Determination of Acceptance Permeability Characteristics for Performance-Related Specifications for Portland Cement Concrete

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16. Abstract

The concrete strength has been measured for a long time; however, it is becoming increasingly desirable to the Florida Department of Transportation (FDOT) to have the ability to measure concrete's durability in addition. One test to assess durability of concrete is the Rapid Chloride Permeability (RCP) test. This test records the amount of charge passed through a sample in order to evaluate its permeability. The FDOT has the desire to make the transition from a prescriptive specification style to a performance-based specification. This research project consists of the determination of the RCP values of all classes of concrete that are specified in FDOT specifications. This goal was accomplished by taking concrete test cylinders from projects that were under construction during the study. Samples are divided by FDOT concrete class and then by composition, specifically their pozzolanic additives, for evaluation. Test value recommendations are made according to these categories. The RCP test has been around for approximately 20 years and is widely used. However, the test is labor intensive and therefore costly. For this reason, an alternative Non Destructive Test (NDT) called the Surface Resistivity test is being evaluated as a possible replacement. The Surface Resistivity test uses a Wenner 4-probe array and a small alternating current to make instantaneous readings. The readings are returned by a data acquisition unit as an indication of the concrete's ability to conduct current. This project also applied this test to the samples in order to reveal a relationship between the two tests (i.e. RCP and Surface Resistivity test) of which a good correlation has been shown. Values for Surface Resistivity as well as a table to aid in the interpretation of results have been provided. Lastly, recommendations for RCP test improvement are suggested in order to improve on the test until an appropriate alternative is arrived at and agreed upon.

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CHAPTER 1
INTRODUCTION

Majority of the Florida Department of Transportation (FDOT) projects consist of the construction and maintenance of reinforced concrete structures. To regulate and predict the performance of these structures two primary characteristics of concrete are scrutinized: strength and durability. Strength is a quality long pursued and widely researched, however durability is gaining focus as the attribute able to deliver a superior product over an extended period of time. This time period is essential to the FDOT both for reasons of economy and public safety.

Florida's unique ecosystems pose a comprehensive threat to reinforced concrete structures placed throughout the state. Our predominantly marine environments constantly expose structures to chloride ions and subsequent corrosion of reinforcing steel. Chloride ions penetrate concrete through surface cracking, capillary action, air voids, hydrostatic pressure, gravity, and continuous exposure. As penetration advances, reinforcing steel corrodes resulting in a reduction of its maximum load capability. In addition to this performance reduction, the products of corroding steel have a greater volume than the original, uncorroded steel bar. The expansion of reinforcing steel causes tensile stresses within the concrete causing spalling, cracking, and further deterioration of the concrete, ultimately compromising the structural integrity of the entire project. The FDOT is searching for a method to predict service life of concrete structures exposed to chloride ion ingress.

The primary objective of this research project consists of testing concrete samples from FDOT projects around the state of Florida using a procedure designed to indicate a particular concrete permeability to the chloride ion. This test is known as the Rapid Chloride Permeability (RCP) test and FDOT has required this test for Class V special concrete. Results of this testing will be compiled for all classes of concrete and statistically analyzed in order to make recommendations to the FDOT for maximum allowable test values for each class of concrete. This will guide the FDOT to determine threshold values for each class of concrete for the purposes of acceptance and payment. The FDOT wishes to make the transition from a prescriptive specification to a more flexible performance specification. These threshold values are necessary for such a change.

A new test has also been developed which has to its credit speed and simplicity. It is called the Surface Resistivity test. The second objective of this research is to evaluate this test, using this new method the same samples being tested in the aforementioned RCP test in order to correlate the results, and further build a case for the possible future replacement of the RCP test by this Surface Resistivity test.

Finally, taking into account that the RCP test is slow and laborious and that its replacement by the Surface Resistivity test remains a possible alternative for the future, the third objective of this research was to make recommendations to improve the current procedures of the RCP test.

CHAPTER 2
LITERATURE REVIEW

The factors that allow concrete to obtain high compressive strength have been widely known and utilized in structures for many years. The strength of concrete was then further enhanced by the use of reinforcing steel, which allows for structures of many shapes and sizes to be built today. However, the factors affecting the durability of concrete—many of which may affect the strength as well—are not as recognizable. There is an approximately equal inverse relationship between penetrability and compressive strength (Savas, 1999). Durability of concrete is defined by the American Concrete Institute in ACI 116R as its ability to resist weathering action, chemical attack, abrasion, and other conditions of service. Durability of concrete can be defined as the capability of the material by itself of keeping the original properties for a certain period (Collepardi, 2000); durable concrete may be defined as concrete that retains its original form, quality, and serviceability when exposed to its environment (Savas, 1999). Durable concrete is concrete that in the particular environment of service resists the forces in that environment that tend to cause it to disintegrate without requiring excessive effort for maintenance during its service life (Transportation Research Board, 1999). A multitude of factors affects durability of concrete either directly or indirectly. Some may be physical and perpetuate upon themselves, while others may be inherent to the properties of a specific mix design. This study focuses on the mix design aspects, but the Literature Review will discuss physical facets as well.

The fundamental durability issue of this study is the intrusion of chloride (i.e., salt-water) into concrete, or its permeability. Permeability of concrete is believed to be the most important characteristic of concrete that affects its durability (Baykal, 2000). The principal result of the intrusion of an element into concrete is the corrosion of the reinforcing steel. Once this occurs, the structure will no longer maintain its structural integrity; the lifespan is reduced, and the general safety of the public is severely degraded. For reinforced concrete bridges, one of the major forms of environmental attack is chloride ingress (Samples and Ramirez, 1999), which leads to corrosion of the reinforcing steel and a subsequent reduction in the strength, serviceability, and aesthetics of the structure (Stanish et al., 1997). It is increasingly apparent that for many concrete members, the ability of the concrete to resist chloride penetration is an essential factor in determining its successful performance over an extended period (Stanish et al., 2000).

Concrete permeability will determine how quickly oxygen, water, and chloride ions will reach the layer of steel (Samples and Ramirez, 1999), the single most important factor affecting the rates of deterioration from reinforcing bar corrosion, carbonation, alkali-aggregate reaction, or freeze thaw cycles, all of which may be occurring simultaneously (Carter, 1991). The time-to-corrosion initiation and subsequent corrosion induced damage is related to the time that it takes chloride ions to reach a critical level at the steel (Berke and Hicks, 1992). The following sections discuss the durability factors of concrete.

Physical Factors

Physical factors have a significant impact on the durability of concrete; these factors may be environmental, design oriented, or results of facility operation. All of these issues will be discussed in the Literature Review, but the study focuses primarily on environmentally induced deterioration of concrete due to penetration of chloride ions.

Environmental

Environmental factors are a result of the immediate surroundings and exposure of the concrete structure. There is a wide range of environmental factors based on weather and physical location of the concrete; this has been an area of study over the last several decades as the properties affecting concrete durability are realized. A given concrete with a given set of properties will endure without noticeable change for centuries or even millennia in one environment yet it will be reduced to fragments in a few years or even a few months in another (Transportation Research Board, 1999). A mix design that exhibits good compressive strength and durability in one environment may be ill suited for service in another environment.

<u>Absorption/ diffusivity</u>**.** Capillary action will cause a given specimen to absorb liquid, much like a sponge; this is an inherent trait of many materials. Typically, an equilibrium state of saturation causes liquid in a specimen to move from one saturation gradient to another (low-to-high or high-to-low); for example, dry, brittle material will absorb liquid until it is in equilibrium with the ambient atmosphere. However, pressure gradients can also supply the necessary force to move liquid through concrete; for example, hydrostatic pressure supplied by a constant wave action or a retained body of water. This is an important idea for this study because the FDOT manages, operates, and

builds bridges, piers, dams, etc. throughout Florida that are exposed to the marine environment.

Freeze-thaw. The freeze-thaw phenomenon occurs primarily in Northern climates. Liquid that is contained in the specimen either due to micro-structural elements or that is trapped due to saturation will expand upon freezing and contract as it thaws. During this process, the concrete is subjected to significant forces that are capable of breaking the bonds holding the aggregate together. Repeated cycles of freeze-thaw deteriorate concrete substantially

Aggressive chemical attack. Chemical attacks on concrete may cause severe deterioration of the concrete and reinforcing steel. The attacking chemical may occur in a natural state, such as soil or seawater, or may be from an industrial or commercial use. The importance of concrete as a building material exposes it to many varying chemicals; common chemicals include (Forster, 2000):

- Sulfates: found in soils as sodium, calcium, magnesium, and potassium
- Sea water
- Carbon dioxide

Methods to combat chemical attack (Forster, 2000):

- Use dense, low permeability concrete
- Low water/ cementitious ratio
- Pozzolans and blast furnace slag may increase resistance to sulfate attack

Alkali-aggregate reaction. Alkali-aggregate reactions come in two types (Forster, 2000):

- Alkali-silica reaction forms gels that expand

- Alkali-carbonate reaction forms brucite, which changes volume

Methods to reduce AAR:

- Low alkali cements
- Addition of pozollans, silica fume, ground granulated blast furnace slag, and lithium chemicals

Design

The great compressive strength of concrete has allowed many structures to be built, supporting significant loads both vertically and longitudinally. Inherent characteristics of concrete— workability, low technology, and ability to create different shapes—have made concrete an attractive building material. Inherent weak points of concrete (Collepardi, 2000):

- Low tensile strength
- High modulus of elasticity; shrinkage
- Microcracks formed as a result of above mentioned weak points
- Microcracks become preferential paths for aggressive environmental agents
- Corrosion when exposed to humid air or chloride ions penetrating through microcracks
- Expansive-disruptive nature of the corrosion process causing macrocracks in the concrete cover

<u>Concrete/ reinforcing steel system.</u> There is a belief among some experts that the concrete/ reinforcing steel system is not fundamentally sound concerning longevity and

durability. Durability of reinforced concrete structures seems to be poor when compared with those of ancient un-reinforced structures (Collepardi, 2000). These inherent weak points make the concrete/ reinforcing steel structural system susceptible to damage from:

- Chemical attack or intrusion through cracks
- Inability to absorb internal pressures from expansion differentials between concrete and steel
- Rapid deterioration once failure has begun

Design parameters should be strictly followed to decrease the inherent risks of the concrete/ reinforcing steel system. The American Concrete Institute codes state that in order to decrease chloride induced corrosion the following shall be applied (Berke and Hicks, 1992):

- Maximum water to cement ratio of 0.4
- Minimum concrete cover of reinforcing steel for non-marine environments of 1.5 in. (38 mm)
- Minimum concrete cover of reinforcing steel for marine environments of 2.5 in. (64 mm)
- Maximum crack size of 0.006 in. (0.15 mm) and 0.007 in. (0.18 mm) for marine and deicing salt environments respectively

However, despite precautions, studies show that even in low permeability, high resistivity concrete, the embedded reinforcing steel goes into corrosion after five years of accelerated laboratory testing (Geiger and Poirier, 1973 and Berke and Hicks, 1992). These studies suggest that the chemical composition of concrete reacts with the steel, creating an electrolytic situation that induces corrosion of the steel. Once the corrosion process begins, it perpetuates upon itself. The corroding steel expands, creating internal pressure on the concrete member. Existing cracks in the concrete grow and new cracks form, allowing further exposure to deteriorating chemicals or atmosphere.

