5	9.25	6.06	0.009	0.008	5.90	0.024	0.019	9.13	0.010	0.005
9.5-10.0	9.75	6.14	0.009	0.006	7.36	0.029	0.020	7.79	0.015	0.014
10.0-10.5	10.25	8.73	0.012	0.011	7.77	0.031	0.024	9.24	0.031	0.013
10.5-11.0	10.75	8.15	0.019	0.018	7.83	0.036	0.033	7.22	0.049	0.041
11.0-11.5	11.25	4.57	0.021	0.019	8.79	0.088	0.087	8.52	0.083	0.053
11.5-12.0	11.75	6.63	0.052	0.047	8.73	0.127	0.127	10.60	0.120	0.102
12.0-12.5	12.25	7.19	0.061	0.060	8.59	0.170	0.167	8.50	0.101	0.076
12.5-13.0	12.75	8.38	0.103	0.100	6.90	0.185	0.177	9.94	0.155	0.117
13.0-13.5	13.25	6.92	0.133	0.128	6.06	0.184	0.171	8.45	0.156	0.124
13.5-14.0	13.75	6.85	0.166	0.163	9.49	0.211	0.155	7.64	0.183	0.134
14.0-14.5	14.25									
14.5-15.0	14.75									
10.0-10.5	10.25									
10.5-11.0	10.75									
11.0-11.5	11.25									
11.5-12.0	11.75									
12.0-12.5	12.25	9.65	0.071	0.067	8.40	0.161	0.160	8.09	0.177	0.155
12.5-13.0	12.75	9.54	0.105	0.099	7.85	0.171	0.161	6.94	0.156	0.119
13.013.5	13.25	10.1	0.172	0.154	9.32	0.294	0.287	6.46	0.183	0.146
13.5-14.0	13.75	11.7	0.215	0.211	11.00	0.352	0.343	3.27	0.116	0.095
14.0-14.5	14.25	10.8	0.295	0.292	9.86	0.352	0.342	5.23	0.220	0.180
14.5-15.0	14.75	11.5	0.291	0.286	9.04	0.333	0.319	7.19	0.744	0.696

Original Concrete, concentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49F(east to west) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50F(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53E(east to west) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	323.1	11.42	10.40	323.1	8.51	6.55	323.1	17.97	14.06
0.5-1.0	0.75	323.1	8.25	7.28	323.1	7.59	6.04	323.1	12.71	9.45
1.0-1.5	1.25	323.1	9.51	9.26	323.1	6.29	4.98	323.1	8.84	6.16
1.5-2.0	1.75	323.1	7.38	6.60	323.1	4.73	3.59	323.1	9.31	6.85
2.0-2.5	2.25	323.1	5.38	4.58	323.1	3.15	2.56	323.1	8.87	5.89
2.5-3.0	2.75	323.1	3.84	3.44	323.1	2.81	2.06	323.1	7.97	5.59
3.0-3.5	3.25	323.1	3.83	2.78	323.1	1.50	1.04	323.1	6.34	3.96
3.5-4.0	3.75	323.1	1.62	1.50	323.1	0.93	0.69	323.1	4.21	2.69
4.0-4.5	4.25	323.1	0.92	0.80	323.1	0.58	0.34	323.1	2.95	2.02
4.5-5.0	4.75	323.1	0.41	0.38	323.1	0.53	0.36	323.1	2.04	1.15
5.0-5.5	5.25	323.1	0.31	0.27	323.1	0.48	0.24	323.1	1.32	0.68
5.5-6.0	5.75	323.1	0.56	0.48	323.1	0.49	0.27	323.1	0.81	0.43
6.0-6.5	6.25	323.1	0.43	0.32	323.1	0.40	0.37	323.1	0.53	0.26
6.5-7.0	6.75	323.1	0.44	0.33	323.1	0.37	0.22	323.1	0.50	0.18
7.0-7.5	7.25	323.1	0.31	0.26	323.1	0.35	0.32	323.1	0.10	0.14
7.5-8.0	7.75	323.1	0.47	0.39	323.1	0.48	0.40	323.1	0.54	0.30
8.0-8.5	8.25	323.1	0.30	0.25	323.1	0.71	0.66	323.1	0.42	0.46
8.5-9.0	8.75	323.1	0.30	0.21	323.1	0.89	0.82	323.1	1.60	0.32
9.0-9.5	9.25	323.1	0.48	0.43	323.1	1.31	1.04	323.1	0.35	0.18
9.5-10.0	9.75	323.1	0.47	0.32	323.1	1.27	0.88	323.1	0.62	0.58
10.0-10.5	10.25	323.1	0.44	0.41	323.1	1.29	1.00	323.1	1.08	0.45
10.5-11.0	10.75	323.1	0.75	0.71	323.1	1.49	1.36	323.1	2.19	1.83
11.0-11.5	11.25	323.1	1.48	1.34	323.1	3.24	3.20	323.1	3.15	2.01
11.5-12.0	11.75	323.1	2.53	2.29	323.1	4.70	4.70	323.1	3.66	3.11
12.0-12.5	12.25	323.1	2.74	2.70	323.1	6.40	6.28	323.1	3.84	2.89
12.5-13.0	12.75	323.1	3.97	3.86	323.1	8.66	8.29	323.1	5.04	3.80
13.0-13.5	13.25	323.1	6.21	5.98	323.1	9.81	9.12	323.1	5.97	4.74
13.5-14.0	13.75	323.1	7.83	7.69	323.1	7.18	5.28	323.1	7.74	5.67
14.0-14.5	14.25									
14.5-15.0	14.75									
10.0-10.5	10.25									
10.5-11.0	10.75									
11.0-11.5	11.25									
11.5-12.0	11.75									
12.0-12.5	12.25	323.1	2.38	2.24	323.1	6.19	6.15	323.1	7.07	6.19
12.5-13.0	12.75	323.1	3.56	3.35	323.1	7.04	6.63	323.1	7.26	5.54
13.013.5	13.25	323.1	5.50	4.93	323.1	10.19	9.95	323.1	9.15	7.30
13.5-14.0	13.75	323.1	5.94	5.83	323.1	10.34	10.08	323.1	11.46	9.39
14.0-14.5	14.25	323.1	8.83	8.74	323.1	11.54	11.21	323.1	13.59	11.12
14.5-15.0	14.75	323.1	8.18	8.04	323.1	11.90	11.40	323.1	33.44	31.28

