Technical Memorandum

Date December 11, 2012

To: David Rhodes, P.G.
Florida Department of Environmental Protection

cc: Eric Glidden
Useppa Island Utility

From: Andrew McThenia, P.G.
Joshua Epting

RE: **EX-1 Injection Test Results and Recommendations**
Lee County – UIC
Permit/Cert No. 45884-002-UC/5X
Class V Group 9 Exploratory Injection Well

Cardno ENTRIX

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1.0 Introduction and Objectives

Cardno ENTRIX was contracted by the Useppa Utility Company (Utility) to provide hydrogeologic services in support of drilling and testing of a Class V Group 9 Exploratory Injection Well to determine the feasibility of construction of Class V Group 4 disposal system for reverse osmosis concentrate. Exploratory well EX-1 (EX-1) was constructed during the Spring of 2012, in accordance with Florida Department on Environmental Protection (FDEP) Underground Injection Control (UIC) Permit 45884-002-UC/5X. EX-1 was completed with an open borehole from 50 to 60 feet below land surface (bls) which is the proposed injection zone. Results from the exploratory drilling program indicated a lack of an Underground Sourse of Drinking Water (USDW) above the proposed injection zone and the presence of significant confinement between the proposed injection zone and the identified underlying USDW's. Based on the local geological framework, the injection of the Utilities RO concentrate is not expected to result in adverse impacts to any potential developable water resources in the area of the injection well. In the Completion Report for EX-1(Cardno ENTRIX, April 2012), Cardno ENTRIX reported an estimated transmissivity of the proposed injection zone of about 12,000 to 17,000 gallons per day per foot based on data collected during the constant rate drawdown test.

On October 31, 2012, Cardno ENTRIX conducted a 24-hour injection test of EX-1 using potable water from the Utility's water treatment plant. Pre-test background and post-test recovery water level and water quality data were recorded in well EX-1 and in several shallow monitor wells. This technical memorandum provides the injection testing procedures, results, and recommendations.

2.0 Well Construction

The exploratory well, four pad monitor wells, and monitor well MW-52184 were utilized to monitor water levels and collect water samples during the three distinct phases of injection test.

During construction of well EX-1, a pad monitor well was constructed on each corner of the drilling pad. These four monitor wells were designated according to their approximately location in relation to well EX-1 as NWMW, NEMW, SEMW, and SWMW (**Figure 1**). The pad monitor wells were constructed with 10 feet of 2-inch diameter, 0.01-inch millslot screen. The screen interval of each pad monitor well is about five to 15 feet bls. The Utility's drain field monitor well MW-52184 was also used to record water levels and collect water samples. Well MW-52184 is also a 2-inch diameter monitor well and is screened from about 5 to 10 feet bls. A temporary stilling well was installed on the bridge that crosses the adjacent tidal creek in order to record the local tidal cycles at the project site.

Refer to the report entitled *Completion Report for Class V Exploratory Well EX-1* (Cardno ENTRIX, April 2012) prepared for the Utility for a more detailed description of the injection well and pad monitor well construction and the hydrogeology encountered at the project site.

3.0 Injection Test Procedures

The three phases of the injection test were conducted to collect background, injection, and recovery data. Data collection was initiated on October 24 and was completed on November 9, 2012. Potable water was injected into EX-1 at a rate of about 32 gallons per minute (gpm) for approximately 24-hours beginning on October 31 and ending on November 1, 2012. Monitoring during testing was conducted of water levels in EX-1, the four pad monitor wells, monitor well MW-52184, and the adjacent tidal creek. **Figure 2** shows a hydrograph of all of the monitoring data over the complete background, injection, and recovery phases of the test.

Background Data

On October 24, 2012, Cardno ENTRIX surveyed the elevations of the tops of casings of well EX-1, the pad monitoring wells (4 total), the Utility's monitor well MW-52184, and the top of the temporary stilling well casing that was installed in the adjacent tidal creek. Water samples were collected from all six wells and the tidal creek and analyzed for temperature, specific conductivity, and total dissolved chloride concentration (**Table 1**).

The Utility connected approximately 150 feet of 2-inch diameter PVC piping from an existing potable supply line to well EX-1. A 2-inch diameter temporary flow meter and in-line valve was installed between the end of the piping and EX-1 to monitor and control the injection rate. On October 24, 2012, Cardno ENTRIX conducted a brief injection test for approximately 45 minutes at a rate of about 35 gpm to ensure that the piping was connected properly and the transducers were accurately recording water level data. Approximately 1,532 gallons were injected during the pre-test according to the flow meter's totalizer. The transducers recorded pre-test background water levels at 15 minutes for approximately one week prior to the start of the injection test.

Insitu Leveltroll® Model 700 and 500 pressure transducers/dataloggers were installed in the six wells and began recording water elevations at 15 minute intervals. Because the top of casing elevations were surveyed, the transducers were programmed to record water level elevation in feet above the National Geodetic Vertical Datum of 1929 (NGVD29) rather than the depth of water above the sensor.

Injection Test Data

After collecting background data for approximately one week, Cardno ENTRIX began the injection test on October 31, 2012. Prior to starting the test, the background data was downloaded from the pressure transducers/dataloggers and they were re-set to record water levels on a logarithmic scale (not to exceed 1-minute) beginning at 12:00 p.m. Water quality samples were also collected from the six wells and the tidal creek prior to starting the injection test. All wells were allowed to recover for over an hour prior to starting the injection test. The flow meter totalizer reading was 2,051,140 gallons prior to starting the test. The injection test began at 12:01 p.m. The initial injection rate of approximately 40 gpm was adjusted to approximately 35 gpm within about 17 minutes. The injection rate remained relatively steady but decreased slightly throughout the test and was 32 gpm immediately prior to terminating the test. The injection test continued for approximately 24 hours.