Corrosion of embedded steel**.** The majority of concrete deterioration cases are connected to corrosion of reinforcement due to carbonation or chloride-induced depassivation of steel bars (Papadakis, 2000). Concrete is a porous substance; the inherent permeability allows corrosive agents to intrude the concrete and attack the reinforcing steel, resulting in corrosion. The destruction or deterioration of a material after reacting with the environment is defined as corrosion (Samples and Ramirez, 1999). The corrosive action is expansive and causes tensile stress in the concrete (spalling may result) (Goodspeed et al., 1996). When a reinforcing bar corrodes, its volume will increase, and eventually, the surrounding concrete will crack (Dagher et al., 1990). Corrosion of steel causes cracks in concrete that allow the intrusion of additional damaging chloride ions; this cycle perpetuates on itself (Smutzer and Chang, 1993).

The chloride-induced corrosion of reinforcing steel is the major cause for the premature deterioration and degradation of the majority of field concrete structures built in salt-laden environments, and therefore, the chloride permeability of concrete has been recognized to be the critical intrinsic property of the concrete (Wee et al., 2000). For reinforced concrete bridges, one of the major forms of environmental attack is chloride ingress, which leads to corrosion of the reinforcing steel and a subsequent reduction in the strength, serviceability, and aesthetics of the structure (Stanish et al., 1997).

There are two types of corrosion (Samples and Ramirez, 1999):

- Dry corrosion

    - Occurs without a liquid phase
    - The metal reacts with gases or vapors (typically occurs at high temperatures)
- Wet corrosion
    - Involves a reaction between a metal and an aqueous liquid
    - Primarily electrochemical in nature

Corrosion due to electrochemical action is the most common. Presence of chloride, oxygen, and moisture will cause corrosion by galvanic processes (Samples and Ramirez, 1999). Electrochemical reactions occur when a potential difference exists between two or more dissimilar materials with an electrolyte conductor present. Water and saltwater are the most common electrolytes, but neither sodium nor chloride participate in the electrochemical reaction. Typically, potential difference is associated with metals, but two different levels of chloride concentration will exhibit a potential difference and promote corrosion; this scenario becomes an electrochemical reaction (Samples and Ramirez, 1999). The ions will naturally transfer from one state to another in an effort to reach equilibrium. Necessary components for an electrochemical reaction (Samples and Ramirez, 1999):

- Metallic path: steel ties, chairs, and reinforcing steel
- Electrolyte: moist concrete
- Anode and cathode: will naturally develop due to potential differences in the reinforcing steel (potential differences may be caused by: differences in chloride ion concentrations, moisture content, and oxygen content)

Methods available to reduce the time to corrosion for reinforcing steel:

- Use dense, low permeability concrete
- Sufficient cover
- Ontario method
    - Isotropic design, only use steel necessary to reduce temperature cracking and limit shrinkage. Compared to the AASHTO method may reduce steel by approximately 60% (Dagher et al., 1990).
    - It was estimated in 1990, pursuing the Ontario method would save Florida $7 million per year in reinforcing steel costs (Dagher et al., 1990).

Once the reinforcing steel is corroding, the resitivity values can be affected by the corrosion process, and can no longer be expected to reflect the permeability of the concrete (Berke and Hicks, 1992). Performing durability tests on field sample may be difficult at best.

Surface cracking. Surface cracks are inherent to concrete. During the curing process, the cement paste will expand and contract creating internal pressures resulting in surface cracks. These cracks allow corrosive elements to penetrate the concrete and reach the reinforcing steel. Transverse cracking may accelerate corrosion of reinforcing steel, deterioration and leaching of concrete, damage to structural members and components beneath the deck, and appearance concerns; generally, cracking reduces durability (McDonald, 1995). Once the corrosion process has begun, it perpetuates upon itself. According to a US Army Corps of Engineer study in 1950, regarding the effects of severe weather exposure on the durability of prestressed concrete beams, flexural cracks less than 0.016 inches wide did not seem to increase the rate of steel corrosion (Novokshchenov, 1991).

Surface cracks can be controlled to a limited degree by:

- Placing control joints in the concrete to establish paths for which the internal pressures may be relieved and controlled. Larger mass concrete may require larger control cuts or construction joints to alleviate the internal pressures.
- Proper curing
- Proper finishing
- Use of reinforcing mesh

Operational

Operational stresses may affect the durability of concrete. Constant banging and/or abrasion may wear the concrete, reducing its ability to prohibit corrosive agents.

Surface abrasion. Surface abrasion from constant rolling of machinery and equipment will reduce the concrete cover for reinforcing steel, cause surface cracking, and impart point stresses on the concrete member. Although the functions may have deleterious effects, the facility must operate. Therefore, the mix design used should perform under the specific conditions. Surface abrasion correlates well with concrete strength, density, and type of aggregate (Forster, 2000). Wear resistance is increased with greater water curing times, approximately a 10% increase for concrete with 50% fly ash replacement of cement (Vieira et al., 2000). Increasing fly ash content increases abrasion wear (Vieira et al., 2000).

Micro-Level of Concrete

Pore Structure

The penetrability of the concrete is related to the pore structure of the cement paste matrix. A relationship between permeability/ penetrability and microstructure exists; as pore volume increases, the apparent chloride diffusion coefficients increase (Savas, 1999). Water permeability is frequently a controlling factor in rate of deterioration (Savas, 1999). This will be influenced by the water-cement ratio of the concrete, the inclusion of supplementary cementing materials, which serve to subdivide the pore structure (McGrath, 1996), and the degree of hydration of the concrete (Stanish et al., 1997). Microstructural properties such as size, distribution, and interconnection of pores and microcracks determine the permeability of the concrete (Savas, 1999). As fresh concrete begins to harden, a network of internal pores and voids form, providing the concrete with an air content that allows for porosity and permeability. Factors affecting the permeability are dependent on several factors: water/ cement ratio, chemical composition of the concrete, and type of aggregate (Neville, 1996 and Walls, 2000). The resistivity of concrete is principally determined by the pore structure and pore solution composition (Stanish et al., 2000). Pore structure is a factor that influences the electrical resistance—a measure of permeability—of concrete. Pore structure of concrete varies with age and depth from the exposed surface (Saricimen et al., 2000). The microstructure of concrete affects both its mechanical and durability properties (Savas, 1999). Pore structure is influenced by (Elkey and Sellevold, 1995 and Savas, 1999):

- Total porosity
- Pore size distribution

    - Adding silica fume (or fly ash) creates a much finer pore structure, increasing resistivity
    - Type of cement and fly ash effect pore structure
    - High strength cements exhibit higher resistivity than ordinary Portland cement
- Degree of continuity
    - As water/ cementitious ratio increases, the pore structure becomes more continuous; therefore decreasing electrical resistivity
    - An increase in curing temperature improves continuity; therefore, decreasing electrical resistivity
- Water to cementious materials ratio
- Curing
- Type and quantity of chemical and mineral admixtures
- A finer microstructure typically leads to more impermeable concrete and an improvement in durability in aggressive environments.

Corrosive agents—liquid or gaseous—may penetrate the concrete through capillary absorption, hydrostatic pressure, or diffusion. Capillary absorption, typically, does not result in deep penetration, but does shorten the required distance for diffusion to occur (Stanish et al., 1997). Young concrete has a tendency to absorb more water than mature concrete (Saricimen et al., 2000). Capillary absorption is the concrete property most affected by the cement replacement by fly ash (Vieira et al., 2000). Moisture absorption is particularly relevant to durability of concrete concerning sulfate attack, reinforcement corrosion, and alkali-aggregate expansion (Saricimen et al., 2000). A close correlation has been established between capillary absorption and oxygen permeability of the concrete (Vieira et al., 2000). Concrete capillary absorption increases with cement replacement by fly ash; however, this amount decreases as water-curing time increases (Vieira et al., 2000). Poor curing results in extremely high absorptivity near the surface, and the effect of curing is most pronounced in the first 30 mm from the surface (Saricimen et al., 2000).

Diffusion is the process whereby particles of liquids, gases, or solids intermingle as the result of spontaneous movement caused by thermal agitation and in dissolved substances move from a region of higher to one of lower concentration. The rate of diffusion is controlled not only by the diffusion coefficient through the pore solution but also by the physical characteristics of the capillary pore structure (Stanish et al., 1997). Concrete must have a continuous liquid phase and there must be a chloride ion concentration gradient (Stanish et al., 1997). As pore volume increases, the apparent chloride diffusion coefficients increase (Savas, 1999). The ion diffusivity is more sensitive to the presence of silica fume and the reduction of water cement ratio, both of which contribute to the densification of the microstructure (Baroghel-Bouny and de Larrard, 2000). There is an approximately equal inverse relationship between penetrability and diffusion coefficients as well (Savas, 1999).

Pore Water Composition

Pore water in concrete occurs at the micro level; pore water is naturally occurring in the transition zone that bonds the cement paste and aggregate. Electrical current is passed predominantly by the movement of ions in the pore water (Elkey and Sellevold, 1995). The diffusion of chloride ions takes place primarily in the fluid filled pores

(MacDonald and Northwood, 2000). Total ionic concentration of the pore water is a factor that influences the resistivity of concrete (Elkey and Sellevold, 1995). Over time, pore water solution high in chloride ions promotes corrosion of reinforcing steel (Goodspeed et al., 1996). If the pore solution contained an ion with a significantly higher ionic mobility, the resistivity of the concrete would drop significantly without changing the diffusivity. Such an ion is the nitrate ion that is the primary component of corrosion inhibiting admixtures. Concretes with these types of admixtures would not be reflected properly using a resistivity test (Stanish et al., 2000). Any change in the chemical composition of the pore water is likely to affect the resistance values significantly; increasing ions in the pore water will decrease electrolytic resistance (Elkey and Sellevold, 1995). For a constant water/ cement ratio, increasing the paste volume decreases the resistivity at a rate of approximately 1% per 1% change in paste, creating more channels—pore water—for electrolytic movement (Elkey and Sellevold, 1995). The type of cement significantly affects the pore water chemistry. Adding silica fume (or fly ash) lowers the ionic concentration in the pore water, increasing resistivity (Elkey and Sellevold, 1995). The presence of silica fume or fly ash may greatly enhance the effects of other variables, such as water/cement ratio. At higher temperatures, more ions will dissolve into the pore water (Elkey and Sellevold, 1995). The range where the pore water begins to lose continuity—increase in resistance—tends to occur between 60-80% water saturation (Elkey and Sellevold, 1995). Chloride migration test may alter the pore water composition (Elkey and Sellevold, 1995).

Mix Design Factors

Concrete has many components: cementitious materials, aggregate, mineral admixtures, and water. The inherent characteristics of the components, either individually or in combination, affect the durability of the concrete. An approved mix design will establish specific proportions for each component. As mentioned before, the strength characteristics of concrete are well documented, but the durability characteristics are not as well known. There is a need for technology-based mix proportioning procedures for chloride ion resistant concrete that would allow for the design of mixes to be based on their diffusivity (MacDonald and Northwood, 2000). The current practice is based predominately on prescription type specifications that incorporate silica fume, slag, or fly ash in combination with Portland cement as the sole starting point for the design (MacDonald and Northwood, 2000). Mixing ingredients and proportions thereof, mixing sequence, curing conditions, and concrete permeability affect the ability of concrete in a saturated condition to resist deterioration when subject to freezing and thawing and deicing (chloride ionic solution). Important characteristics include the air-void system, soundness of the aggregate, and concrete maturity (Goodspeed et al., 1996). An objective of this study is to gain further understanding of the influential components concerning durability. This Literature Review will discuss many components of concrete, but the study will focus on those that are relevant to the geographic area.