Original Concrete, concentration in pounds per cubic yard of concrete										
Sample	Location	Slice 48-49, 49F(west to east)			Slice 50-51, 50F(west to east)			Slice 52-53, 53E(west to east)		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	323.1	8.18	8.04	323.1	8.51	6.55	323.1	33.44	31.28
0.5-1.0	0.75	323.1	8.83	8.74	323.1	7.59	6.04	323.1	13.59	11.12
1.0-1.5	1.25	323.1	5.94	5.83	323.1	6.29	4.98	323.1	11.46	9.39
1.5-2.0	1.75	323.1	5.50	4.93	323.1	4.73	3.59	323.1	9.15	7.30
2.0-2.5	2.25	323.1	3.56	3.35	323.1	3.15	2.56	323.1	7.26	5.54
2.5-3.0	2.75	323.1	2.38	2.24	323.1	2.81	2.06	323.1	7.07	6.19
3.0-3.5	3.25	323.1	2.53	2.29	323.1	1.50	1.04	323.1	3.66	3.11
3.5-4.0	3.75	323.1	1.48	1.34	323.1	0.93	0.69	323.1	3.15	2.01
4.0-4.5	4.25	323.1	0.75	0.71	323.1	0.58	0.34	323.1	2.19	1.83
4.5-5.0	4.75	323.1	0.44	0.41	323.1	0.53	0.36	323.1	1.08	0.45
5.0-5.5	5.25	323.1	0.47	0.32	323.1	0.48	0.24	323.1	0.62	0.58
5.5-6.0	5.75	323.1	0.48	0.43	323.1	0.49	0.27	323.1	0.35	0.18
6.0-6.5	6.25	323.1	0.30	0.21	323.1	0.40	0.37	323.1	1.60	0.32
6.5-7.0	6.75	323.1	0.30	0.25	323.1	0.37	0.22	323.1	0.42	0.46
7.0-7.5	7.25	323.1	0.47	0.39	323.1	0.35	0.32	323.1	0.54	0.30
7.5-8.0	7.75	323.1	0.31	0.26	323.1	0.48	0.40	323.1	0.10	0.14
8.0-8.5	8.25	323.1	0.44	0.33	323.1	0.71	0.66	323.1	0.50	0.18
8.5-9.0	8.75	323.1	0.43	0.32	323.1	0.89	0.82	323.1	0.53	0.26
9.0-9.5	9.25	323.1	0.56	0.48	323.1	1.31	1.04	323.1	0.81	0.43
9.5-10.0	9.75	323.1	0.31	0.27	323.1	1.27	0.88	323.1	1.32	0.68
10.0-10.5	10.25	323.1	0.41	0.38	323.1	1.29	1.00	323.1	2.04	1.15
10.5-11.0	10.75	323.1	0.92	0.80	323.1	1.49	1.36	323.1	2.95	2.02
11.0-11.5	11.25	323.1	1.62	1.50	323.1	3.24	3.20	323.1	4.21	2.69
11.5-12.0	11.75	323.1	3.83	2.78	323.1	4.70	4.70	323.1	6.34	3.96
12.0-12.5	12.25	323.1	3.84	3.44	323.1	6.19	6.15	323.1	7.97	5.59
12.5-13.0	12.75	323.1	5.38	4.58	323.1	7.04	6.63	323.1	8.87	5.89
13.0-13.5	13.25	323.1	7.38	6.60	323.1	10.19	9.95	323.1	9.31	6.85
13.5-14.0	13.75	323.1	9.51	9.26	323.1	10.34	10.08	323.1	8.84	6.16
14.0-14.5	14.25	323.1	8.25	7.28	323.1	11.54	11.21	323.1	12.71	9.45
14.5-15.0	14.75	323.1	11.42	10.40	323.1	11.90	11.40	323.1	17.97	14.06

Patch Concrete, concentration in weight pct in powder sample

Sample range, in.	Location inches	Slice 48-49, 49B(east to west) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50B(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53B(east to west) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	3.65	0.287	0.287	4.80	0.434	0.317	4.21	0.455	0.433
0.5-1.0	0.75	5.03	0.239	0.235	3.69	0.142	0.111	3.95	0.111	0.069
1.0-1.5	1.25	5.74	0.237	0.213	3.07	0.110	0.086	4.45	0.126	0.109
1.5-2.0	1.75	4.80	0.077	0.068	3.68	0.149	0.135	3.99	0.124	0.084
2.0-2.5	2.25	4.55	0.072	0.052	3.60	0.112	0.104	5.19	0.144	0.113
2.5-3.0	2.75	5.54	0.075	0.072	3.21	0.071	0.058	4.33	0.127	0.094
3.0-3.5	3.25	6.85	0.072	0.070	3.25	0.089	0.068	4.94	0.144	0.091
3.5-4.0	3.75	6.45	0.065	0.063	3.74	0.093	0.076	5.17	0.119	0.083
4.0-4.5	4.25	5.37	0.052	0.049	4.19	0.130	0.124	5.21	0.091	0.057
4.5-5.0	4.75	5.80	0.052	0.051	4.14	0.099	0.094	5.98	0.067	0.040
5.0-5.5	5.25	5.67	0.072	0.053	4.81	0.114	0.102	7.50	0.039	0.018
5.5-6.0	5.75	6.77	0.047	0.041	5.53	0.045	0.042	7.67	0.020	0.010
6.0-6.5	6.25	6.59	0.034	0.031	7.64	0.045	0.038	9.22	0.018	0.005
6.5-7.0	6.75	5.91	0.027	0.024	4.27	0.026	0.011	6.37	0.014	0.005
7.0-7.5	7.25	7.05	0.014	0.012	5.47	0.031	0.030	7.35	0.017	0.016
7.5-8.0	7.75	5.88	0.016	0.013	8.17	0.022	0.019	9.08	0.019	0.010
8.0-8.5	8.25	5.32	0.026	0.019	8.60	0.039	0.035	7.39	0.015	0.009
8.5-9.0	8.75	8.68	0.051	0.043	7.23	0.021	0.007	7.64	0.019	0.007
9.0-9.5	9.25	9.14	0.065	0.063	5.21	0.015	0.013	8.45	0.027	0.011
9.5-10.0	9.75	5.85	0.061	0.060	5.00	0.020	0.013	6.06	0.036	0.018
10.0-10.5	10.25	3.83	0.040	0.038	6.21	0.043	0.026	6.83	0.082	0.053
10.5-11.0	10.75	5.33	0.116	0.104	8.80	0.071	0.048	4.54	0.085	0.060
11.0-11.5	11.25	4.80	0.062	0.060	4.80	0.087	0.077	4.85	0.114	0.113
11.5-12.0	11.75	3.95	0.042	0.039	5.23	0.114	0.105	5.01	0.117	0.094
12.0-12.5	12.25				3.30	0.080	0.068	4.62	0.139	0.098
12.5-13.0	12.75				3.77	0.096	0.081	4.38	0.097	0.070
13.0-13.5	13.25				3.85	0.093	0.087	5.70	0.047	0.038
13.5-14.0	13.75							5.47	0.070	0.043
14.0-14.5	14.25							5.22	0.081	0.055
14.5-15.0	14.75							7.61	0.019	0.015
10.0-10.5	10.25	4.39	0.067	0.064						
10.5-11.0	10.75	3.92	0.075	0.073						
11.0-11.5	11.25	5.09	0.130	0.122						
11.5-12.0	11.75	6.52	0.154	0.147	4.49	0.156	0.130			
12.0-12.5	12.25	8.25	0.168	0.162	4.13	0.115	0.097			
12.5-13.0	12.75	6.41	0.096	0.091	3.59	0.119	0.095			
13.013.5	13.25	4.40	0.029	0.023	3.92	0.062	0.049	5.49	0.077	0.057
13.5-14.0	13.75	4.91	0.034	0.031	2.94	0.152	0.093	4.21	0.021	0.005
14.0-14.5	14.25	3.64	0.198	0.188	6.66	0.183	0.107	5.11	0.063	0.034
14.5-15.0	14.75	0.83	1.51	0.862	5.37	1.160	0.549	4.09	0.262	0.112