Recovery Data

The pressure transducers recorded water levels in EX-1, the four pad monitor wells, MW-52184, and in tidal creek at 1-minute intervals throughout the test. Three water quality sampling events were conducted during the injection test in the pad monitor wells, the tidal creek, and in MW-52184. The injection test was terminated on November 1, 2012 at 12:46 p.m after 1,486 minutes of injection. The final totalizer reading was 2,097,900 gallons. A total of 46,760 gallons were injected over 1,486 minutes, which equals an average injection rate of about 31.5 gpm.

The transducers remained in the wells recording recover data at 1-minute intervals for nine days after the end of the injection test. On November 9, 2012, Cardno ENTRIX removed the transducers from the wells and collected water quality samples from the pad monitor wells, MW-52184, and the tidal creek.

4.0 Injection Well Performance

Background data shown in **Figure 2** indicate that the water level elevation in well EX-1 reacts relatively quickly to changes in tide. While the daily high and low elevations in EX-1 do not fluctuate as drastically as the tide, the water elevation in EX-1 generally follows the tidal cycle. Therefore, a true static water level elevation in EX-1 prior to the test cannot be established because the system is always in a dynamic state. During the last tidal cycle before the injection test (approximately 12 hours prior to the test) the water level in EX-1 ranged from 1.08 to 2.05 feet, which equates to a fluctuation of 0.97 feet. The "static" water level in EX-1 at 11:59 a.m. immediately prior to starting the injection test was 2.05 feet (0.88 psi).

Injection began on October 31, 2012 at 12:01 p.m. The elevation in EX-1 rose from 2.05 feet (0.88 psi) at 12:00 p.m. to 4.85 feet (2.10 psi) at 12:03 p.m (**Figure 3**). At approximately three minutes after the start of injection, water elevations of EX-1 appear to respond mainly to the tidal cycle from 12:03 p.m. and continue to be dominated by the tide throughout the end of the injection test on November 1, 2012 at 12:49 p.m. Using a maximum water level change of 2.80 feet and an average injection rate of 31.5 gpm, the specific injectivity of EX-1 can be expressed as 11.2 gpm/ft or 26.0 gpm/psi.

The injection test was terminated on November 1, 2012, at 12:49 p.m. The water elevation in EX-1 immediately prior to ending the test was 5.27 feet. The water elevation immediately dropped to 2.84 feet within two minutes of the end of injection and then slowly declined to near equilibrium of 2.47 feet by 1:05 p.m. Recovery data indicate that the water elevation in EX-1 began responding to the tidal cycle at 1:15 p.m. The water elevation in EX-1 after the test did not return to the pre-test "static" elevation and remained an average of about 0.8 feet higher than prior to injection. This difference is partially attributed to the density differential between the native salt water and the fresh water "bubble" created around the injection zone and within the injection well casing. Additionally, at the end of the background monitoring period, the transducer in EX-1 was re-referenced (calibrated) because manual depth to water readings taken on November 1 indicated a lower than actual water elevation than what was shown on the transducer possibly due to instrument drift or movement of the probe as the cable relaxed in the well.

5.0 Monitoring Well Response

Water levels were monitored in the Utility's drain field monitor well MW-52184 and the four pad monitoring wells. All four pad monitor wells responded relatively uniformly with respect to response time and maximum water level change. Background data indicates that the water elevation in the pad monitor wells responsed almost instantly to changes in tide with very little lag time. The average fluctuation in the pad monitor wells due to tidal influence was about 0.9 feet during the last tidal cycle before the injection test. The water elevation in all four pad monitor wells deflected from pre-test static conditions at approximately 24 seconds after pumping began (**Figure 4**). After approximately 21 minutes of injecting, the water elevation in the pad monitor wells appears to respond with the tidal cycle from 12:22 p.m. to the end of the injection test on November 1, 2012 at 12:49 p.m as shown in **Figures 2 and 5**. The maximum water level change induced by injecting into EX-1 was approximately 0.8 feet in all four pad monitor wells.

The water elevation in MW-52184 also appears to respond with the tidal cycle although the changes are not as pronounced as the changes in the pad monitor wells. The water level in MW-52184 (located approximately 180 feet from the EX-1) first showed a response to pumping at approximately 12:03 p.m (3 minutes after pumping began). Because MW-52184 was much further away from EX-1 than the pad monitor wells, the water level rise in MW-52184 was gradual and relatively continuous throughout the injection test. The water elevation in MW-52184 immediately prior to the injection test was 1.81 feet. The elevation gradually rose throughout the injection test and was 2.19 feet after approximately 24 hours of pumping when pumping was stopped. It is important to note that MW-52184 is one of the Utility's drain field observation wells and responds to loading of the drain field by the water treatment plant. The treatment plant was operating and discharging to the drain field during the injection test so it is unclear whether the water level change in MW-52184 was attributed to injecting in EX-1 or to loading of the drain field, or to a combination of both. The gradual rise in MW-52184 shown in **Figure 2** from October 31 to November 1 (the time of the injection test) appears to be in response to the injection test as opposed to the immediate rise on November 6, which is likely indicative of drain field loading.

An analysis of the water quality data collected during the test does not indicate any noticable changes in the dissolved chloride concentration of the monitor wells that can be correlated with the injection test (**Figure 6**). The dissolved chloride concentration of each monitor well does fluctuate throughout the background, injecting, and recovery phases of the test; however, the fluctuations do not appear to be caused by the injection test.

6.0 Summary

The maximum water level change induced by injecting approximately 32 gpm into well EX-1 for 24 hours was 2.80 feet (1.21 psi) in well EX-1. The maximum water level change observed in the closest pad monitor well (NWMW) was 0.80 feet. The water level in all four pad monitor wells began to deflect from baseline at about 24 seconds after injection began. All four pad monitor wells responded relatively uniformly with respect to magnitude and response time, which indicates that the increase in pore pressure transmission upward from the injection is rapid and relatively uniform.