Mix designs will dictate specific proportions for the components of the concrete, but all concrete will experience the following three phases (Savas, 1999):

- Aggregate (macro)
- Hydrated cement paste (macro)

- Transition zone (micro)
    - Region between the particles of coarse aggregate and the bulk hydrated cement paste.
    - The hydrated cement paste and transition zone phases change with time, fluctuations in humidity and temperature, as well as other environmental exposures. These two phases affect the permeability and durability characteristics of concrete more than the aggregate.

Although the mix design will dictate the proportions and types of components, a human influence may affect the quality and durability of concrete. The following basic factors will exhibit some degree of human influence (Transportation Research Board, 1999 and Collepardi, 2000):

- Batching
- Mix proportioning
    - Water/ cement ratios
    - Air void system
- Transportation
- Placement
- Consolidation
- Finishing
- Curing
- Inadequate materials
- Inadequate structural design

- Execution

Water-Cement Ratio

The water-cement ratio has a profound effect on several characteristics of concrete; low water/ cement ratios are associated with stronger, more durable concrete, but it is also less workable. The workability of concrete greatly influences the decision as to the means and methods of construction for a particular structural or architectural member. Therefore, a tradeoff between durability and strength versus workability exist. Low water-cement ratio concretes are high strength, low permeability, high durability, and permanent concretes (MacDonald and Northwood, 2000). The water/ cement ratio was the dominant effect on chloride intrusion for low water cement ratio mixtures, around 0.31 to 0.32 w/cm, since moist cured and accelerated cured concretes had similar chloride intrusions at all depths (Sherman et al., 1996). Rates and consequences of reinforcement corrosion depend strongly on the moisture content of the concrete, but this is difficult to accurately measure on field samples (Elkey and Sellevold, 1995). Moisture content has a tremendous impact on resistivity; dry cement may have resistivity values in the range of 10^{8}—10^{9} Ohm-cm, while ordinary Portland cement concrete will typically display ranges between 1,000-10,000 Ohm-cm (Elkey and Sellevold, 1995).

For corrosion protection of reinforcing steel, the water/ cement ratio should not exceed 0.40 with a minimum strength of 35 Mpa (Transportation Research Board, 1999). Reducing the water/ cement ratio and increasing concrete cover over steel greatly reduce the chloride ingress as recommended by the American Concrete Institute codes. Furthermore, further decreases in chloride penetration can be obtained by the use of microsilica in the concrete mixture (Berke and Hicks, 1992).

Precast, prestressed concrete typically display good durability due to the low water cement ratios and high construction quality (Savas, 1999).

Curing Conditions

Proper curing of the concrete specimens appears to have a significant influence on the durability characteristics of concrete. There are several aspects of curing to be considered:

- Length of time
- Quality
- Curing Scenario
    - Normal
    - Steam-cured
    - Moist-cured
- Temperature

In general, concrete performance is improved with longer water curing times (Vieira et al., 2000). Longer curing times result in a more developed pore structure in mature concrete (Stanish et al., 1997); the volume of permeable voids is decreased with longer curing (Saricimen et al., 2000). Wear resistance is increased with greater water curing times (approximately 10% increase for concrete with 50% fly ash replacement of cement) (Vieira et al., 2000). Concrete capillary absorption and oxygen permeability increases with cement replacement by fly ash; however, this amount decreases as water-curing time increases (Vieira et al., 2000). According to a study performed by Vieira, capillary absorption and oxygen permeability of concrete in the study were 50-60% lower at 28 days of water curing time compared to 3 days of water curing time (Vieira et al., 2000).

Adequate curing is imperative for concrete to achieve its potential properties that will enable it to resist the aggressive marine environment (Khatri et al., 2000). Poor curing results in extremely high absorptivity near the surface, and the effect of curing is most pronounced in the first 30 mm from the surface (Saricimen et al., 2000). Constant exposure to this environment may decrease the length required for chloride ions to reach the reinforcing steel via diffusivity (discussed above).

At later ages when the normally-cured concrete has a chance to hydrate more fully, it will have a lower chloride ion diffusion than the high-temperature-cured concrete (Detwiler et al., 1991 and Stanish et al., 1997). Steam curing resulted in poorer resistance to chloride penetration for normal portland cement and 30% fly ash concrete (Khatri et al., 2000). The longer the moist curing period, the higher the degree of hydration, and, of course, the greater the strength and lower the permeability (Savas, 1999). The best curing scenarios were found to be 7-day moist followed by 7-day sealed (Khatri et al., 2000).

Type of Cement and Pozzolanic Admixtures

Cement is the ingredient that has the most influence on concrete strength and durability (Transportation Research Board, 1999). High-volume fly ash blended cements or high-volume fly ash and ground slag blended cements perform very well in concrete mixtures in terms of good workability, high compressive strength, and excellent durability behavior (negligible carbonation and very low chloride penetration) (Collepardi et al., 2000). It is generally recognized that the use of mineral additives such as fly ash, silica fume, and ground granulated blast furnace slag (GGBFS) will improve the pore structures and potentially the durability of concrete (Walls, 2000). The interfacial zone between the aggregate particles and the cement matrix of the concrete plays a significant role in the movement of ions in concrete (MacDonald and Northwood, 2000). The use of mineral admixtures such as silica fume, Class F fly ash, and ground granulated blast furnace slag reduce permeability and improve the chemical durability of moist cured concretes (Savas, 1999). Concrete with mineral additives was much less permeable to chloride ions than the concrete without mineral additives independent of curing and environmental conditions (Torri and Kawamura, 1991 and Walls, 2000). GGBFS- cement pastes have a denser structure than regular cement pastes, improving both the permeability and chemical resistance of concrete (Savas, 1999). Pozzolanic reaction of GGBFS and SF causes the pore microstructure to become relatively denser, torturous, and discontinuous compared with ordinary Portland cement mixtures (Wee et al., 2000). GGBFS is known to have a pore refining effect; it also decreases the Na^+ and OH^- ions from the solution (Shi et al., 1998). The use of pozzolans and GGBFS can greatly reduce the permeability of concrete, and may provide additional benefit to concrete durability by reducing the amount of calcium hydroxide in the hardened cement paste (Transportation Research Board, 1999). The 30% fly ash concrete performed better than normal portland cement concrete with regards to permeability when curing scenarios varied: 1-day sealed, 7-day sealed, 7-day wet, and steam curing (Khatri et al., 2000). After one year of immersion, the chloride concentration beyond a depth of 20 mm of fly ash concretes are significantly lower than those are of normal Portland cement concretes; therefore, the chloride resistance of fly ash concrete is significantly superior to normal

Portland cement concretes (Khatri et al., 2000). Pozzalanic admixtures appear beneficial for protection against chloride-induced reinforcement corrosion (not recommended for freezing environments) (Baroghel-Bouny and de Larrard, 2000). Silica fume decreases permeability and slows down chloride ingress but eventually the chloride reaches the reinforcing bars and corrosion takes place (Berke and Hicks, 1992). As portland cement is replaced with GGBFS and SF the chloride penetration coefficient (90-day ponding test results) decreases; the reduction is greater for GGBFS than it is for SF (Wee et al., 2000). There is an increase in oxygen permeability with increasing cement replacements by fly ash; however, an increase in water-curing time diminishes this affect as well (Vieira et al., 2000). Supplementary cementing materials (lowest to highest for chloride penetrability) (Papadakis, 2000):

- Silica fume
- Low-calcium fly ash
- High-calcium fly ash

Data suggests that cement with fly ash and high strength cement exhibit higher resistivity than ordinary Portland cement, as well as a wide range of resistivity values between different portland cement manufacturers (Elkey and Sellevold, 1995). The specific conductivity of the solid materials (i.e., aggregate) is less than $1X10^{-6}$ S/m while that of the pore solutions in concrete has been measured to be in excess of 3 S/m (MacDonald and Northwood, 2000). Electrical resistivity increases with the replacement of ordinary Portland cement with GGBFS and SF (Wee et al., 2000). High alumina cement has a mature resistivity of 10X that of ordinary Portland cement (Elkey and Sellevold, 1995). Some research suggests that the replacement of Portland cement with supplementary cementing materials, such as silica fume, can reduce the electrical conductivity of the concrete more than 90% due to the change in the chemical composition of the pore solution, which has little to do with the transport of chloride ions in concrete. Thus, it is not correct to use the passed charge as specified in AASHTO T 277 or ASTM C1202 to evaluate the rapid chloride permeability of concrete with supplementary cementing materials (Shi et al., 1998).

Type II cement is preferred for exposure to saltwater (Savas, 1999) or sulfate of 150-1,500 ppm; Type V is preferred for environments ranging above 1,500 ppm (Transportation Research Board, 1999).

For Rapid Chloride Penetration Test, mixtures with GGBFS exhibit lower coulomb values than ordinary Portland cement mixtures; charge passed also decreases with curing period (Wee et al., 2000). For the majority of mixtures containing silica fume and granulated ground blast furnace slag, the chloride penetration coefficient K and the charge-passed data were following different trends. This suggests that the charge-passed and K are the independent properties of concrete controlled by different factors; the charge-passed depends on the microstructure and pore fluid conductivity (especially OH^- ions) of the concrete, while K depends primarily on the microstructure of the concrete (Wee et al., 2000).

Air-Entraining Agents

Air-entraining agents have been used in concrete in colder climates for many years. The available air voids in the concrete allow internal pressures from freeze-thaw cycles to be reduced or absorbed. However, these same voids may also reduce the ability of the concrete to resist chemical intrusion. However, the impact of air-entraining agents on durability in warmer, corrosive environments—such as southeastern marine environments—is not in agreement. Air-entraining concrete may promote deleterious actions by providing an interconnected network of air voids that may allow ease of penetration by corrosive agents; thus, allowing penetration of the corrosive agent to the depth of the reinforcing steel. In some concretes, pore connectivity is greater in air-entrained concretes; therefore creating a preferential path, which impairs the durability characteristics (Baroghel-Bouny and de Larrard, 2000). It is found that the presence of entrained air increases the gas permeability of concrete, indicating an increased potential risk of corrosion of the reinforcement (Baroghel-Bouny and de Larrard, 2000). The ability of concrete to resist chloride penetration is an important factor in determining its potential durability concerning chloride-induced corrosion of reinforcing steel (Stanish et al., 2000).

Measurement Methods of Concrete Durability

Permeability of concrete is believed to be the most important characteristic of the concrete affecting its durability (Baykal, 2000) and is the single most important factor affecting the rates of deterioration from reinforcing bar corrosion, carbonation, alkali-aggregate reaction, and/ or freeze thaw cycles, all of which may be occurring simultaneously (Carter, 1991). Permeability is defined in general as the ease with which fluids, both liquids and gases, can enter into or move through the concrete; fluid movement is also related to its absorption and diffusion characteristics, that is moisture or ion penetrability (Savas, 1999). This section of the Literature Review will discuss several testing procedures that pertain to the permeability and/ or resistivity of concrete, discussing the advantages and disadvantages of each method.

Chloride/ Salt-Ponding Test

Most direct method of measuring chloride penetration is the 90-day, salt-ponding test (Stanish et al., 2000). This test subjects a concrete specimen to a chloride solution—not under pressure—for 90 days. A profile section of concrete is analyzed after this period to determine the penetration of the concrete. The 90-day chloride penetration test is considered the most accurate and informative test (Savas, 1999). A disadvantage of this method is that it is time consuming. Additionally, it may not allow sufficient time for low permeability concretes (Savas, 1999).