Patch Concrete, concentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49B(east to west) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50B(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53B(east to west) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	216.2	17.00	17.00	216.2	19.55	14.28	216.2	23.36	22.23
0.5-1.0	0.75	216.2	10.27	10.10	216.2	8.32	6.50	216.2	6.07	3.78
1.0-1.5	1.25	216.2	8.93	8.02	216.2	7.75	6.06	216.2	6.12	5.29
1.5-2.0	1.75	216.2	3.47	3.06	216.2	8.75	7.93	216.2	6.72	4.55
2.0-2.5	2.25	216.2	3.42	2.47	216.2	6.73	6.24	216.2	6.00	4.71
2.5-3.0	2.75	216.2	2.93	2.81	216.2	4.78	3.91	216.2	6.34	4.69
3.0-3.5	3.25	216.2	2.27	2.21	216.2	5.92	4.52	216.2	6.30	3.98
3.5-4.0	3.75	216.2	2.18	2.11	216.2	5.38	4.39	216.2	4.98	3.47
4.0-4.5	4.25	216.2	2.09	1.97	216.2	6.71	6.40	216.2	3.78	2.37
4.5-5.0	4.75	216.2	1.94	1.90	216.2	5.17	4.91	216.2	2.42	1.45
5.0-5.5	5.25	216.2	2.75	2.02	216.2	5.12	4.58	216.2	1.12	0.52
5.5-6.0	5.75	216.2	1.50	1.31	216.2	1.76	1.64	216.2	0.56	0.28
6.0-6.5	6.25	216.2	1.12	1.02	216.2	1.27	1.08	216.2	0.42	0.12
6.5-7.0	6.75	216.2	0.99	0.88	216.2	1.32	0.56	216.2	0.48	0.17
7.0-7.5	7.25	216.2	0.43	0.37	216.2	1.23	1.19	216.2	0.50	0.47
7.5-8.0	7.75	216.2	0.59	0.48	216.2	0.58	0.50	216.2	0.45	0.24
8.0-8.5	8.25	216.2	1.06	0.77	216.2	0.98	0.88	216.2	0.44	0.26
8.5-9.0	8.75	216.2	1.27	1.07	216.2	0.63	0.21	216.2	0.54	0.20
9.0-9.5	9.25	216.2	1.54	1.49	216.2	0.62	0.54	216.2	0.69	0.28
9.5-10.0	9.75	216.2	2.25	2.22	216.2	0.86	0.56	216.2	1.28	0.64
10.0-10.5	10.25	216.2	2.26	2.14	216.2	1.50	0.91	216.2	2.60	1.68
10.5-11.0	10.75	216.2	4.70	4.22	216.2	1.74	1.18	216.2	4.05	2.86
11.0-11.5	11.25	216.2	2.79	2.70	216.2	3.92	3.47	216.2	5.08	5.04
11.5-12.0	11.75	216.2	2.30	2.13	216.2	4.71	4.34	216.2	5.05	4.06
12.0-12.5	12.25				216.2	5.24	4.45	216.2	6.50	4.59
12.5-13.0	12.75				216.2	5.50	4.64	216.2	4.79	3.45
13.0-13.5	13.25				216.2	5.22	4.88	216.2	1.78	1.44
13.5-14.0	13.75							216.2	2.77	1.70
14.0-14.5	14.25							216.2	3.35	2.28
14.5-15.0	14.75							216.2	0.54	0.43
10.0-10.5	10.25	216.2	3.30	3.15						
10.5-11.0	10.75	216.2	4.14	4.03						
11.0-11.5	11.25	216.2	5.52	5.18						
11.5-12.0	11.75	216.2	5.11	4.87	216.2	7.51	6.26			
12.0-12.5	12.25	216.2	4.40	4.24	216.2	6.02	5.08			
12.5-13.0	12.75	216.2	3.24	3.07	216.2	7.17	5.72			
13.013.5	13.25	216.2	1.42	1.13	216.2	3.42	2.70	216.2	3.03	2.24
13.5-14.0	13.75	216.2	1.50	1.36	216.2	11.18	6.84	216.2	1.08	0.26
14.0-14.5	14.25	216.2	11.76	11.16	216.2	5.94	3.47	216.2	2.67	1.44
14.5-15.0	14.75	216.2	393.28	224.51	216.2	46.70	22.10	216.2	13.85	5.92

Patch Concrete, oncentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49B(west to east) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50B(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53B(west to east) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	216.2	393.28	224.51	216.2	19.55	14.28	216.2	13.85	5.92
0.5-1.0	0.75	216.2	11.76	11.16	216.2	8.32	6.50	216.2	2.67	1.44
1.0-1.5	1.25	216.2	1.50	1.36	216.2	7.75	6.06	216.2	1.08	0.26
1.5-2.0	1.75	216.2	1.42	1.13	216.2	8.75	7.93	216.2	3.03	2.24
2.0-2.5	2.25	216.2	3.24	3.07	216.2	6.73	6.24	216.2	4.79	3.45
2.5-3.0	2.75	216.2	4.40	4.24	216.2	4.78	3.91	216.2	6.50	4.59
3.0-3.5	3.25	216.2	5.11	4.87	216.2	5.92	4.52	216.2	5.05	4.06
3.5-4.0	3.75	216.2	5.52	5.18	216.2	5.38	4.39	216.2	5.08	5.04
4.0-4.5	4.25	216.2	4.14	4.03	216.2	6.71	6.40	216.2	4.05	2.86
4.5-5.0	4.75	216.2	3.30	3.15	216.2	5.17	4.91	216.2	2.60	1.68
5.0-5.5	5.25	216.2	2.25	2.22	216.2	5.12	4.58	216.2	1.28	0.64
5.5-6.0	5.75	216.2	1.54	1.49	216.2	1.76	1.64	216.2	0.69	0.28
6.0-6.5	6.25	216.2	1.27	1.07	216.2	1.27	1.08	216.2	0.54	0.20
6.5-7.0	6.75	216.2	1.06	0.77	216.2	1.32	0.56	216.2	0.44	0.26
7.0-7.5	7.25	216.2	0.59	0.48	216.2	1.23	1.19	216.2	0.45	0.24
7.5-8.0	7.75	216.2	0.43	0.37	216.2	0.58	0.50	216.2	0.50	0.47
8.0-8.5	8.25	216.2	0.99	0.88	216.2	0.98	0.88	216.2	0.48	0.17
8.5-9.0	8.75	216.2	1.12	1.02	216.2	0.63	0.21	216.2	0.42	0.12
9.0-9.5	9.25	216.2	1.50	1.31	216.2	0.62	0.54	216.2	0.56	0.28
9.5-10.0	9.75	216.2	2.75	2.02	216.2	0.86	0.56	216.2	1.12	0.52
10.0-10.5	10.25	216.2	1.94	1.90	216.2	1.50	0.91	216.2	2.42	1.45
10.5-11.0	10.75	216.2	2.09	1.97	216.2	1.74	1.18	216.2	3.78	2.37
11.0-11.5	11.25	216.2	2.18	2.11	216.2	3.92	3.47	216.2	4.98	3.47
11.5-12.0	11.75	216.2	2.27	2.21	216.2	7.51	6.26	216.2	6.30	3.98
12.0-12.5	12.25	216.2	2.93	2.81	216.2	6.02	5.08	216.2	6.34	4.69
12.5-13.0	12.75	216.2	3.42	2.47	216.2	7.17	5.72	216.2	6.00	4.71
13.0-13.5	13.25	216.2	3.47	3.06	216.2	3.42	2.70	216.2	6.72	4.55
13.5-14.0	13.75	216.2	8.93	8.02	216.2	11.18	6.84	216.2	6.12	5.29
14.0-14.5	14.25	216.2	10.27	10.10	216.2	5.94	3.47	216.2	6.07	3.78
14.5-15.0	14.75	216.2	17.00	17.00	216.2	46.70	22.10	216.2	23.36	22.23