Water quality data collected in the pad monitor wells indicates that the dissolved chloride concentration ranged from about 3,000 to 5,200 milligrams per liter (mg/l) in the shallow water-table aquifer (5 to 15 bls) prior to the injection test. Laboratory analysis conducted during the drilling of EX-1 indicates the total dissolved solid (TDS) concentration in the pad monitor wells ranged from about 9,000 to 10,600 mg/l. The dissolved chloride concentration and the TDS of the proposed injection zone of EX-1 (50 to 60 feet bls) was 29,500 mg/l and 48,000 mg/l, respectively.

The data collected during the exploratory drilling of EX-1 and the data collected during the injection test indicate that the strata from land surface to 60 feet bls function as a single aquifer unit. The water levels in the pad monitor wells responded almost instantly during the injection test. Water quality sampling indicates the interval from about 5 to 60 feet bls is highly stratified with regards to the TDS concentration and ranges from highly brackish (8,000 mg/l) near land surface to sea water quality (48,000 mg/l) at the proposed injection zone. The water quality data indicates that an Underground Source of Drinking Water (USDW) is not present between land surface and the proposed injection zone at 50 to 60 feet bls. Further, a comparision of the dissolved chloride concentration of the pad monitor wells sampled during the exploratory drilling program and during the injection test inducates there are no impacts (with regards to altering the dissolved chloride concentration) to the the shallow water table aquifer due to injection (**Table 2**).

The exploratory drilling program of EX-1 indicated that significant vertical confinement is present between the proposed injection zone (50 to 60 feet bls) and the lower USDW zone that the island's Reverse Osmosis supply wells are tapping (280 to 340 feet bls). An approximately 24-foot thick confining unit, consisting of light olive, medium stiff to soft clay, is present from 60 to 84 feet below the proposed injection zone. The TDS of the proposed injection zone is about 48,000 mg/l. The TDS of the strata immediately below the base of this clay strata is about

4,200 mg/l at 90 feet bls, which indicates that the clay strata effectively confines the proposed injection zone from the deeper artesian water bearing zones.

7.0 Recommendations

The results of the exploratory drilling program and the injection test indicate that a USDW is not present from land surface to the base of the proposed injection zone and that significant confinement is present below the proposed injection zone. Cardno ENTRIX requests approval from the FDEP to convert exploratory well EX-1 to test injection well IW-1 to be utilized as the Utility's primary reverse osmosis concentrate disposal well. A request to conduct operational testing will be prepared and submitted in accordance with FDEP UIC requirements.

Cardno ENTRIX requests a meeting with the Utility and FDEP to discuss these findings, the proposed injection well system, and the permitting requirements to transition the system from an exploratory progam into operational testing. Cardno ENTRIX appreciates your attention to this matter. Should you have any questions or required additional information, please do not hesitate to contact Josh Epting or Andrew McThenia at your convienace.

Sincerely,

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AWM/JWE/gng

Cc: Eric Glidden, Utility Manager, Useppa Island Utility

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Tables

TABLE 1. SUMMARY OF WATER QUALITY AND MANUALLY COLLECTED WATER LEVEL DATA

Cardno ENTRIX

Monitoring Data for Injection Testing

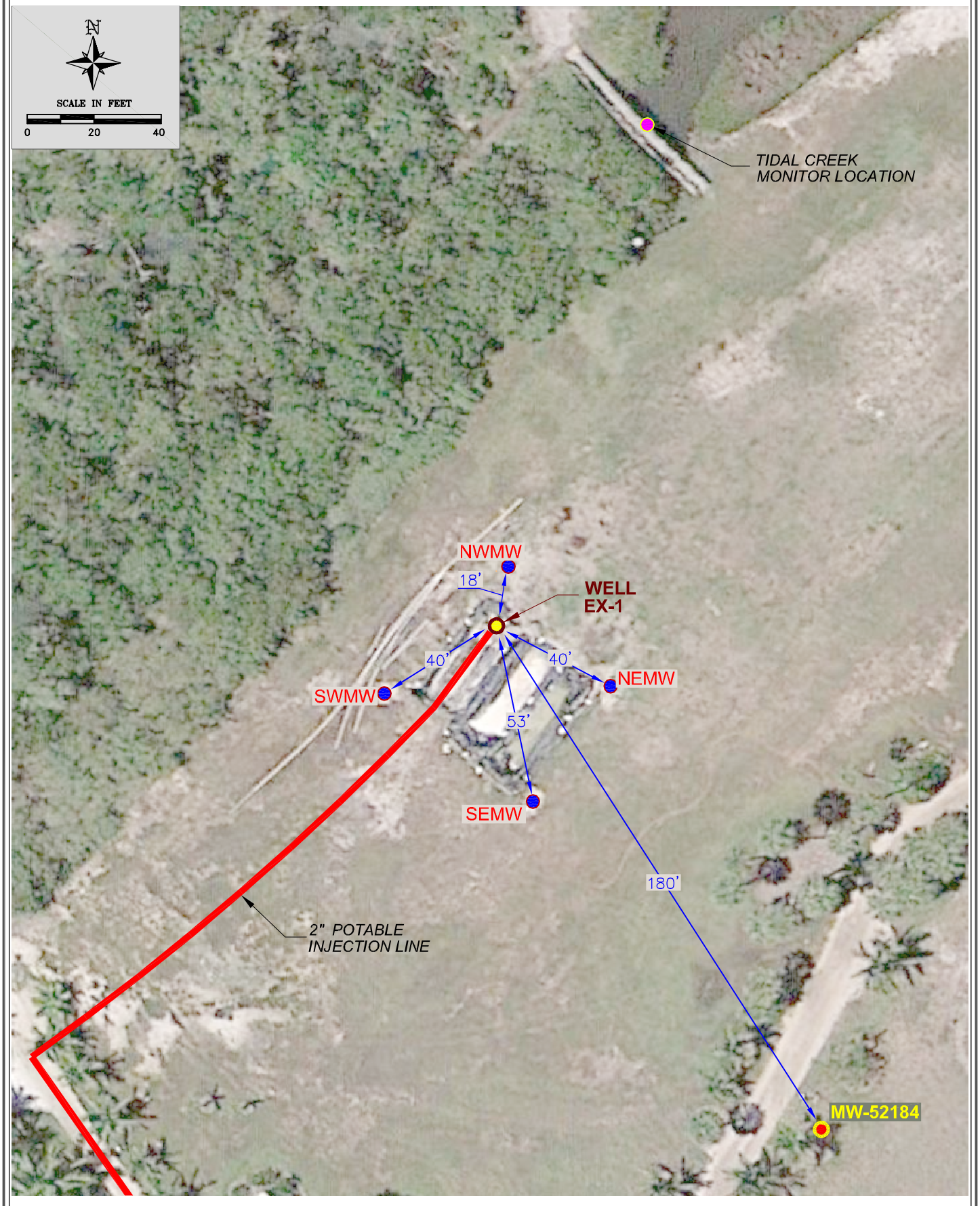
Date: 10/24/12 - 11/09/12
Project Name: Useppa Island Class V Exploratory Well
Job No.: 02626001
Prepared By: Andy McThenia