Rapid Chloride Permeability Test

ASTM C1202, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration," can be used to determine the relative permeability of the concrete specimens. At the end of the six-hour rapid permeability test (discussed in greater detail in the Methodology section), coulomb values representing the total current passed through the concrete slices over the testing period are obtained. The area under the current versus time curve, i.e. the total charge passed in coulombs, correlates with the resistance of the specimen to chloride ion penetration (Whiting, 1981). These values have been shown to be representative of the chloride ion permeability, which is an indirect indication of the permeability of concrete (Baykal, 2000). According to ASTM C 1202, permeability levels relative to RCP values (lower values are desired for durability) (Savas, 1999):

- High 4,000+ coulombs
- Moderate 2,000-4,000 coulombs

- Low 1,000-2,000 coulombs
- Very Low 100-1,000 coulombs
- Negligible <100 coulombs

The rapid chloride permeability test (RCP), designated as AASHTO T 277 in 1983 by the American Association of State Highway and Transportation Officials (AASHTO), was the first-ever test proposed for rapid qualitative assessment of chloride permeability of plain cement concrete. It was shown that the charge passed (RCP) through the plain cement concrete was well correlated with the chloride penetration data generated through the 90-day soaking test (discussed above). Based on the experimental results (RCP and soaking test), guidelines were laid down to qualitatively classify concrete mixtures in different chloride permeability categories (Wee et al., 2000). However, values may be inaccurate if concrete is atypical (Stanish et al., 2000). There is also a sense that RCP data reflects the electrical resistance of concrete rather than the resistance to chloride penetration (Wee et al., 2000).

Electrical conductivity of concrete depends on both its pore structure and its pore solution chemistry (Savas, 1999). Results are affected by the pore solution and changes in pore structure, both of which are a function of the admixtures, water/ cement ratio, etc. Doubts have been raised about the ability of RCP to determine the chloride permeability of concrete mixtures containing mineral admixtures such as silica fume, ground granulated blast furnace slag, and fly ash (Savas, 1999 and Wee et al., 2000). RCP test results may be biased in the presence of chemical and mineral admixtures (Savas, 1999). The replacement of Portland cement with supplementary cementing materials, such as silica fume, can reduce the electrical conductivity of the concrete more than 90% due to the change in the chemical composition of the pore solution, which has little to do with the transport of chloride ions in concrete. Thus, it is not correct to use the passed charge as specified in AASHTO T 277 or ASTM C1202 to evaluate the rapid chloride permeability of concrete with supplementary cementing materials (Shi et al., 1998). The dependence of RCP results on the pore fluid conductivity is purely the property of the test and has no relevance to the chloride permeability of the concrete; therefore, for concrete containing mineral admixtures, the interpretation of chloride permeability based on RCP results becomes unrealistic (Wee et al., 2000). Mixes with fly ash consistently had lower permeability values compared to the corresponding plain Portland cement (Baykal, 2000). Concretes with GGBFS have significantly lower coulomb values than control concretes (Savas, 1999). GGBFS is known to have a pore refining effect; it also decreases the Na^+ and OH^- ions from the solution (Shi et al., 1998).

The addition of chemical admixtures such as calcium nitrite and mineral admixtures affect the concrete pore size distribution and the concrete pore solution chemistry (Savas, 1999), this may have a significant affect on the accuracy of the Coulomb values. Calcium nitrite may reduce resistivity or increase the rapid permeability value of a given concrete, it does not increase the rate of chloride ingress (Berke and Hicks, 1992 and Savas, 1999). Calcium nitrite is found in some corrosion inhibitors (Lane, 2000). This test method can produce misleading results when calcium nitrite has been admixed into a concrete (Savas, 1999). The results from this test on some such concretes indicate higher coulomb values, that is, lower resistance to chloride ion penetration, than from tests on identical concrete mixtures without calcium nitrite. However, long-term chloride ponding tests indicate the concretes with calcium nitrite were at least as resistant to chloride ion penetration as the control mixtures (Lane, 2000). Other admixtures may affect results similarly (Lane, 2000). Comparison between mixtures must be evaluated with caution (Savas, 1999).

Another criticism of the RCP test is that the current passed is related to all ions in the pore solution not just chloride ions (Stanish et al., 1997). Suggesting that it is not the permeability that is being measured but ionic movement; the movement of all ions, not just chloride ions, affects the test result (Stanish et al., 1997).

Direct current may cause a polarization in the pore water and a transport of ions, altering the pore water composition (Elkey and Sellevold, 1995). Alternating current reduces the polarization effect (Elkey and Sellevold, 1995).

Electrical resistivity increases with decreasing moisture content; all mixes exhibit a sharp change between 40-60% saturation (pore water begins to gain or lose continuity); resulting in a 3% fluctuation in RCP value per each % change in degree of saturation (Elkey and Sellevold, 1995).

Temperature affects the resistivity of concrete; for every degree of change (Celsius) will exhibit a 3% difference in the resistivity of the concrete (Elkey and Sellevold, 1995). Another complaint of the RCP test, applying high voltage to lower quality concretes leads to an increase in temperature that may result in a higher Coulomb value (El-Belbol and Buenfeld, 1989 and Stanish et al., 2000). However, if a lower voltage is used, the test will be substantially longer, i.e. 4 days at 40 V (El-Belbol and Buenfeld, 1989). Data suggests that the six-hour time interval may be unnecessary; one 30-minute interval multiplied by 12 will be relatively accurate (Stanish et al., 2000).

Curing conditions may have an affect on the RCP values. Coulomb values for standard cured specimens are lower than for accelerated cured specimens (Savas, 1999). Presence of calcium nitrite appears to affect RCP values only under accelerated curing conditions; increasing the coulomb value (Savas, 1999).

Presence of chlorides reduces resistivity substantially (Elkey and Sellevold, 1995). The electrical resistivity of concrete specimens contaminated with chloride plus sulfate salts is generally lower than that of specimens contaminated with only chloride ions (Dehwah et al., 2000). Resistivity of samples with pore water containing 6% NaCl was less than 40% of concrete with no additional chlorides; samples exhibit a 50% difference in RCP value due to replacement of pore water by 3% or 6% NaCl solution (Elkey and Sellevold, 1995).

Since the test results are a function of the electrical resistance of the specimen, the presence of reinforcing steel or other embedded electrically conductive materials may have a significant effect (Stanish et al., 1997). The test is not valid for specimens containing reinforcing steel positioned longitudinally, that is, providing a continuous electrical path between the two ends of the specimen (Lane, 2000). Corrosion of the reinforcing steel may affect the resitivity values; therefore, the values can no longer be expected to reflect the permeability of the concrete (Berke and Hicks, 1992).
Resistivity of concrete can be expressed by the following equation (MacDonald and Northwood, 2000):

$$p_c = V_c \, A \, R_r \, / \, V_r \, l$$

A = area of plane perpendicular to the potential difference

L = length of the concrete sample

R_r = known resistance

V_c =voltage measured across the concrete

V_r = voltage measured across the resistor

p_c = resistivity of concrete

Single operator coefficient of variation of a single test has been found to be 12.3%, and thus two properly conducted tests should vary by no more than 35% if done by one person (Mobasher and Mitchell, 1988). Separate laboratories will have a single-test coefficient of variation of 18.0%. The average of three samples should vary by no more than 29% between two laboratories (Stanish et al., 1997).

Migration Cells

This test is similar to RCP, but one cell has a chloride solution while the other cell is chloride-free; the movement of chlorides to the chloride-free cell is then measured (Stanish et al., 2000). Electrical migration proceeds for some set time, then the specimens are split in half, and a silver nitrate is sprayed on the sample (Stanish et al., 1997). Silver chloride will become white and silver oxide will become brown, illustrating the depth of the chloride ion penetration (Stanish et al., 2000). Criticisms of this method are that it is time consuming and it has a problem with conductive material (i.e. reinforcing steel, etc.) located in the concrete.

Surface Electrical Resistivity Test

There is a desire to replace the current standard for the measurement of concrete durability for several reasons. The RCP test, which is the current standard, is obviously not without fault. The above-mentioned shortcomings and disagreements among professionals leave much to be desired. In addition to this fact is the condition that the RCP test is a three-day, time and labor-intensive test. The industry is looking for a suitable replacement to carry on the testing of concrete's durability. One of the most promising alternatives is electrical Surface Resistivity. Using a test probe to measure the resistivity of a material was developed by geologists to measure the resistivity of soil when investigating soil strata (Ewins, 1990). There are several configurations of the test probes. Some have two probes, some four. The spacing of the probes ranges from a few centimeters apart to hundreds of meters apart, as in the Schlumberger array. For the small scale used for concrete resistivity studies however, the Wenner array is used exclusively (Millard, "Reinforced" 75). The Wenner array utilizes four equally spaced surface contacts. A small alternating current I is passed through the concrete between the outer pair of contacts. The resultant potential difference between the two inner electrodes V is measured with a digital voltmeter (Broomfield and Millard, 2002). The resistance (R) gives a ratio of voltage to current. See Figure 2.1 for an illustration of this device and currents.

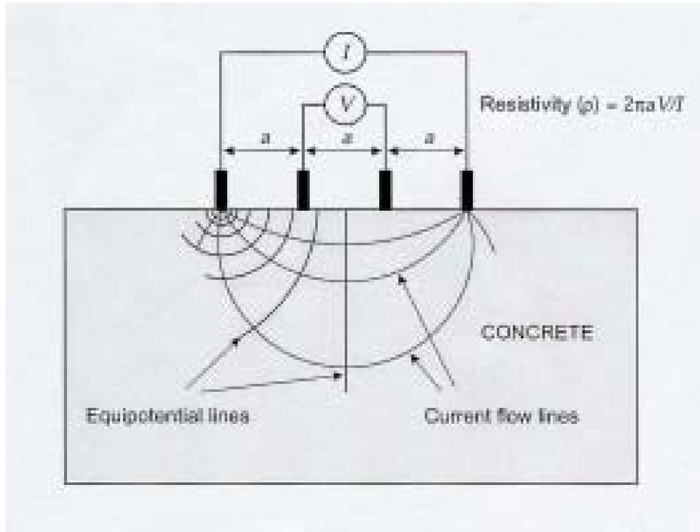

Figure 2.1 Diagram of Surface Resistivity Using a Wenner Probe (Broomfield 39).

From this the resistivity is obtained by multiplying the measured resistance by a conversion factor, called the cell constant (Polder, 2001). The cell constant is a function of the geometry of the specimen and there exists three formulas for three different geometric forms. The first is the basis for the other two and provides the resistivity of a material as the resistance of a cube of one unit size. Concurrently, the resistivity ρ of a prismatic section of length L and section A is given by:

$$\rho = RA / L \tag{1}$$

where R is the resistance of the specimen calculated by dividing voltage (V) by current (I) (Millard, 1991).

The next variation of the formula commonly used is for the application of taking resistivity measurements of concrete cylinders. The resistivity ρ can be determined for a cylindrical sample with the application of the second formula:

$$\rho = (\pi d^2 / 4L)(V / I) \tag{2}$$

where L is the cylinder length and d its diameter (Morris, 1996).

The last condition assumed for resistivity reading of concrete is a semi-infinite geometry, in relation to the probe spacing. The formula adapted for this measurement is as follows:

$$\rho = (2\pi a)(V/I) \tag{3}$$

where *a* is the electrode spacing (Morris, 1996).

It was determined early in testing that alternating current (AC) was preferred over the use of direct current (DC) due to the polarization phenomena which occurs across the current probes at the probe contact interface (Ewins, 1990). A sine-wave alternating current however posed the problem of measuring impedance between voltage probes rather than a resistance (Ewins, 1990). An additional hurdle for an alternating current application is skewed data due to capacitive effects. Different frequencies of AC were tested to arrive at 300Hz as the most suitable reconciliation to minimize these capacitance effects (Millard, Harrison, and Edwards, 1992).