F.2 CHLORIDE DATA AFTER 1.0 year ICCP

Original Concrete, concentration in weight pct in powder sample										
Sample	Location	Slice 48-49, 49F(east to west)			Slice 50-51, 50F(west to east)			Slice 52-53, 53E(east to west)		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	6.41	0.185	0.160	6.41	0.191	0.176	7.44	0.451	0.378
0.5-1.0	0.75	7.39	0.253	0.247	9.13	0.239	0.222	6.54	0.285	0.233
1.0-1.5	1.25	10.50	0.382	0.350	3.61	0.060	0.049	7.60	0.269	0.239
1.5-2.0	1.75	8.16	0.223	0.190	5.30	0.070	0.063	9.51	0.225	0.199
2.0-2.5	2.25	9.46	0.160	0.142	8.43	0.081	0.069	8.25	0.152	0.123
2.5-3.0	2.75	7.43	0.066	0.063	5.71	0.052	0.039	6.54	0.087	0.072
3.0-3.5	3.25	10.60	0.078	0.070	8.79	0.053	0.046	8.62	0.071	0.059
3.5-4.0	3.75	9.67	0.041	0.037	9.53	0.030	0.026	10.30	0.056	0.046
4.0-4.5	4.25	8.31	0.017	0.017	8.94	0.016	0.012	9.61	0.025	0.023
4.5-5.0	4.75	7.99	0.012	0.009	8.34	0.008	0.006	10.50	0.015	0.014
5.0-5.5	5.25	7.62	0.009	0.004	9.51	0.008	0.003	10.00	0.008	0.008
5.5-6.0	5.75	7.17	0.007	0.004	7.76	0.010	0.007	12.10	0.007	0.007
6.0-6.5	6.25	7.28	0.006	0.004	6.85	0.007	0.007	11.70	0.007	0.006
6.5-7.0	6.75	8.71	0.006	0.005	4.15	0.007	0.005	10.50	0.006	0.006
7.0-7.5	7.25	9.76	0.008	0.006	2.66	0.007	0.004	7.72	0.006	0.005
7.5-8.0	7.75	7.15	0.008	0.005	7.12	0.009	0.006	10.30	0.006	0.005
8.0-8.5	8.25	5.15	0.007	0.005	7.88	0.006	0.005	9.99	0.008	0.007
8.5-9.0	8.75	9.32	0.006	0.003	7.41	0.006	0.006	12.30	0.006	0.004
9.0-9.5	9.25	7.36	0.006	0.005	7.31	0.007	0.005	7.92	0.009	0.007
9.5-10.0	9.75	7.75	0.005	0.005	9.54	0.007	0.004	11.50	0.007	0.006
10.0-10.5	10.25	7.76	0.010	0.009	8.52	0.006	0.006	9.08	0.010	0.010
10.5-11.0	10.75	8.83	0.028	0.021	7.78	0.017	0.012	8.84	0.019	0.019
11.0-11.5	11.25	7.30	0.032	0.030	7.68	0.027	0.024	9.95	0.034	0.028
11.5-12.0	11.75	8.61	0.061	0.049	7.29	0.052	0.044	10.70	0.062	0.055
12.0-12.5	12.25	8.78	0.097	0.083	5.57	0.061	0.054	7.47	0.041	0.040
12.5-13.0	12.75	7.65	0.097	0.081	8.37	0.109	0.099	9.85	0.133	0.110
13.0-13.5	13.25	6.61	0.104	0.084	8.56	0.164	0.139	8.66	0.171	0.160
13.5-14.0	13.75	6.51	0.182	0.150	9.52	0.249	0.223	4.59	0.136	0.091
14.0-14.5	14.25	9.15	0.318	0.254	5.65	0.180	0.154	9.4	0.253	0.248
14.5-15.0	14.75							8.25	0.287	0.224
10.0-10.5	10.25									
10.5-11.0	10.75									
11.0-11.5	11.25									
11.5-12.0	11.75									
12.0-12.5	12.25									
12.5-13.0	12.75	6.34	0.107	0.087	5.98	0.104	0.088			
13.013.5	13.25	7.12	0.147	0.122	4.63	0.077	0.075	10.20	0.147	0.123
13.5-14.0	13.75	7.38	0.197	0.174	7.27	0.240	0.222	8.30	0.188	0.179
14.0-14.5	14.25	7.46	0.252	0.223	10.30	0.397	0.395	8.00	0.260	0.237
14.5-15.0	14.75	6.9	0.218	0.197	7.22	0.297	0.249	8.72	0.380	0.378