Well	Date	Collection Time	TOC Elevation (ft. NGVD)	Depth to Water (ft BTOC)	Water Level (ft NGVD)	Temp. (°C)	Chlorides (mg/L)	Conductivity (mS)
NWMW	10/24/2012	10:00	3.89	2.12	1.77	27.5	4250	14.59
NEMW	10/24/2012	10:05	4.05	2.25	1.80	na	5100	16.54
SEMW	10/24/2012	10:10	3.76	1.94	1.82	na	5000	16.44
SWMW	10/24/2012	10:15	3.00	1.28	1.72	na	4500	14.86
Tidal Creek	10/24/2012	11:50	8.67	7.40	1.27	na	14250	44.63
MW-52184	10/24/2012	10:45	4.66	2.78	1.88	na	1900	6.79
EX-1	10/24/2012	11:40	5.09	4.36	0.73	na	na	na
NWMW	10/31/2012	9:45	3.89	2.64	1.25	24.5	5500	14.64
NEMW	10/31/2012	9:55	4.05	2.66	1.39	25.5	5300	16.57
SEMW	10/31/2012	9:58	3.76	2.35	1.41	27.0	4625	16.03
SWMW	10/31/2012	10:05	3.00	1.78	1.22	26.6	4875	15.18
Tidal Creek	10/31/2012	11:20	8.67	8.30	0.37	19.8	16750	51.60
MW-52184	10/31/2012	11:30	4.66	2.85	1.81	27.7	3040	11.29
EX-1	10/31/2012	11:42	5.09	3.20	1.89	28.0	240	0.827
NWMW	10/31/2012	13:00	3.89	1.48	2.41	27.7	4875	14.67
NEMW	10/31/2012	13:05	4.05	1.71	2.34	27.1	5000	16.39
SEMW	10/31/2012	12:10	3.76	1.38	2.38	27.4	4800	16.16
SWMW	10/31/2012	13:15	3.00	0.72	2.28	26.9	4600	15.03
Tidal Creek	10/31/2012	13:20	8.67	7.65	1.02	21.0	18000	52.20
MW-52184	10/31/2012	13:30	4.66	2.79	1.87	27.1	3600	11.09
POTABLE	10/31/2012	13:35	na	na	na	25.1	60	0.397
NWMW	10/31/2012	14:15	3.89	1.35	2.54	27.3	4500	14.85
NEMW	10/31/2012	14:20	4.05	1.58	2.47	27.2	5000	16.47
SEMW	10/31/2012	14:25	3.76	1.24	2.52	27.1	5900	16.07
SWMW	10/31/2012	14:30	3.00	0.64	2.36	26.8	4750	15.13
Tidal Creek	10/31/2012	14:35	8.67	7.41	1.26	21.2	19100	52.30
MW-52184	10/31/2012	14:40	4.66	na	na	27.5	3980	11.14
POTABLE	10/31/2012	14:45	na	na	na	25.9	62	0.3864
NWMW	10/31/2012	15:25	3.89	1.21	2.68	26.4	4250	15.27
NEMW	10/31/2012	15:30	4.05	1.53	2.52	27.1	5000	17.01
SEMW	10/31/2012	15:35	3.76	1.18	2.58	26.8	4800	16.47
SWMW	10/31/2012	15:40	3.00	0.59	2.41	26.3	4600	15.55
Tidal Creek	10/31/2012	15:45	8.67	7.27	1.40	21.5	21500	52.50
MW-52184	10/31/2012	15:50	4.66	2.73	1.93	27.5	4000	11.45
NWMW	11/1/2012	10:50	3.89	1.49	2.40	27.2	4960	15.41
NEMW	11/1/2012	11:03	4.05	1.67	2.38	27.1	5015	16.42
SEMW	11/1/2012	11:10	3.76	1.38	2.38	26.9	4900	15.59
SWMW	11/1/2012	11:14	3.00	0.75	2.25	26.9	4950	14.99
Tidal Creek	11/1/2012	11:20	8.67	8.39	0.28	22.9	19800	51.30
MW-52184	11/1/2012	11:24	4.66	2.51	2.15	27.3	4750	16.07
NWMW	11/1/2012	11:56	3.89	1.37	2.52	27.4	4750	15.48
NEMW	11/1/2012	12:00	4.05	1.56	2.49	27.8	5025	16.39
SEMW	11/1/2012	12:05	3.76	1.25	2.51	27.3	4800	15.58
SWMW	11/1/2012	12:11	3.00	0.65	2.35	27.0	4650	14.87
Tidal Creek	11/1/2012	12:15	8.67	7.89	0.78	22.9	18250	51.10
MW-52184	11/1/2012	12:18	4.66	2.46	2.20	27.4	4300	16.12
NWMW	11/9/2012	11:20	3.89	2.44	1.45	26.9	4000	13.56
NEMW	11/9/2012	11:30	4.05	2.55	1.50	26.3	5250	16.24
SEMW	11/9/2012	11:38	3.76	2.19	1.57	25.3	4050	13.08
SWMW	11/9/2012	11:46	3.00	1.60	1.40	25.1	4200	14.03
Tidal Creek	11/9/2012	12:00	8.67	8.20	0.47	20.9	15500	48.02
MW-52184	11/9/2012	12:10	4.66	2.79	1.87	24.8	2400	8.91