An alternative way however, to reduce the above mentioned capacitance effects is to use a square wave current source "and make the voltage measurement in the middle of the positive half cycle. If a suitable, not too high frequency is chosen for the square wave, the voltage wave will have settled down and be no longer changing with time in the middle of the positive (or negative) half cycle. Measurements by Millard, Harrison, and Edwards showed that the upper frequency limit for this to be true is 60 kHz.

Contact Spacing. The spacing of the test probes is a critical task for an accurate measurement of concrete resistivity. An assumption is made when using the Wenner resistivity technique that the material being measured is homogeneous. Conversely, concrete contains aggregate particles, which normally have a very high resistivity and cement paste with a much lower resistivity (Gowers, 1999). To ensure an interference-free reading, it has been determined that the minimum probe spacing must be 1.5 times that of the maximum aggregate size (Broomfield 2002, and Gowers 1999). To practice this advice seems easy enough, however there is another consideration that must be addressed. The thickness of the model being measured is also important with regard to probe spacing. Although there is no finite depth of penetration of the current field (Millard, Harrison, and Edwards, 1992), theoretically 77% of the current flows to a depth 4 times that of the probe spacing (Ewins 1990, and Millard, Harrison, and Edwards, 1992). It is therefore recommended that probe spacing be minimally set to ¼ the depth of the specimen to be evaluated (Gowers 537).

The decision of probe spacing is a balance between several considerations: those mentioned above and the final variable, which addresses the noteworthy affect of scatter. Scatter is a product of the shear fact that concrete is simply not a homogeneous material. The presence of aggregate particles, which are essentially inert bodies, have nearly zero conductivity. Hence the current implemented by the first probe and withdrawn by the final probe must go around these inert bodies. This interference is referred to as scatter (Millard, 1993). "Considerable scatter is present in most sets of resistivity measurements, even if they concern data from laboratory specimens cast from the same mix and exposed identically. In any set of measurements on 'identical' specimens, coefficients of variation of 10% are good and 20% must be considered normal. In the field, errors of 25% are well possible" (Polder, 2001). When honoring this guidance caution must be exercised not to choose spacing too small, however similar problems exist for contact spacing too generous. Many authors adopted a probe spacing of 50mm as the best conciliation.

Semi-infinite Model. Theories on which the Wenner array and surface resistivity test are built include two given circumstances: a homogeneous material and a semi-infinite model. The first of these has been previously addressed leaving only the size of the test sample in question. A semi-infinite model is defined in relation to the probe spacing, which has already been established as typically having a 50mm spacing. For concrete specimens with a sectional depth of less than 200mm, either a smaller probe spacing can be adopted, at the risk of accepting more interference from scatter, or a mathematical correction factor can be employed.

Another consideration of the sample's geometry regarding this test has to do with edge and end conditions. See Figure 2.2 for clarification of edge and end conditions. In the case that the contact electrodes are placed close to a corner [edge] of the test specimen, an error will occur in the resistivity measurement due to the fact that the section cannot be considered as semi-infinite (Millard, 1991). An error of less than 10% has been found only if electrodes are positioned at least 2a (a = probe spacing) from an edge (Broomfield, 2002). To be clear, this condition is with the linear array parallel to an edge.

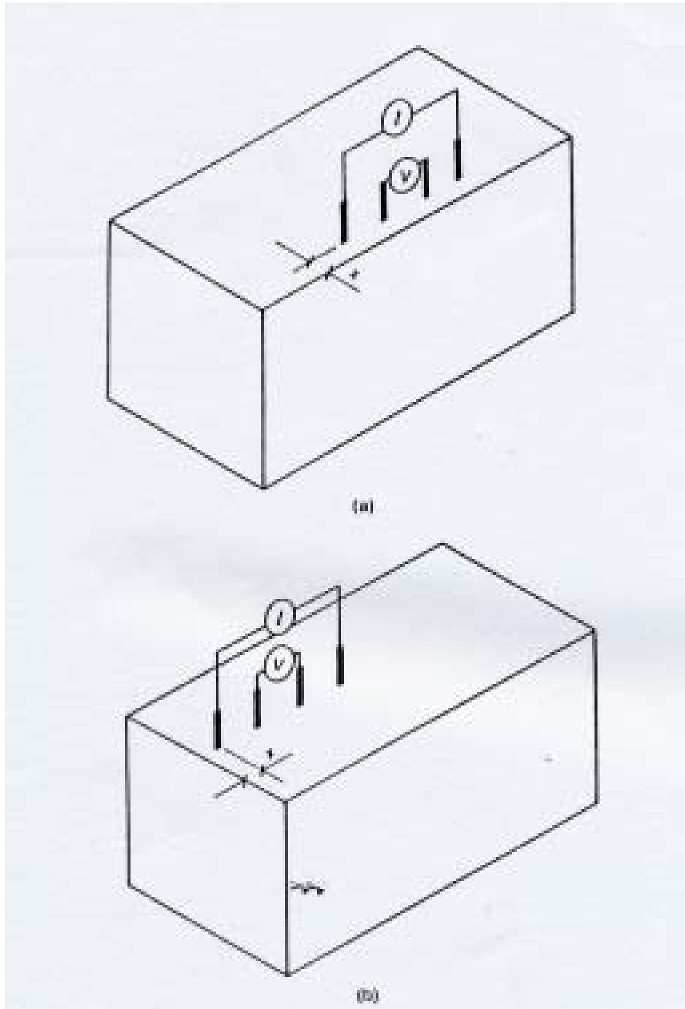

Figure 2.2 Edge (a) and End (b) Conditions (Millard, "Reinforced" 80)

Conversely, an edge transverse, or perpendicular to the axis of the array is more commonly referred to as an end. Effects of placing the array near the end of a sample are minimal (Millard, 1991). "Even when one contact was positioned right at the end of the section, there was only a 10% overestimation in the resulting measurement of the concrete resistivity" (Gowers, 1999). This information is specifically applicable to researchers and professionals wishing to perform surface resistivity measurements on 4x8 inch concrete cylinders or cores. As was mentioned above, a cell constant correction factor *K* as defined by W. Morris et al. can be applied for the rectification of values measured from samples not conforming to the semi-infinite geometry. If the value displayed on the screen of a commercial probe/voltmeter combination is named ρ_{app}, then the following correction formula is offered by W. Morris et al (1996)

$$\rho = \rho_{app} / K \tag{4}$$

where K is a function of the inter-probe distance, a, and the geometry of the concrete body tested.

Due to the various complications germane to this test accompanied by the non-homogeneity of concrete, it is recommended that readings are taken at a number of locations and averaged to determine a resistivity figure. For in-situ measurements this includes several readings in the same location but varying direction and orientation of the array and then averaging (Polder, 2001). This is also the case when evaluating test cylinders. Test cylinder readings show variability at different tangential locations on the cylinder's surface, as well as when rotating the probe array on the cylinder face. "Since each resistivity reading is nearly instantaneous and no custom fitting of the specimen is needed, large numbers of specimens can be characterized in a short time, even when a number of readings per specimen are made for averaging" (Morris, 1996). This technique has been found to yield a more accurate indication of a specimen's true resistivity.

Surface Layers. Since only the surface layers of concrete specimens are exposed to differing atmospheric conditions, there can exist a layer of high or low resistivity, or both one on top the other. These layers can differ greatly from the whole of the sample. Each of these three conditions has a significantly different affect on taking a surface resistivity measurement. Some of the generatives of this situation can be poor curing conditions, recent rainfall, acid rain, and exposure to sea water (Millard, 1993).

A layer of high resistivity concrete over more normal concrete is found to have little affect on measurement if its thickness is small in relation to probe spacing. This is because current makes it through the thin layer of high resistivity, travels through the rest of the concrete section and returns through the high resistivity giving an accurate result of the concrete's resistivity (Gowers, 1999). Conversely, for a specimen having a layer of low resistivity at the surface the affects are significant. The reason for this is that having a layer (or path) of low resistance on the surface of the concrete, where the probes are placed for reading, the current simply flows in this layer (the path of least resistance) rather than moving through the cross section of the concrete. It is for this reason that readings are skewed (Millard, 1993). To avoid this circumstance, a probe spacing of not less that 8 times that of the thickness of the low resistivity layer are selected (Gowers, 1999). The only condition of this recommendation is that if the depth of the low resistivity layer is greater than that of the concrete cover, then: "it will be the resistivity of the carbonated layer that will influence the rate of corrosion, not that of the underlying uncarbonated concrete. In this case a resistivity contact spacing equal to or less than the carbonation layer thickness is recommended to ensure that an accurate measurement of the resistivity of the carbonated later is made" (Gowers, 1999). Lastly, the most menacing condition of these deviant surface layers is when there exists a high resistivity layer directly under a low resistivity layer. This condition is difficult to overcome. In this case the secondary layer of high surface resistivity creates an insulating layer between the surface layer of low resistivity and the rest of the concrete sample. The most common example of when this occurs is where the high resistivity layer exists from carbonation due to environmental conditions and several consecutive days of dryness allow the concrete dry, subsequent rain would induce a layer of low resistivity on top of the layer of carbonation (Gowers, 1999). The best way to avoid measurements affected by this circumstance is careful planning of test execution. Avoid taking measurements within 24 hours of rain following several days of dry conditions (Millard, 1991).

Water-Cement Ratio. Jin-Kiang Su et al. (2002) performed research on the effects water-cement ratios have on concrete durability. Testing included three different w/c ratios: 0.45, 0.55, and 0.65. Findings showed that Resistivity readings taken from the 0.55 were lower (less resistive) than those observed in the 0.45 mix. However little decrease was evident between the 0.55 and 0.65 mixes. All testing was performed with saturated concrete.

Ambient Conditions. The ambient environmental conditions have a significant effect on the measurement of surface resistivity. Research shows that as temperature decreases resistivity increases. Millard, Harrison, and Edwards (1992) found one test in particular where the temperature and resistivity was logged over a 10 day period, a 21°C increase in temperature caused the resistivity to drop from 7.5 kΩ.cm to 3.8 kΩ.cm. They concluded that the effects on resistivity of temperature changes over this period were far more significant than any moisture content changes due to rain showers or drying effects. This is explained as being a "result of temperature influences on ion mobility, ion-ion and ion-solid interactions. Due to the complex nature of the interaction, an empirical approach must be followed. From laboratory work, it appears that the temperature effect may vary with moisture content, with 3% for saturated and 5% for dry concrete for each degree K temperature change" (Polder, 2001). Now these considerations are exclusive to in-situ readings of structures exposed to the ever-changing environment. Conveniently, laboratory temperatures are controlled for the comfort of the lab operators.

Steel Reinforcing._The presence of steel reinforcing embedded in concrete is not a situation that can be avoided. Consequently, when taking a surface resistivity measurement, there exists a risk of the steel short-circuiting the test by allowing the current to bypass much of the concrete. There are several strategies for the avoidance of interference from steel reinforcing. Gowers and Millard (1999) found that errors in measurement were only significant if the probe positioning was directly over a reinforcing bar. The error was not found to be significant if the reading was taken at a position orthogonal (perpendicular) to a bar or placed remote from a parallel bar (Gowers, 1999). Many authors recommend the employment of a covermeter to determine reinforcement position and orientation before taking measurements (Broomfield, 2002). Research has also been performed on the influence of different kinds of reinforcing, i.e. mild steel as opposed to stainless with a negligible difference being determined. Additionally, study shows that bar diameter also has a negligible effect (Millard, 1993). So this being said, if avoidance is not possible, then the selection of a probe spacing of less than 2/3 the concrete cover can prevent significant error (Gowers, 1999). If a situation arises where it is not possible or convenient to employ a small contact spacing, it is necessary to use a correction factor to rectify resistivity measurements taken directly over and parallel to steel reinforcing bars beneath the surface. These additional calculations will compensate for the presence of the bar (Gowers, 1999). Avoidance however, remains the best solution.