Original Concrete, concentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49F(east to west) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50F(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53E(east to west) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	325.6	9.40	8.13	325.6	9.70	8.94	325.6	19.74	16.54
0.5-1.0	0.75	325.6	11.15	10.88	325.6	8.52	7.92	325.6	14.19	11.60
1.0-1.5	1.25	325.6	11.85	10.85	325.6	5.41	4.42	325.6	11.52	10.24
1.5-2.0	1.75	325.6	8.90	7.58	325.6	4.30	3.87	325.6	7.70	6.81
2.0-2.5	2.25	325.6	5.51	4.89	325.6	3.13	2.67	325.6	6.00	4.85
2.5-3.0	2.75	325.6	2.89	2.76	325.6	2.97	2.22	325.6	4.33	3.58
3.0-3.5	3.25	325.6	2.40	2.15	325.6	1.96	1.70	325.6	2.68	2.23
3.5-4.0	3.75	325.6	1.38	1.25	325.6	1.02	0.89	325.6	1.77	1.45
4.0-4.5	4.25	325.6	0.67	0.67	325.6	0.58	0.44	325.6	0.85	0.78
4.5-5.0	4.75	325.6	0.49	0.37	325.6	0.31	0.23	325.6	0.47	0.43
5.0-5.5	5.25	325.6	0.38	0.17	325.6	0.27	0.10	325.6	0.26	0.26
5.5-6.0	5.75	325.6	0.32	0.18	325.6	0.42	0.29	325.6	0.19	0.19
6.0-6.5	6.25	325.6	0.27	0.18	325.6	0.33	0.33	325.6	0.19	0.17
6.5-7.0	6.75	325.6	0.22	0.19	325.6	0.55	0.39	325.6	0.19	0.19
7.0-7.5	7.25	325.6	0.27	0.20	325.6	0.86	0.49	325.6	0.25	0.21
7.5-8.0	7.75	325.6	0.36	0.23	325.6	0.41	0.27	325.6	0.19	0.16
8.0-8.5	8.25	325.6	0.44	0.32	325.6	0.25	0.21	325.6	0.26	0.23
8.5-9.0	8.75	325.6	0.21	0.10	325.6	0.26	0.26	325.6	0.16	0.11
9.0-9.5	9.25	325.6	0.27	0.22	325.6	0.31	0.22	325.6	0.37	0.29
9.5-10.0	9.75	325.6	0.21	0.21	325.6	0.24	0.14	325.6	0.20	0.17
10.0-10.5	10.25	325.6	0.42	0.38	325.6	0.23	0.23	325.6	0.36	0.36
10.5-11.0	10.75	325.6	1.03	0.77	325.6	0.71	0.50	325.6	0.70	0.70
11.0-11.5	11.25	325.6	1.43	1.34	325.6	1.14	1.02	325.6	1.11	0.92
11.5-12.0	11.75	325.6	2.31	1.85	325.6	2.32	1.97	325.6	1.89	1.67
12.0-12.5	12.25	325.6	3.60	3.08	325.6	3.57	3.16	325.6	1.79	1.74
12.5-13.0	12.75	325.6	4.13	3.45	325.6	4.24	3.85	325.6	4.40	3.64
13.0-13.5	13.25	325.6	5.12	4.14	325.6	6.24	5.29	325.6	6.43	6.02
13.5-14.0	13.75	325.6	9.10	7.50	325.6	8.52	7.63	325.6	9.65	6.46
14.0-14.5	14.25	325.6	11.32	9.04	325.6	10.37	8.87	325.6	8.76	8.59
14.5-15.0	14.75							325.6	11.33	8.84
10.0-10.5	10.25									
10.5-11.0	10.75									
11.0-11.5	11.25									
11.5-12.0	11.75									
12.0-12.5	12.25									
12.5-13.0	12.75	325.6	5.50	4.47	325.6	5.66	4.79			
13.013.5	13.25	325.6	6.72	5.58	325.6	5.42	5.27	325.6	4.69	3.93
13.5-14.0	13.75	325.6	8.69	7.68	325.6	10.75	9.94	325.6	7.38	7.02
14.0-14.5	14.25	325.6	11.00	9.73	325.6	12.55	12.49	325.6	10.58	9.65
14.5-15.0	14.75	325.6	10.29	9.30	325.6	13.39	11.23	325.6	14.19	14.11

Original Concrete, concentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49F(west to east) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50F(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53E(west to east) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	325.6	10.29	9.30	325.6	9.70	8.94	325.6	14.19	14.11
0.5-1.0	0.75	325.6	11.00	9.73	325.6	8.52	7.92	325.6	10.58	9.65
1.0-1.5	1.25	325.6	8.69	7.68	325.6	5.41	4.42	325.6	7.38	7.02
1.5-2.0	1.75	325.6	6.72	5.58	325.6	4.30	3.87	325.6	4.69	3.93
2.0-2.5	2.25	325.6	4.13	3.45	325.6	3.13	2.67	325.6	4.40	3.64
2.5-3.0	2.75	325.6	3.60	3.08	325.6	2.97	2.22	325.6	1.79	1.74
3.0-3.5	3.25	325.6	2.31	1.85	325.6	1.96	1.70	325.6	1.89	1.67
3.5-4.0	3.75	325.6	1.43	1.34	325.6	1.02	0.89	325.6	1.11	0.92
4.0-4.5	4.25	325.6	1.03	0.77	325.6	0.58	0.44	325.6	0.70	0.70
4.5-5.0	4.75	325.6	0.42	0.38	325.6	0.31	0.23	325.6	0.36	0.36
5.0-5.5	5.25	325.6	0.21	0.21	325.6	0.27	0.10	325.6	0.20	0.17
5.5-6.0	5.75	325.6	0.27	0.22	325.6	0.42	0.29	325.6	0.37	0.29
6.0-6.5	6.25	325.6	0.21	0.10	325.6	0.33	0.33	325.6	0.16	0.11
6.5-7.0	6.75	325.6	0.44	0.32	325.6	0.55	0.39	325.6	0.26	0.23
7.0-7.5	7.25	325.6	0.36	0.23	325.6	0.86	0.49	325.6	0.19	0.16
7.5-8.0	7.75	325.6	0.27	0.20	325.6	0.41	0.27	325.6	0.25	0.21
8.0-8.5	8.25	325.6	0.22	0.19	325.6	0.25	0.21	325.6	0.19	0.19
8.5-9.0	8.75	325.6	0.27	0.18	325.6	0.26	0.26	325.6	0.19	0.17
9.0-9.5	9.25	325.6	0.32	0.18	325.6	0.31	0.22	325.6	0.19	0.19
9.5-10.0	9.75	325.6	0.38	0.17	325.6	0.24	0.14	325.6	0.26	0.26
10.0-10.5	10.25	325.6	0.49	0.37	325.6	0.23	0.23	325.6	0.47	0.43
10.5-11.0	10.75	325.6	0.67	0.67	325.6	0.71	0.50	325.6	0.85	0.78
11.0-11.5	11.25	325.6	1.38	1.25	325.6	1.14	1.02	325.6	1.77	1.45
11.5-12.0	11.75	325.6	2.40	2.15	325.6	2.32	1.97	325.6	2.68	2.23
12.0-12.5	12.25	325.6	2.89	2.76	325.6	3.57	3.16	325.6	4.33	3.58
12.5-13.0	12.75	325.6	5.51	4.89	325.6	4.24	3.85	325.6	6.00	4.85
13.0-13.5	13.25	325.6	8.90	7.58	325.6	5.42	5.27	325.6	7.70	6.81
13.5-14.0	13.75	325.6	11.85	10.85	325.6	10.75	9.94	325.6	11.52	10.24
14.0-14.5	14.25	325.6	11.15	10.88	325.6	12.55	12.49	325.6	14.19	11.60
14.5-15.0	14.75	325.6	9.40	8.13	325.6	13.39	11.23	325.6	19.74	16.54