TABLE 2. SUMMARY OF DISSOLVED CHLORIDE CONCENTRATIONS IN THE PAD MONITOR WELLS

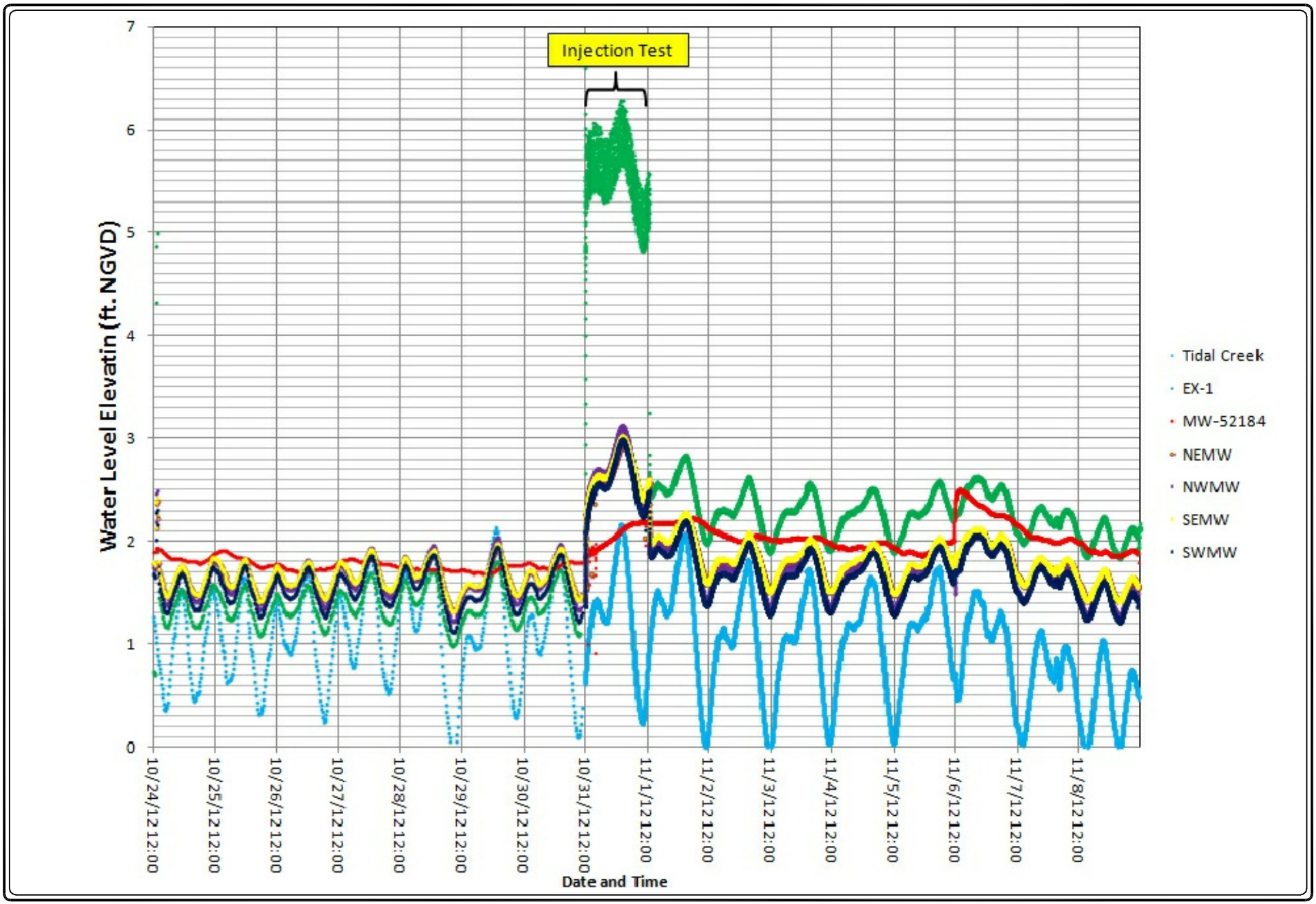
Activity	NEWM		SEMW		SWMW		NWMW	
	Date / Time	Chlorides	Date / Time	Chlorides	Date / Time	Chlorides	Date / Time	Chlorides
EX-1 Drilling	1/24/12 11:32	5100	1/24/12 13:30	4750	1/24/12 14:45	3875	1/24/12 15:45	4125
	1/31/12 10:09	5550	1/31/12 10:40	4875	1/31/12 11:25	4050	1/31/12 12:12	4250
	2/7/12 8:00	5250	2/7/12 8:15	4800	2/7/12 8:30	4500	2/7/12 8:45	4625
	2/14/12 8:00	5125	2/14/12 8:15	5000	2/14/12 8:30	4500	2/14/12 8:45	4125
	2/21/12 8:00	4875	2/21/12 8:15	4800	2/21/12 8:40	4750	2/21/12 9:00	4250
	2/28/12 12:30	5250	2/28/12 12:50	4800	2/28/12 13:10	4250	2/28/12 13:30	4250
Background	10/24/12 10:05	5100	10/24/12 10:10	5000	10/24/12 10:15	4500	10/24/12 10:00	4250
	10/31/12 9:55	5300	10/31/12 9:58	4625	10/31/12 10:05	4875	10/31/12 9:45	5500
Injection Test	10/31/12 13:05	5000	10/31/12 12:10	4800	10/31/12 13:15	4600	10/31/12 13:00	4875
	10/31/12 14:20	5000	10/31/12 14:25	5900	10/31/12 14:30	4750	10/31/12 14:15	4500
	10/31/12 15:30	5000	10/31/12 15:35	4800	10/31/12 15:40	4600	10/31/12 15:25	4750
	11/1/12 11:03	5015	11/1/12 11:10	4900	11/1/12 11:14	4950	11/1/12 10:50	4960
	11/1/12 12:00	5025	11/1/12 12:05	4800	11/1/12 12:11	4650	11/1/12 11:56	4750
Recovery	11/9/2012 11:30	5250	11/9/2012 11:38	4050	11/9/2012 11:46	4200	11/9/2012 11:20	4000