Wood Tips. Several different configurations of test probes, have been developed. Some use two contacts, some four. Among the four probe types contact spacing can range from a couple of centimeters to several hundred meters. Different means of making as close to a uniform contact connection have been employed. The type used in conjunction with the square-wave meter (used in this research) employs the use of saturated wooden dowels inserted in the tips of the stainless steel test probes. Two of the probes are spring-loaded, to make an adaptable contact profile (Millard, Harrison, and Gowers, 1991). This system has proven to be very forgiving hence its selection. However some discretion is required during implementation. Accurate Resistivity measurements cannot be counted on if these wooden tips are allowed to dry out during data collection. Millard, Harrison, and Gowers (1991) advise the renewal of the wooden inserts regularly in order to avoid the build up of concrete dust and dirt on the tip faces, this condition may influence the measurement.

Time Drying of Samples. The degree of surface dryness affects surface resistivity in the various ways previously mentioned and by the enabling of high and/or low resistivity surface layers. Jin-Kiang Su et al. (2002) state that under 8 hour air-dry conditions, the water loss ratio is about 0.7% and the concrete resistivity increases about 5% ~ 10%. Observations indicate that the longer a saturated sample is allowed to dry, the higher will be its resistivity.

Honeycombed. If concrete placement is done so poorly as to result in highly honeycombed concrete, misleading Surface Resistivity readings can be expected. The honeycombed concrete can be so porous as to place the concealed reinforcing steel effectively under atmospheric conditions, therefore allowing virtually unbridled corrosion. Conversely the air voids prove to be an insulator to the current passed between the probes of the resistivity meter resulting in a reading consistent to that of a concrete of much higher actual durability. Consequently the test reading and realistic conditions are unrelated and results therefore misleading (Millard, 1993).

Chlorides. The presence of chlorides in a concrete specimen do in fact have a desirable effect on taking test readings. “Chlorides in concrete can be hygroscopic, i.e. they encourage the concrete to retain water. For this reason, chlorides are wrongly considered to reduce concrete resistivity” (Broomfield, 2002). It has been demonstrated that water saturated concrete provides the most uniform measurement of a concrete’s Resistivity. Chlorides then aid measurements made by a Wenner probe and meter by evaluating the actual concrete itself by reducing the amount of micro-environmental variation (differences in level of saturation).

CHAPTER 3
METHODOLOGY

Rapid Chloride Permeability Test

This Methodology is to read as a narrative. The reason is to exemplify the time intensive nature of this testing procedure therefore establishing the necessity to improve it. All methods conform to ASTM 1202 and AASHTO T 277 test standards.

Samples were collected from all eight FDOT geographic districts for this research and consisted of three 4-inch by 8-inch cylinders comprising one sample set. Each cylinder in a set was labeled: A, B, and C. Said samples were taken of concrete being placed on FDOT jobsites, kept in a 100% humidity environment and trucked to the State Materials Office (SMO) in Gainesville Florida for testing. Upon arrival, all samples entered a laboratory environment and were subsequently treated equally. Their treatment prior to arriving at the State Materials Office however, cannot be ensured as uniform.

Sample Preparation

As samples arrived at the (SMO) office they were checked in and stored in a moist room sustaining 100% humidity until they are 26 days old. At that time the sample set was removed and samples A and B were cut on a concrete saw. Cutting consisted of the removal of a ¼ inch slice (Figure 3.1) to dress the top (troweled) edge and then cutting a 2 inch slice (Figure 3.2) required for testing. The remainder of samples A and B together with the uncut sample C were placed, submerged in a holding tank. The two, 2-inch samples were painted with Sikadur 32 Hi-Mod epoxy around their circumferences

(Figure 3.3) and left to dry. Before close of business the two samples rejoined the rest of the sample set in the holding tank. This marked the end of day 26.

Figure 3.1 Cutting a ¼” Slice off the Sample to Dress the Troweled Edge.

Figure 3.2 Cutting the 2” Slice for Testing.

Figure 3.3 Application of Epoxy around the Sample's Circumference.

Pre-test Requirements

Day 27 began with removing the 2-inch samples from cylinders A and B and placing them in the desiccation chamber. Using an electric pump, a vacuum of pressure less than 1 mm Hg (133 Pa) was drawn for 3 hours. At that time de-aired water was introduced to the chamber (Figure 3.4) while keeping the vacuum until the samples were submerged and the pump was let to run an additional hour. At the conclusion of this 4-hour desiccation the chamber was returned to atmospheric pressure and the samples were left submerged in this state (over night) for 18 hours, plus or minus 2 hours. This concluded the activities of day 27.

Figure 3.4 Desiccation Chamber.

Run Test and Collect Data

Day 28 was the actual testing day. The 2-inch samples from cylinders A and B were removed from the desiccation chamber and either wiped dry or allowed to surface dry. They were then siliconed into an acrylic test cell (Figure 3.5) comprised of two sides: one positive and one negative. The samples were placed into their respective cells, top of the sample into the negative side and the 90° joint sealed with silicone between the surface of the acrylic and the surface of the epoxy all the way around the circumference, and on both sides. A schematic diagram provided by David Whiting is pictured here in Figure 3.6. The silicone was then allowed to cure (approximately 2 hours). During curing, the positive and negative test leads in addition to the thermocouples were connected (Figure 3.7) as well as the information necessary to initiate the test entered into the software responsible for data collection during the test. After the silicone dried enough to prevent leaking, the cells were filled with hand mixed chemical solutions. The positive side was filled with a 0.3 N sodium hydroxide solution (NaOH) and the negative side with a 3% by mass sodium chloride solution (NaCl). At this time the test was begun and run for 6 hours, the software taking readings every 5 minutes. The particular program used in this project recorded the time, temperature, charge passed and current. It determined the cumulative charge passed during the 6-hour test in coulombs (ampere-second) by measuring the area underneath the curve of current (in amperes) versus time (in second).

Figure 3.5 Siliconning Sample into the Test Cell.

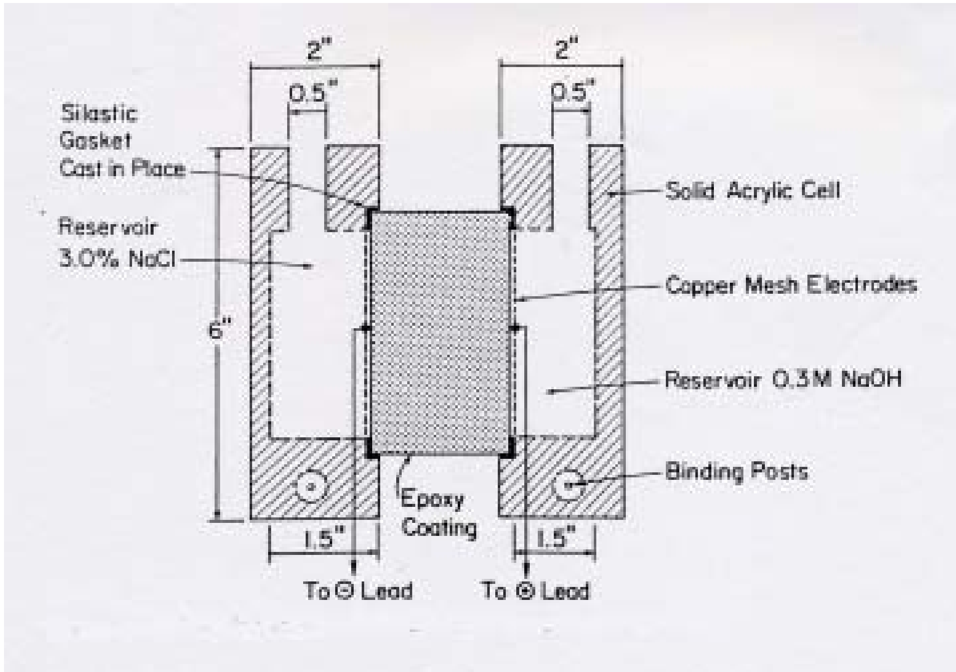

Figure 3.6 Schematic of RCP test set up from David Whiting.

Figure 3.7 The Complete Testing Configuration (Sample A and B).

Clean Up

The post-test day entailed separating the samples from the reusable acrylic cells using a utility knife (Figure 3.8) and cleaning those cells. Cleaning the cells required the removal of all silicone and dipping them in a muratic acid bath before rinsing and drying until their next use (Figure 3.9). The previous day's test results were also printed and cataloged for record. The 2-inch samples were discarded and the remaining portions of the A and B cylinders awaited their 91-day test date to repeat this battery.

Figure 3.8 Disassembly of the Test Cells.

Figure 3.9 Test Cells Cleaned and Ready for Next Test.

Surface Resistivity Test

For purposes of comparison, surface resistivity readings were taken on day 28 and 91 in order to build correlating data relating the two tests and their resultant quantities. On day 28, the remaining pieces of samples A and B in the set as well as sample C were removed from the holding tank in the morning and allowed to surface air dry. The time allotment for surface drying was not carefully monitored. After surface dry conditions were realized, surface resistivity readings were taken longitudinally around the sample's circumference (Figure 3.10) at eight different tangential points per cylinder at 0°, 90°, 180°, 270°, and again at 0°, 90°, 180°, 270° and then averaged. This technique aids in the minimization of interference by individual imperfections and the presence of a single aggregate particle interfering with readings. No readings were taken on either end of the samples.

Figure 3.10 Taking Surface Resistivity Measurements.

Samples A and B were approximately 5½ inches long while sample C remained an uncut specimen at 8 inches long. When taking Surface Resistivity measurements, two factors implored a difference in samples A and B from sample C. Those two differences were as follows: first the difference in length accounted for a change in the geometry of the sample. Second, the shorter samples being approximately 5½ inches long and the Wenner 4-probe array having an inter-probe spacing of roughly 1½ inches, there was left only ½ inch between the end of the array and the end of the sample. These two conditions were rectified separately and then combined into one correction factor.

The length difference was the first and most complicated rectification. Using a graph provided by Morris et al. which is presented here in Figure 3.11, the correction factor K was determined for both the 5½ and 8 inch lengths and the difference was taken to be 10%. Next, it is reported by S.G. Millard that errors less than 10% were found when taking measurements directly on the end of a specimen (“Reinforced” 79). When these two figures were assembled to form a correction factor of 20% it proved to consistently over shoot the C sample readings. The fact that S.G. Millard reported errors of less than 10% combined with the situation that readings were not directly on the end but ½ inch from it, the former 10% was reduced to 5% therefore effecting the combined correction factor to 15%. This figure satisfied the necessity as well as rectified the A and B sample results with the C sample results well.