Patch Concrete, concentration in weight pct in powder sample

Sample range, in.	Location inches	Slice 48-49, 49B(east to west) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50B(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53B(east to west) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	4.13	0.135	0.086	3.33	0.417	0.404	6.32	0.187	0.167
0.5-1.0	0.75	5.98	0.140	0.116	5.22	0.071	0.066	6.44	0.171	0.170
1.0-1.5	1.25	6.48	0.193	0.172	3.76	0.071	0.065	5.95	0.188	0.180
1.5-2.0	1.75	5.36	0.101	0.088	4.93	0.095	0.092	5.83	0.154	0.153
2.0-2.5	2.25	4.79	0.075	0.064	4.87	0.125	0.118	6.15	0.111	0.111
2.5-3.0	2.75	5.15	0.058	0.053	5.22	0.125	0.117	5.46	0.095	0.094
3.0-3.5	3.25	3.99	0.031	0.031	5.93	0.155	0.150	4.43	0.052	0.052
3.5-4.0	3.75	4.16	0.026	0.019	6.49	0.158	0.158	4.73	0.043	0.042
4.0-4.5	4.25	6.48	0.025	0.019	5.28	0.125	0.113	4.57	0.023	0.023
4.5-5.0	4.75	4.96	0.014	0.010	5.24	0.115	0.110	3.60	0.014	0.013
5.0-5.5	5.25	4.35	0.009	0.006	4.04	0.093	0.083	5.78	0.011	0.010
5.5-6.0	5.75	6.65	0.007	0.005	4.29	0.086	0.076	5.87	0.009	0.008
6.0-6.5	6.25	5.66	0.005	0.004	0.00	0.000	0.000	5.60	0.007	0.006
6.5-7.0	6.75	7.83	0.019	0.017	4.82	0.063	0.060	5.18	0.007	0.007
7.0-7.5	7.25	8.23	0.054	0.047	4.56	0.069	0.051	4.92	0.007	0.006
7.5-8.0	7.75	4.99	0.049	0.040	6.57	0.050	0.043	5.54	0.006	0.006
8.0-8.5	8.25	3.23	0.036	0.032	6.38	0.045	0.033	5.51	0.006	0.005
8.5-9.0	8.75	3.99	0.058	0.050	5.12	0.020	0.017	6.03	0.014	0.014
9.0-9.5	9.25	4.69	0.080	0.076	5.88	0.020	0.015	5.84	0.022	0.021
9.5-10.0	9.75	4.54	0.100	0.087	5.39	0.023	0.021	5.87	0.041	0.041
10.0-10.5	10.25	5.62	0.108	0.097	5.64	0.041	0.037	7.83	0.062	0.062
10.5-11.0	10.75	4.88	0.097	0.090	5.62	0.055	0.050	8.02	0.080	0.079
11.0-11.5	11.25	5.88	0.126	0.108	5.46	0.070	0.067	6.25	0.118	0.116
11.5-12.0	11.75	7.15	0.156	0.148	6.50	0.078	0.072	6.81	0.118	0.116
12.0-12.5	12.25	6.04	0.166	0.151	6.90	0.103	0.095	6.88	0.162	0.158
12.5-13.0	12.75	5.63	0.155	0.148	6.83	0.097	0.090	3.78	0.115	0.115
13.0-13.5	13.25	6.04	0.183	0.164				5.00	0.128	0.127
13.5-14.0	13.75	5.2	0.167	0.149				7.05	0.188	0.184
14.0-14.5	14.25	6.04	0.219	0.196				7.55	0.164	0.143
14.5-15.0	14.75	4.91	0.168	0.153				6.11	0.241	0.222
10.0-10.5	10.25									
10.5-11.0	10.75									
11.0-11.5	11.25				5.36	0.087	0.081			
11.5-12.0	11.75				5.87	0.119	0.107			
12.0-12.5	12.25				7.63	0.219	0.212			
12.5-13.0	12.75				9.23	0.231	0.218			
13.013.5	13.25	4.76	0.182	0.156	5.12	0.159	0.146	5.68	0.148	0.127
13.5-14.0	13.75	5.30	0.205	0.191	5.33	0.233	0.220	7.24	0.178	0.160
14.0-14.5	14.25	5.83	0.189	0.156	5.97	0.223	0.213	6.04	0.209	0.197
14.5-15.0	14.75	4.69	0.433	0.3	5.22	0.090	0.079	5.76	0.290	0.222