Figures



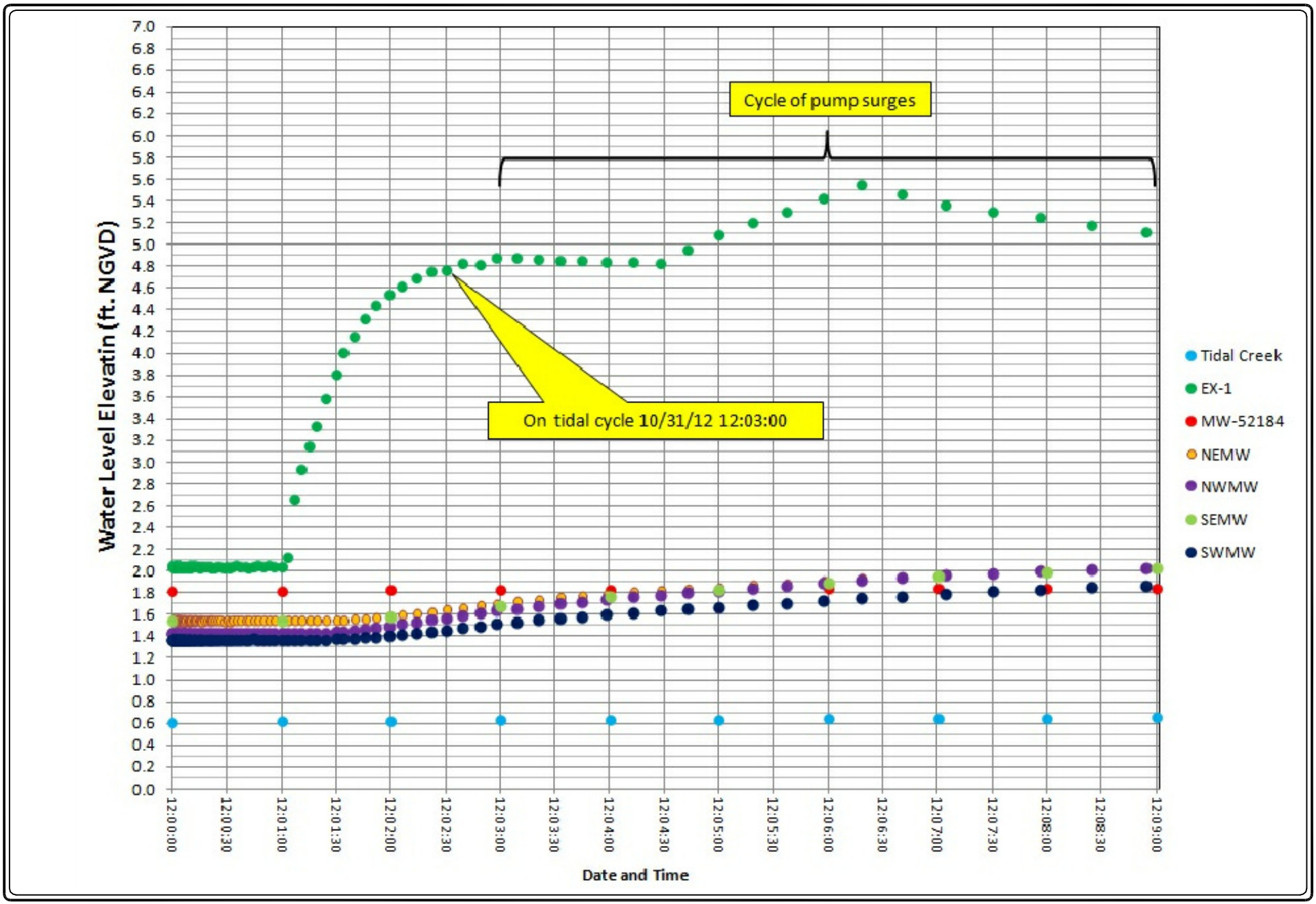
Cardno ENTRIX	PROJECT NAME: USEPPA ISLAND RO CONCENTRATE DISPOSAL	DWG. NUMBER: 02626001je2
	PROJECT NUMBER: 02626001	DATE: 08/23/12

FIGURE 1. AERIAL SHOWING WATER LEVEL MONITORING SITES.