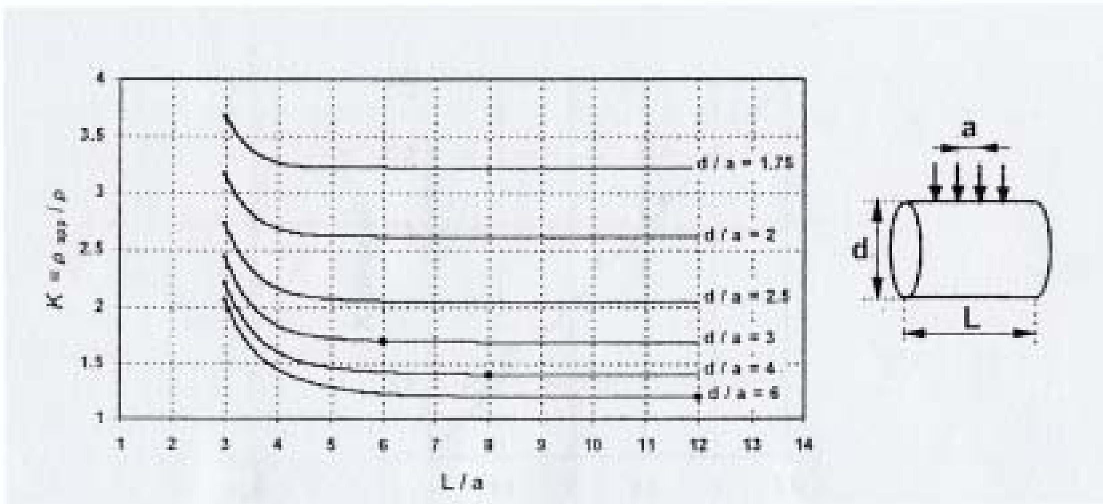

Figure 3.11 Graph Provided by Morris et al. for determination of *K* Values.

After the aforementioned readings were taken the sample set was returned to the holding tank to await the 91-day test date for repetition. The only difference is that at 91 days, after an additional 2-inch slice was cut (for the RCP test) from cylinders A and B, there was not enough left to take a surface resistivity reading. Therefore readings were only taken on sample cylinder C at the 91-day mark.

CHAPTER 4
DATA PRESENTATION

Sample

The sample size targeted for this project was 500 sets of samples. The research team achieved this goal; successfully testing more than 500 sample sets.

Sample Population

Concrete Classes

The FDOT specifications classify concrete in eleven classes. Each class has an individual set of defining characteristics and normal usage found in Table 4.1.

Table 4.1 Specified Compressive Strength of FDOT Concrete Classes

	FDOT Concrete Classes	Strength
1	Class I	3000
2	Class I Special	3000
3	**Class II**	**3400**
4	**Class II Bridge Deck**	**4500**
5	Class III	5000
6	Class III Seal	3000
7	**Class IV**	**5500**
8	**Class IV Drill Shaft**	**4000**
9	**Class V**	**6500**
10	**Class V Special**	**6000**
11	**Class VI**	**8500**

The classes of concrete that will be analyzed in this report are Class II and Class II Bridge Deck, Class IV and Class IV Drilled Shaft, Class V and Class V Special, and Class VI concrete. These are presented in bold type in Table 4.1. The others are used infrequently enough to not attract the attention of the FDOT for research purposes or did not have enough sample representation to warrant discussion. This leaves 500 projected sets of samples to be divided among seven classes of concrete in order to attain equal representation. This equality was desired but not achieved. Considerable effort has been placed in the requisition of equal quantities of sample however, since samples were collected from actual job sites of actual concrete pours, strict control of the testing quarry was not possible. Figure 4.1 and Table 4.2 show the distribution of samples across concrete classes.

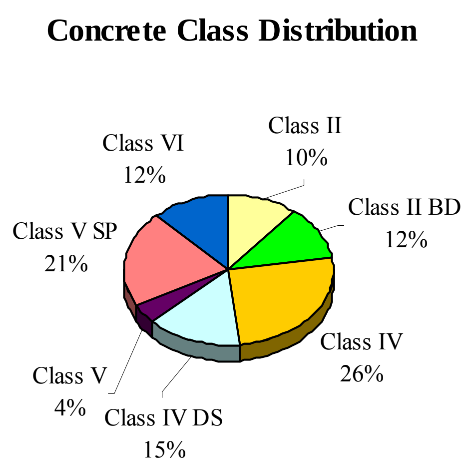

Figure 4.1 Concrete Class Distribution Graph.

Table 4.2 Sampling Distribution from each Class of Concrete

Class of Concrete	**No of Sets of samples**
Class II	53
Class II BD	61
Class IV	132
Class IV DS	74
Class V	22
Class VI SP	106
Class VI	60
Total	**508**

Geographic Districts

In addition to the separation of concrete by class the state of Florida is divided by the FDOT into geographic regions. (See Figure 4.2.) There are eight regions in total; seven geographic portions of the state and one that isolates the Florida Turnpike. Again, effort was made to balance the quantities of samples received across the various districts but reality is that numbers weighed heavily on the State Materials Office's home district (where research was conducted) and the farther away a district was, the more slim its representation. Distribution across districts is explained by Table 4.3 and represented in Figure 4.3.

Table 4.3 Sample Distributions Across FDOT Districts

FDOT District	**No of Sets of Samples**
District 1	104
District 2	181
District 3	53
District 4	11
District 5	37
District 6	6
District 7	88
District 8	28
Total	**508**

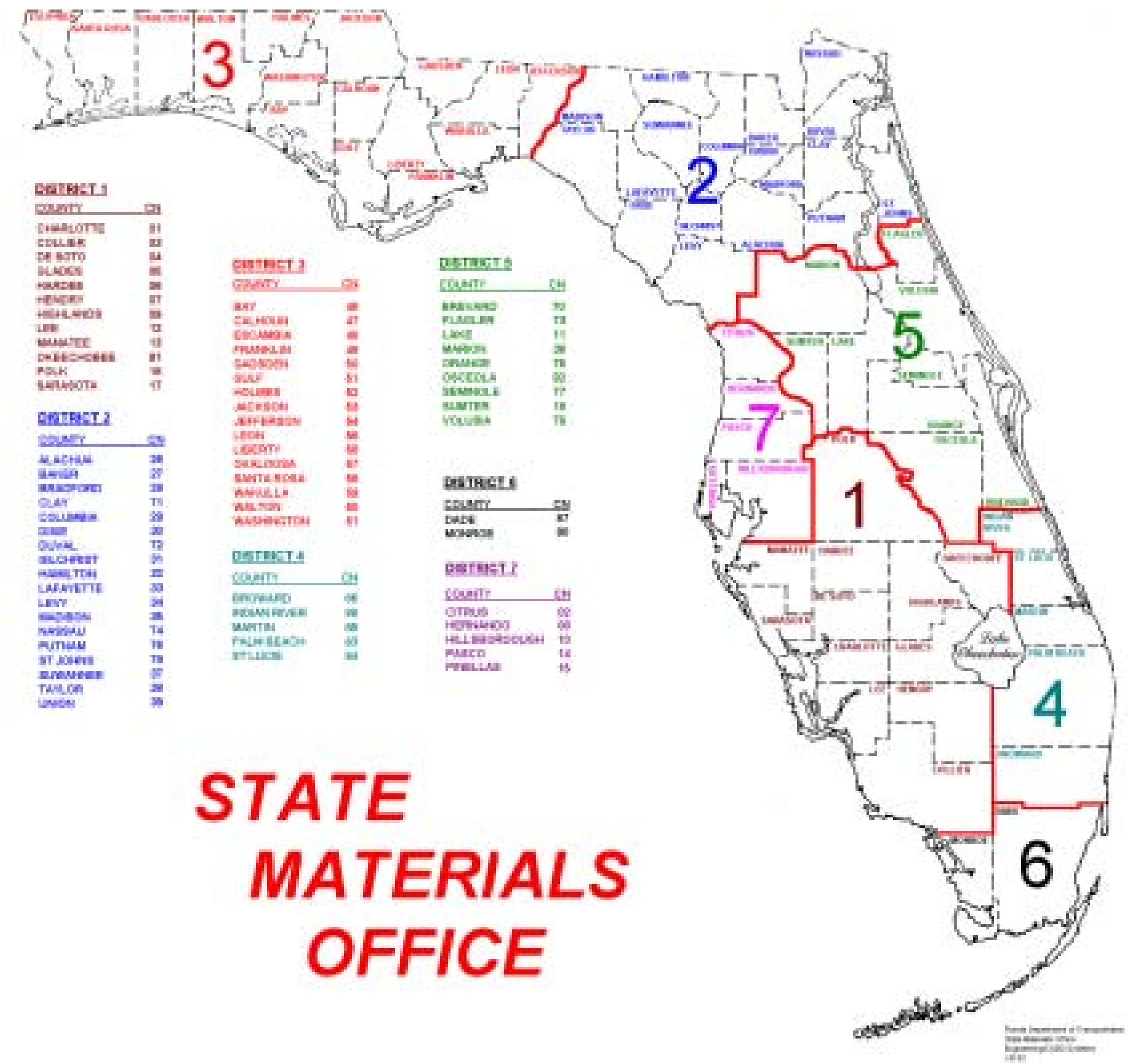

Figure 4.2 FDOT District Map.

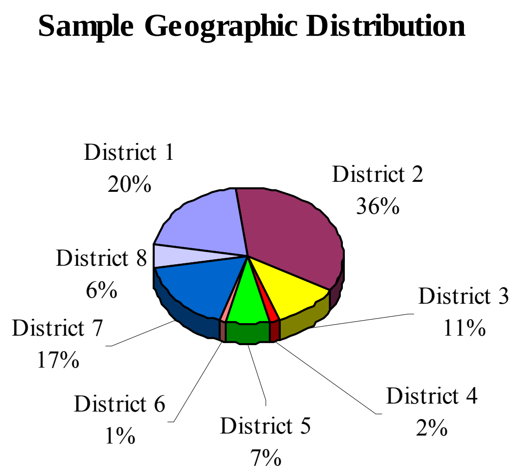

Figure 4.3 Distribution of Sample Geographic Origin by District.

Concrete Mix Designs

A final stratification of the concrete samples is by the actual concrete mix design. The project tested 134 different mix designs. A concrete mix is formulated by a manufacturer who then submits the design and the results of tested samples of the mix to the FDOT for approval. Once approved, that mix can be used on FDOT projects. There are thousands of such approved mix designs and new ones are always being created in the pursuit of value, economy, and performance. Most of the mix designs represented in this research have a small number of tested sample sets; between 1 and 5. However some reach as high as 20 sets of samples for the same mix design. Stratifying the data by individual mix design would be fruitless since, as stated above, most have modest representation. What is more important however, is the classification of mix designs based on their pozzolanic content. Data for the different classes of concrete has been presented first as an entire class and then distilled into those containing only Fly Ash as a pozzolan, only Ground Granulated Blast Furnace Slag as a pozzolan, those containing any amount of Silica Fume, and those with either Portland Cement only or whose composition is undeterminable. By this distillation of data, common mixes in each class with common pozzolanic materials are grouped for analysis and evaluation.

From this point forward, data will only be discussed in terms of their respective classes of concrete as well as their pozzolanic content.

Samples with High RCP Values

Some samples throughout the project yielded RCP test values that were extraordinarily high. These single samples contributed to skewing all the data when included in the analysis, so a cap value was placed on the 91-day test date in order to control these outliers. In the AASHTO T 277 standard a table is presented to guide the interpretation of RCP test results. This table is presented here as Table 4.4. It specifies that a test result in excess of 4000 coulombs is high and constitutes easily permeable concrete. The table was meant to guide decisions on tests made of core extractions of existing structures and not necessarily of new samples. In addition, as will be demonstrated later in this chapter, some pozzolanic materials delayed their effect by about two months. Taking this into account the 4000 coulomb limit would be unreasonable to apply at the 28-day test but appeared sufficient for the 91-day test.

Table 4.4 AASHTO Table Guiding RCP Test Value Interpretation.