Patch Concrete, concentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49B(east to west) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50B(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53B(east to west) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	222.7	7.28	4.64	222.7	27.89	27.02	222.7	6.59	5.89
0.5-1.0	0.75	222.7	5.21	4.32	222.7	3.03	2.82	222.7	5.91	5.88
1.0-1.5	1.25	222.7	6.63	5.91	222.7	4.21	3.85	222.7	7.04	6.74
1.5-2.0	1.75	222.7	4.20	3.66	222.7	4.29	4.16	222.7	5.88	5.84
2.0-2.5	2.25	222.7	3.49	2.98	222.7	5.72	5.40	222.7	4.02	4.02
2.5-3.0	2.75	222.7	2.51	2.29	222.7	5.33	4.99	222.7	3.88	3.83
3.0-3.5	3.25	222.7	1.73	1.73	222.7	5.82	5.63	222.7	2.61	2.61
3.5-4.0	3.75	222.7	1.39	1.02	222.7	5.42	5.42	222.7	2.02	1.98
4.0-4.5	4.25	222.7	0.86	0.65	222.7	5.27	4.77	222.7	1.12	1.12
4.5-5.0	4.75	222.7	0.63	0.45	222.7	4.89	4.68	222.7	0.87	0.80
5.0-5.5	5.25	222.7	0.46	0.31	222.7	5.13	4.58	222.7	0.42	0.39
5.5-6.0	5.75	222.7	0.23	0.17	222.7	4.46	3.95	222.7	0.34	0.30
6.0-6.5	6.25	222.7	0.20	0.16				222.7	0.28	0.24
6.5-7.0	6.75	222.7	0.54	0.48	222.7	2.91	2.77	222.7	0.30	0.30
7.0-7.5	7.25	222.7	1.46	1.27	222.7	3.37	2.49	222.7	0.32	0.27
7.5-8.0	7.75	222.7	2.19	1.79	222.7	1.69	1.46	222.7	0.24	0.24
8.0-8.5	8.25	222.7	2.48	2.21	222.7	1.57	1.15	222.7	0.24	0.20
8.5-9.0	8.75	222.7	3.24	2.79	222.7	0.87	0.74	222.7	0.52	0.52
9.0-9.5	9.25	222.7	3.80	3.61	222.7	0.76	0.57	222.7	0.84	0.80
9.5-10.0	9.75	222.7	4.91	4.27	222.7	0.95	0.87	222.7	1.56	1.56
10.0-10.5	10.25	222.7	4.28	3.84	222.7	1.62	1.46	222.7	1.76	1.76
10.5-11.0	10.75	222.7	4.43	4.11	222.7	2.18	1.98	222.7	2.22	2.19
11.0-11.5	11.25	222.7	4.77	4.09	222.7	2.86	2.73	222.7	4.20	4.13
11.5-12.0	11.75	222.7	4.86	4.61	222.7	2.67	2.47	222.7	3.86	3.79
12.0-12.5	12.25	222.7	6.12	5.57	222.7	3.32	3.07	222.7	5.24	5.11
12.5-13.0	12.75	222.7	6.13	5.85	222.7	3.16	2.93	222.7	6.78	6.78
13.0-13.5	13.25	222.7	6.75	6.05	222.7	3.62	3.37	222.7	5.70	5.66
13.5-14.0	13.75	222.7	7.15	6.38	222.7	4.52	4.06	222.7	5.94	5.81
14.0-14.5	14.25	222.7	8.08	7.23	222.7	6.39	6.19	222.7	4.84	4.22
14.5-15.0	14.75				222.7	5.57	5.26	222.7	8.78	8.09
10.0-10.5	10.25									
10.5-11.0	10.75									
11.0-11.5	11.25									
11.5-12.0	11.75									
12.0-12.5	12.25				222.7	6.39	6.19			
12.5-13.0	12.75				222.7	5.57	5.26			
13.013.5	13.25	222.7	8.52	7.30	222.7	6.92	6.35	222.7	5.80	4.98
13.5-14.0	13.75	222.7	8.61	8.03	222.7	9.74	9.19	222.7	5.48	4.92
14.0-14.5	14.25	222.7	7.22	5.96	222.7	8.32	7.95	222.7	7.71	7.26
14.5-15.0	14.75	222.7	20.56	14.25	222.7	3.84	3.37	222.7	11.21	8.58

Patch Concrete, concentration in pounds per cubic yard of concrete

Sample range, in.	Location inches	Slice 48-49, 49B(west to east) Ca	Cl(total)	Cl(sol)	Slice 50-51, 50B(west to east) Ca	Cl(total)	Cl(sol)	Slice 52-53, 53B(west to east) Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	222.7	20.56	14.25	222.7	27.89	27.02	222.7	11.21	8.58
0.5-1.0	0.75	222.7	7.22	5.96	222.7	3.03	2.82	222.7	7.71	7.26
1.0-1.5	1.25	222.7	8.61	8.03	222.7	4.21	3.85	222.7	5.48	4.92
1.5-2.0	1.75	222.7	6.75	6.05	222.7	4.29	4.16	222.7	5.80	4.98
2.0-2.5	2.25	222.7	6.13	5.85	222.7	5.72	5.40	222.7	6.78	6.78
2.5-3.0	2.75	222.7	6.12	5.57	222.7	5.33	4.99	222.7	5.24	5.11
3.0-3.5	3.25	222.7	4.86	4.61	222.7	5.82	5.63	222.7	3.86	3.79
3.5-4.0	3.75	222.7	4.77	4.09	222.7	5.42	5.42	222.7	4.20	4.13
4.0-4.5	4.25	222.7	4.43	4.11	222.7	5.27	4.77	222.7	2.22	2.19
4.5-5.0	4.75	222.7	4.28	3.84	222.7	4.89	4.68	222.7	1.76	1.76
5.0-5.5	5.25	222.7	4.91	4.27	222.7	5.13	4.58	222.7	1.56	1.56
5.5-6.0	5.75	222.7	3.80	3.61	222.7	4.46	3.95	222.7	0.84	0.80
6.0-6.5	6.25	222.7	3.24	2.79				222.7	0.52	0.52
6.5-7.0	6.75	222.7	2.48	2.21	222.7	2.91	2.77	222.7	0.24	0.20
7.0-7.5	7.25	222.7	2.19	1.79	222.7	3.37	2.49	222.7	0.24	0.24
7.5-8.0	7.75	222.7	1.46	1.27	222.7	1.69	1.46	222.7	0.32	0.27
8.0-8.5	8.25	222.7	0.54	0.48	222.7	1.57	1.15	222.7	0.30	0.30
8.5-9.0	8.75	222.7	0.20	0.16	222.7	0.87	0.74	222.7	0.28	0.24
9.0-9.5	9.25	222.7	0.23	0.17	222.7	0.76	0.57	222.7	0.34	0.30
9.5-10.0	9.75	222.7	0.46	0.31	222.7	0.95	0.87	222.7	0.42	0.39
10.0-10.5	10.25	222.7	0.63	0.45	222.7	1.62	1.46	222.7	0.87	0.80
10.5-11.0	10.75	222.7	0.86	0.65	222.7	2.18	1.98	222.7	1.12	1.12
11.0-11.5	11.25	222.7	1.39	1.02	222.7	2.86	2.73	222.7	2.02	1.98
11.5-12.0	11.75	222.7	1.73	1.73	222.7	2.67	2.47	222.7	2.61	2.61
12.0-12.5	12.25	222.7	2.51	2.29	222.7	3.32	3.07	222.7	3.88	3.83
12.5-13.0	12.75	222.7	3.49	2.98	222.7	5.57	5.26	222.7	4.02	4.02
13.0-13.5	13.25	222.7	4.20	3.66	222.7	6.92	6.35	222.7	5.88	5.84
13.5-14.0	13.75	222.7	6.63	5.91	222.7	9.74	9.19	222.7	7.04	6.74
14.0-14.5	14.25	222.7	5.21	4.32	222.7	8.32	7.95	222.7	5.91	5.88
14.5-15.0	14.75	222.7	7.28	4.64	222.7	3.84	3.37	222.7	6.59	5.89