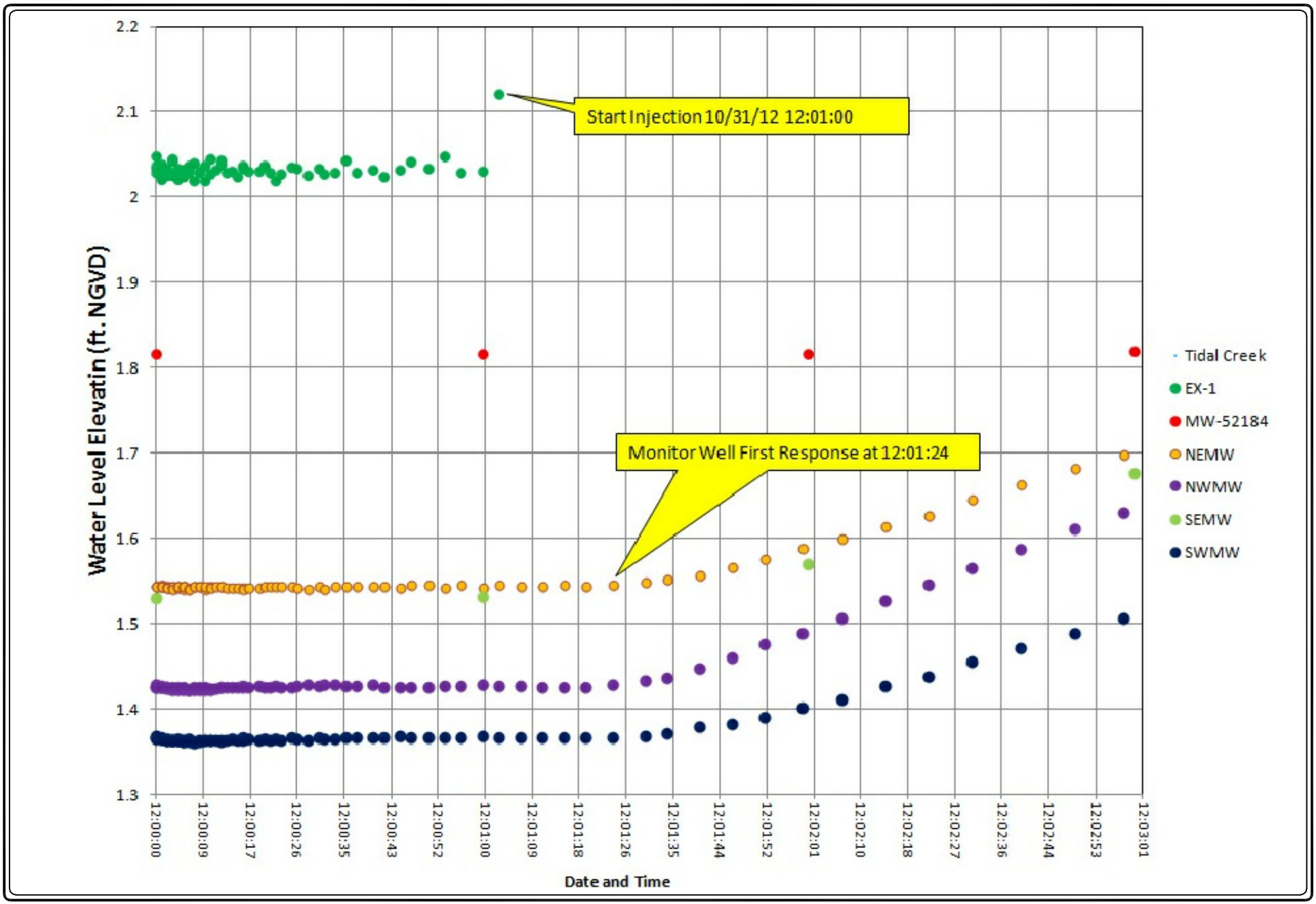
Cardno ENTRIX	PROJECT NAME: USEPPA ISLAND RO CONCENTRATE DISPOSAL	DWG. NUMBER: 02626001je2
	PROJECT NUMBER: 02626001	DATE: 10/26/12

FIGURE 2. INJECTION TEST HYDROGRAPH – BACKGROUND THROUGH RECOVERY.



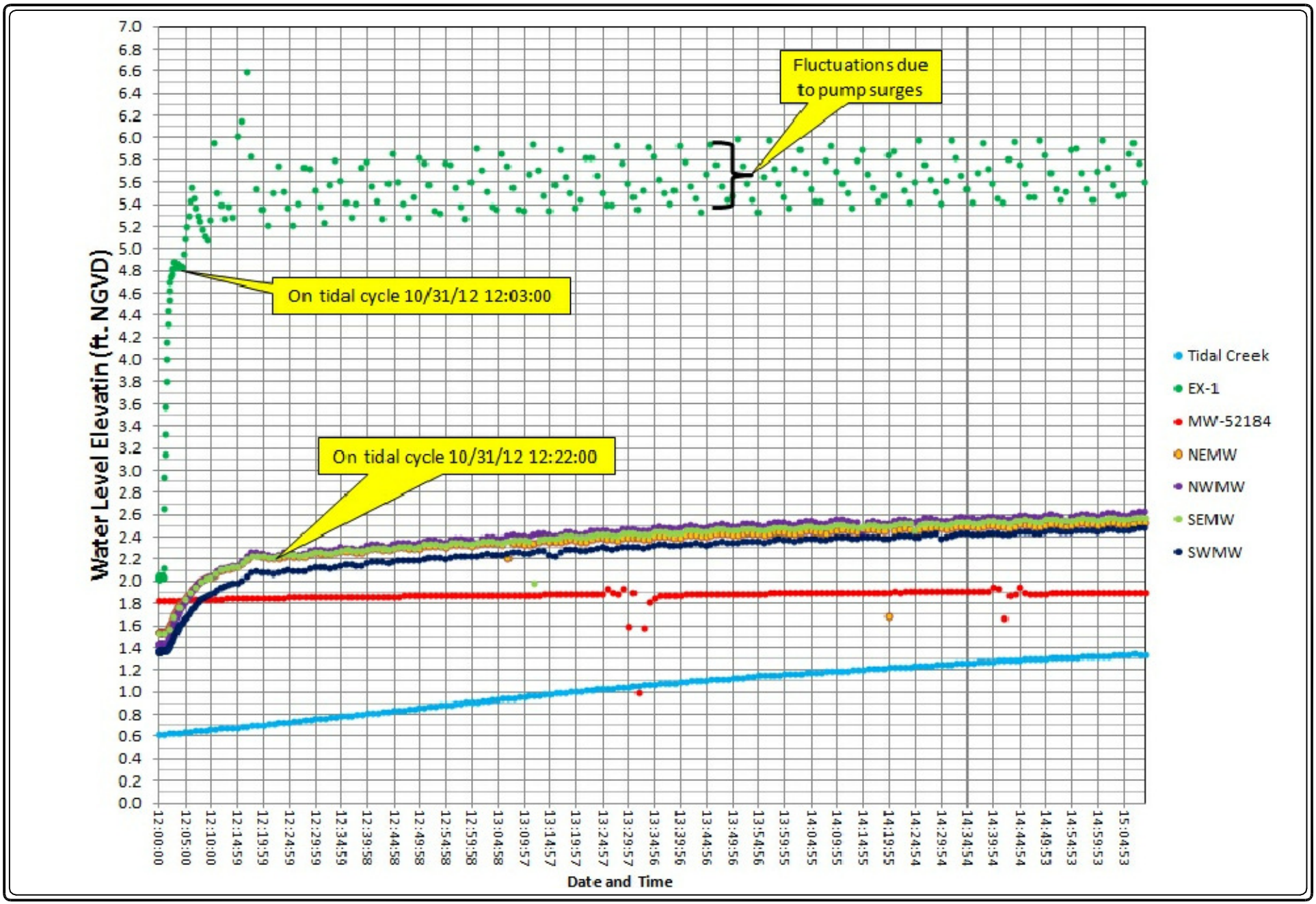
Cardno ENTRIX	PROJECT NAME: USEPPA ISLAND RO CONCENTRATE DISPOSAL	DWG. NUMBER: 02626001je2
	PROJECT NUMBER: 02626001	DATE: 10/26/12