F.3 AVERAGE CHLORIDE PROFILE DATA – “as-received”, 0.5 and 1.0 years ICCP

Original Concrete, AVERAGE concentration in pounds per cubic yard of concrete										
Sample	Location	“as-received”			0.5 year ICCP (49F and 50F)			1.0 year ICCP		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	297.0	7.52	7.06	323.1	8.34	7.30	325.6	11.39	10.78
0.5-1.0	0.75	297.0	6.50	6.16	323.1	8.21	7.39	325.6	10.03	9.10
1.0-1.5	1.25	297.0	4.89	3.85	323.1	6.11	5.40	325.6	7.16	6.37
1.5-2.0	1.75	297.0	3.50	3.27	323.1	5.11	4.26	325.6	5.24	4.46
2.0-2.5	2.25	297.0	2.31	2.23	323.1	3.35	2.96	325.6	3.88	3.25
2.5-3.0	2.75	297.0	0.56	0.40	323.1	2.60	2.15	325.6	2.78	2.35
3.0-3.5	3.25	297.0	0.37	0.25	323.1	2.02	1.67	325.6	2.05	1.74
3.5-4.0	3.75	297.0	0.64	0.43	323.1	1.21	1.02	325.6	1.19	1.05
4.0-4.5	4.25	297.0	0.38	0.27	323.1	0.67	0.52	325.6	0.77	0.64
4.5-5.0	4.75	297.0	0.39	0.28	323.1	0.49	0.38	325.6	0.36	0.32
5.0-5.5	5.25	297.0	0.54	0.35	323.1	0.48	0.28	325.6	0.23	0.16
5.5-6.0	5.75	297.0	0.46	0.28	323.1	0.49	0.35	325.6	0.35	0.27
6.0-6.5	6.25	297.0	0.50	0.28	323.1	0.35	0.29	325.6	0.23	0.18
6.5-7.0	6.75	297.0	0.68	0.35	323.1	0.33	0.24	325.6	0.42	0.31
7.0-7.5	7.25	297.0	0.71	0.38	323.1	0.41	0.35	325.6	0.47	0.29
7.5-8.0	7.75	297.0	0.64	0.39	323.1	0.39	0.33	325.6	0.31	0.23
8.0-8.5	8.25	297.0	0.61	0.33	323.1	0.57	0.50	325.6	0.22	0.19
8.5-9.0	8.75	297.0	0.70	0.37	323.1	0.66	0.57	325.6	0.24	0.20
9.0-9.5	9.25	297.0	0.52	0.33	323.1	0.94	0.76	325.6	0.27	0.20
9.5-10.0	9.75	297.0	0.52	0.26	323.1	0.79	0.57	325.6	0.29	0.19
10.0-10.5	10.25	297.0	0.57	0.31	323.1	0.85	0.69	325.6	0.39	0.34
10.5-11.0	10.75	297.0	0.82	0.48	323.1	1.20	1.08	325.6	0.74	0.65
11.0-11.5	11.25	297.0	1.32	0.64	323.1	2.43	2.35	325.6	1.43	1.24
11.5-12.0	11.75	297.0	2.02	1.55	323.1	4.26	3.74	325.6	2.47	2.11
12.0-12.5	12.25	297.0	3.04	2.58	323.1	5.02	4.80	325.6	3.60	3.17
12.5-13.0	12.75	297.0	5.44	3.99	323.1	6.21	5.60	325.6	5.25	4.53
13.0-13.5	13.25	297.0	8.22	5.25	323.1	8.78	8.27	325.6	7.34	6.56
13.5-14.0	13.75	297.0	7.31	6.73	323.1	9.93	9.67	325.6	11.37	10.35
14.0-14.5	14.25	297.0	12.46	11.88	323.1	9.89	9.25	325.6	12.63	11.66
14.5-15.0	14.75	297.0	12.22	11.65	323.1	11.66	10.90	325.6	14.18	11.97

Patch Concrete, AVERAGE concentration in pounds per cubic yard of concrete

Sample	Location	"as-received"			0.5 year ICCP			1.0 year ICCP		
range, in.	inches	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)	Ca	Cl(total)	Cl(sol)
0.0-0.5	0.25	231.2	10.83	10.87	216.2	60.00	60.00	222.7	19.89	16.62
0.5-1.0	0.75	231.2	15.78	15.22	216.2	7.21	6.30	222.7	5.99	5.35
1.0-1.5	1.25	231.2	15.55	15.92	216.2	1.29	0.81	222.7	6.10	5.60
1.5-2.0	1.75	231.2	13.76	13.81	216.2	2.23	1.69	222.7	5.61	5.06
2.0-2.5	2.25	231.2	12.25	12.17	216.2	4.01	3.26	222.7	6.21	6.01
2.5-3.0	2.75	231.2	11.25	10.89	216.2	5.45	4.42	222.7	5.57	5.22
3.0-3.5	3.25	231.2	6.47	6.49	216.2	5.08	4.46	222.7	4.85	4.68
3.5-4.0	3.75	231.2	4.27	4.26	216.2	5.30	5.11	222.7	4.80	4.55
4.0-4.5	4.25	231.2	3.28	3.40	216.2	4.09	3.44	222.7	3.97	3.69
4.5-5.0	4.75	231.2	1.80	1.67	216.2	2.95	2.41	222.7	3.64	3.43
5.0-5.5	5.25	231.2	0.96	1.03	216.2	1.77	1.43	222.7	3.86	3.47
5.5-6.0	5.75	231.2	0.61	0.81	216.2	1.11	0.89	222.7	3.03	2.79
6.0-6.5	6.25	231.2	0.33	0.49	216.2	0.90	0.63	222.7	1.88	1.65
6.5-7.0	6.75	231.2	0.32	0.38	216.2	0.75	0.52	222.7	1.88	1.73
7.0-7.5	7.25	231.2	0.14	0.18	216.2	0.52	0.36	222.7	1.93	1.51
7.5-8.0	7.75	231.2	0.74	0.67	216.2	0.46	0.42	222.7	1.16	1.00
8.0-8.5	8.25	231.2	0.26	0.23	216.2	0.73	0.52	222.7	0.80	0.65
8.5-9.0	8.75	231.2	1.03	0.95	216.2	0.77	0.57	222.7	0.45	0.38
9.0-9.5	9.25	231.2	0.59	0.36	216.2	1.03	0.80	222.7	0.44	0.35
9.5-10.0	9.75	231.2	0.95	0.77	216.2	1.93	1.27	222.7	0.61	0.52
10.0-10.5	10.25	231.2	1.06	0.93	216.2	2.18	1.67	222.7	1.04	0.90
10.5-11.0	10.75	231.2	1.89	1.83	216.2	2.93	2.17	222.7	1.39	1.25
11.0-11.5	11.25	231.2	3.29	3.15	216.2	3.58	2.79	222.7	2.09	1.91
11.5-12.0	11.75	231.2	3.61	3.86	216.2	4.29	3.10	222.7	2.34	2.27
12.0-12.5	12.25	231.2	5.34	5.23	216.2	4.63	3.75	222.7	3.24	3.06
12.5-13.0	12.75	231.2	6.01	6.11	216.2	4.71	3.59	222.7	4.36	4.09
13.0-13.5	13.25	231.2	9.26	9.33	216.2	5.09	3.81	222.7	5.67	5.28
13.5-14.0	13.75	231.2	10.44	10.75	216.2	7.52	6.66	222.7	7.80	7.28
14.0-14.5	14.25	231.2	9.54	9.67	216.2	8.17	6.94	222.7	6.48	6.05
14.5-15.0	14.75	231.2	3.01	2.65	216.2	20.18	19.62	222.7	5.90	4.63