FIGURE 3. INJECTION TEST HYDROGRAPH – FIRST 8 MINUTES.



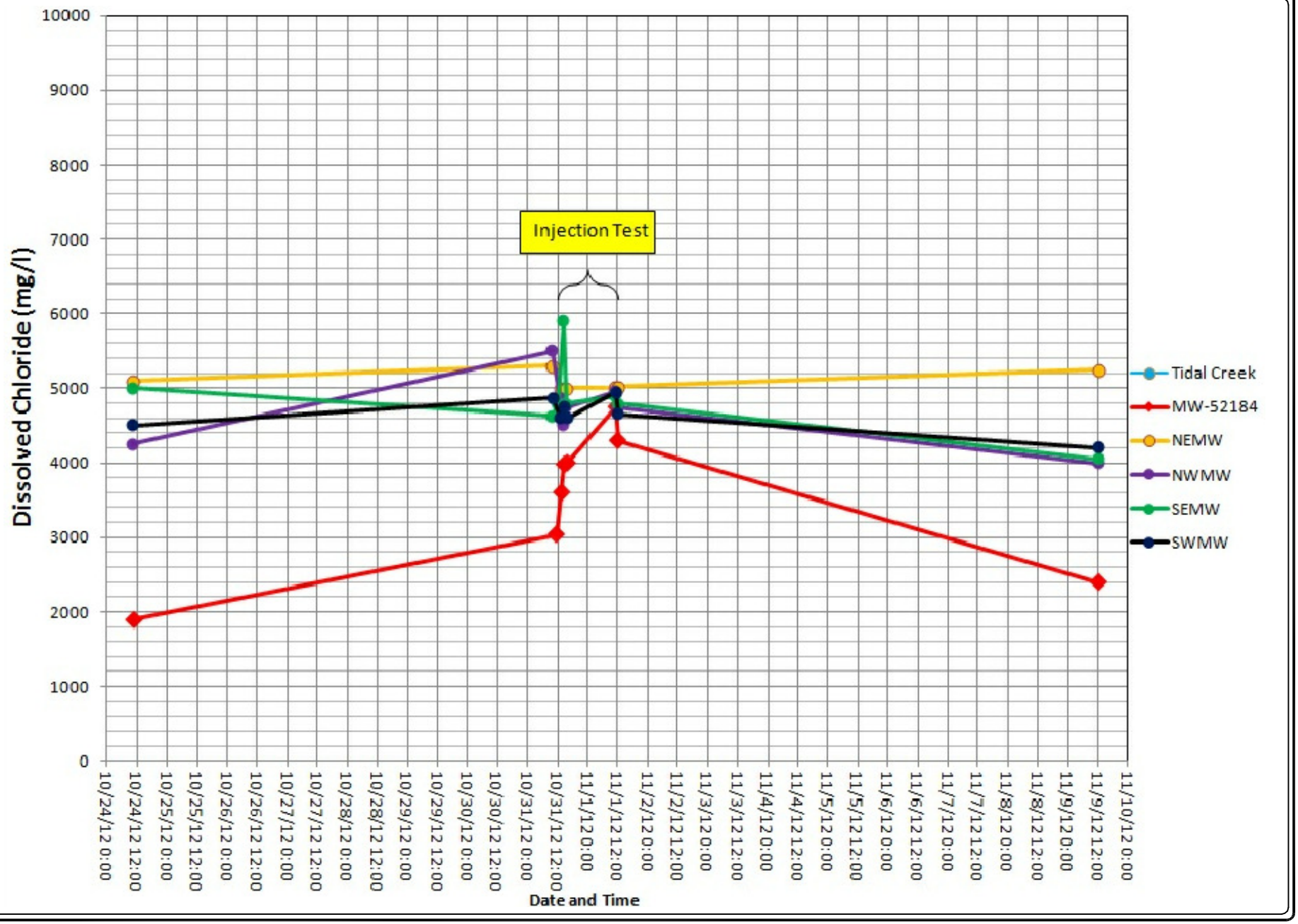
Cardno ENTRIX	PROJECT NAME: USEPPA ISLAND RO CONCENTRATE DISPOSAL	DWG. NUMBER: 02626001je2
	PROJECT NUMBER: 02626001	DATE: 10/26/12

FIGURE 4. INJECTION TEST HYDROGRAPH – FIRST 3 MINUTES.



Cardno ENTRIX	PROJECT NAME: USEPPA ISLAND RO CONCENTRATE DISPOSAL	DWG. NUMBER: 02626001je2
	PROJECT NUMBER: 02626001	DATE: 10/26/12

FIGURE 5. INJECTION TEST HYDROGRAPH – FIRST 6 HOURS.



Cardno ENTRIX	PROJECT NAME: USEPPA ISLAND RO CONCENTRATE DISPOSAL	DWG. NUMBER: 02626001je2
	PROJECT NUMBER: 02626001	DATE: 10/26/12

FIGURE 6. INJECTION TEST WATER QUALITY.