Charged Passed (coulombs)	Chloride Ion Permeability
> 4,000	High
2,000-4,000	Moderate
1,000-2,000	Low
100-1,000	Very Low
< 100	Negligible

In total 46 of the 508 sets of samples tested were over this limit. This amounts to approximately 9% of the sample and must be considered when drawing conclusions later in this report. Table 4.5 demonstrates the distribution by concrete Class of all the failing samples. Twenty-two of the total failing samples were of Class II, which accounts for 42% of the Class II samples collected and tested. This is the highest incidence in the project however no explanation of this can be determined. Eleven of the 22 Class II failed samples were of the same mix design but collected and tested over 5 different dates.

Table 4.5 Failed Samples by Class.

Samples exceeding 4k Coulombs			
Class:	Amount Exceeding	Total # of Samples	Percent Failed
II	22	53	42%
II BD	4	61	7%
IV	5	132	4%
IV DS	5	74	7%
V	1	22	5%
V SP	5	106	5%
VI	4	60	7%
Total	46	508	9%

Class II

Rapid Chloride Permeability Test

A statistical summary of all Class II data follows directly in Table 4.6. There were 31 sets of Class II samples tested at 28 days and 29 sets tested at 91 days. As the table shows, the results average 4924 coulombs for the 28-day test and 2136 coulombs for the 91-day test. Their standard deviations were 3005 and 922 coulombs, respectively. The data is then separated by pozzolanic additive into those with Fly Ash and those with Blast Furnace Slag. There were not enough samples in this concrete class to present any data on those containing Silica Fume or those utilizing only Portland cement. Any category not represented by at least 10 samples has not been presented.

Looking solely at the results of the samples containing Fly Ash, the averages were 6776 coulombs at 28 days and 2593 coulombs at 91 days with standard deviations of 2377 coulombs and 883 coulombs. Conversely, the samples utilizing Blast Furnace Slag had an average at 28 days of only 1960 coulombs and 1402 coulombs at 91 days with a standard deviation of a mere 514 and 420, respectively. This shows that Blast Furnace Slag has been more successful at lowering the RCP values than has Fly Ash.

Surface Resistivity

Surface Resistivity results are inversely proportionate to RCP results: The sample size for both the 28 day and 91 day surface resistivity tests are identical to the RCP tests. The overall Class II data show the average 28-day test to be 14.0 kΩ.cm and 91-day test to be 21.9 kΩ.cm. The standard deviations were 9.1 and 8.9 kΩ.cm, respectively. If separated into pozzolanic categories, a trend emerges to mimic the RCP results. For Fly Ash only the averages were 7.9 kΩ.cm at 28 days and 17.7 kΩ.cm at 91 days. Each had a standard deviation of 2.6 and 5.5 kΩ.cm, respectively. However, samples with Blast Furnace Slag averaged 23.9 kΩ.cm at 28 days and 29.1 kΩ.cm at 91. Their standard deviations were 7.3 and 9.0 kΩ.cm, respectively. Again, Blast Furnace Slag is shown to out perform Fly Ash. All data show an improvement in every case at the 91-day test over the 28-day test because concrete, if cured properly, becomes less permeable with time.

Table 4.6 RCP and Surface Resistivity Test Results of Class II Concrete.

	RCP		**Surface Resistivity**		
	28 Day	91 Day	28 Day	91 Day	
# Samples	31	29	31	29	# Samples
Average	4924	2136	14.0	21.9	Average
Maximum	10636	3956	37.6	44.8	Maximum
Minimum	1231	861	4.8	11.7	Minimum
Std. Dev.	3005	922	9.1	8.9	Std. Dev.
Median	4672	1872	10.1	19.3	Median
	FLY ASH ONLY				
# Samples	18	17	18	17	# Samples
Average	6776	2593	7.9	17.7	Average
Maximum	10636	3956	14.2	27.7	Maximum
Minimum	2742	1345	4.8	11.7	Minimum
Std. Dev.	2377	883	2.6	5.5	Std. Dev.
Median	7157	2742	7.0	14.7	Median
	BLAST FURNACE SLAG ONLY				
# Samples	11	11	11	11	# Samples
Average	1960	1402	23.9	29.1	Average
Maximum	3116	2233	37.6	44.8	Maximum
Minimum	1231	861	13.0	16.8	Minimum
Std. Dev.	514	420	7.3	9.0	Std. Dev.
Median	1991	1398	23.2	30.6	Median

(RCP in coulombs, Resistivity in ohms-cm)

The RCP test results and Surface Resistivity test results for Class II samples correlate well. The 28-day test results tend to correlate more closely than those of 91-day tests for most of the classes tested.

To aid in a scientific approach to comparing the strength of the relationships, a value known as an R^2 value is employed. The R^2 value is an indicator that ranges in value from 0 to 1 and reveals the proportion of variation in the dependent variable accounted for by variation in the independent variable. The dependence is greatest when R^2 is at or near 1. The square root of R^2 is the correlation coefficient, R.

The Student's t was used to test the hypothesis that the correlation coefficient was zero (H_o: r = 0). The test used the standard formula

$$t = \{R\ [\sqrt{(n-2)}]\}\ /\ (1 - R^2)$$

where *n* is the sample size. This formula produces a t-value with *n-2* degrees of freedom.

Figures 4.4 and 4.5 show the comparison of all Class II data together. The Determination of Surface Resistivity by RCP for the 28-day testing, the R^2 value is 0.9406 and the correlation coefficient is –0.973, which is significant at the 95% confidence level with 29 degrees of freedom. The 91-day testing drops down a bit to an R^2 value of 0.8985 and the correlation coefficient is –0.948, which is significant at the 95% level of confidence with 27 degrees of freedom.

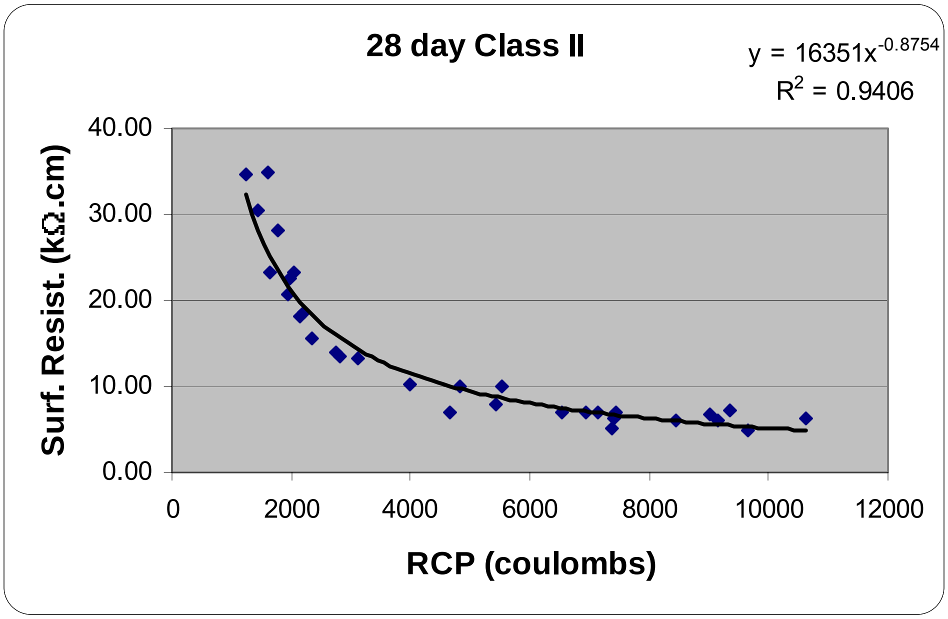

Figure 4.4 Correlation between Test Results of RCP and SR at 28-Days - Class II.

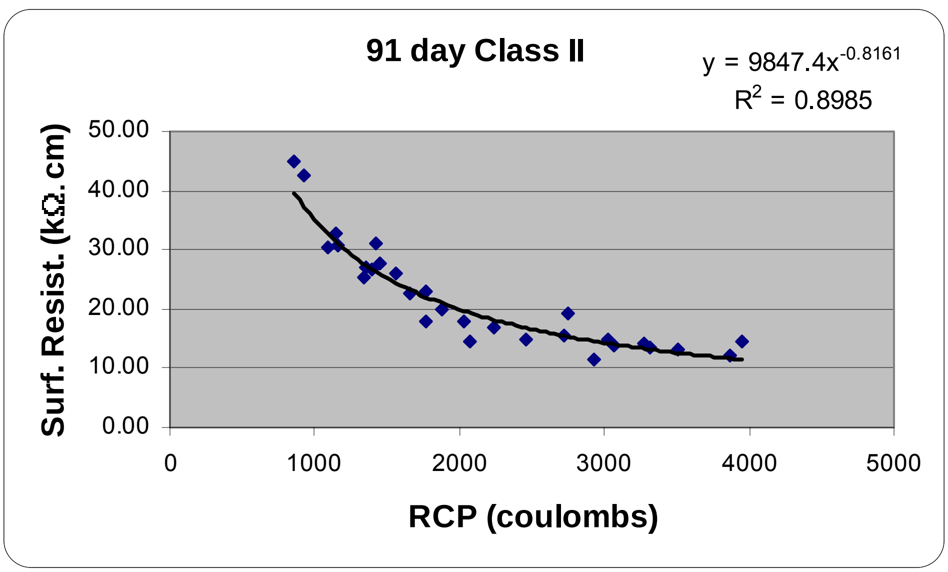

Figure 4.5 Correlation between Test Results of RCP and SR at 91-Days - Class II.

Next is to view the data divided into their pozzolanic categories. The samples containing Fly Ash as pozzolanic material correlate poorly at both test days. Correlation between RCP and Surface Resistivity for samples containing Fly Ash as pozzolanic material is shown in Figures 4.6 and 4.7. R^2 values for 28 and 91-day tests are 0.7846 and 0.8121, respectively, and associated correlation coefficients of –0.886 and –0.901, respectively. Both correlation coefficients are significant at the 95% level of confidence.

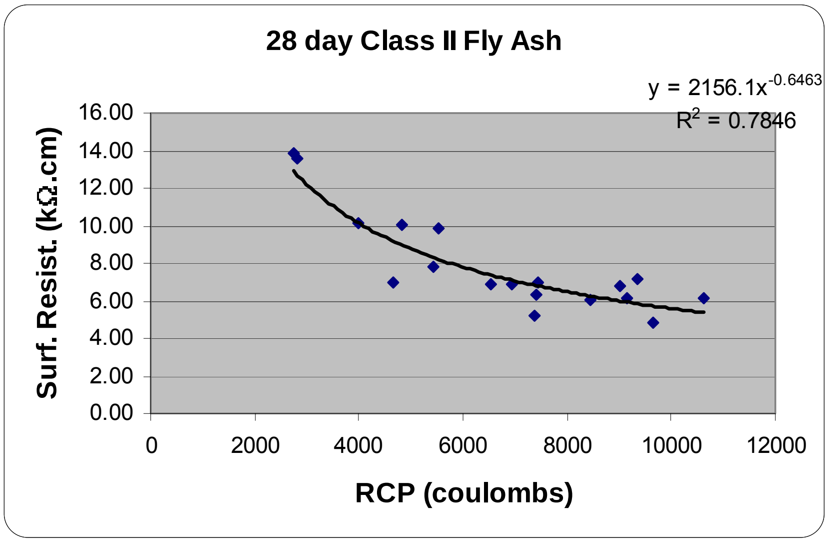

Figure 4.6 Correlation between Test Results of RCP and SR at 28-Days - Class II FA.

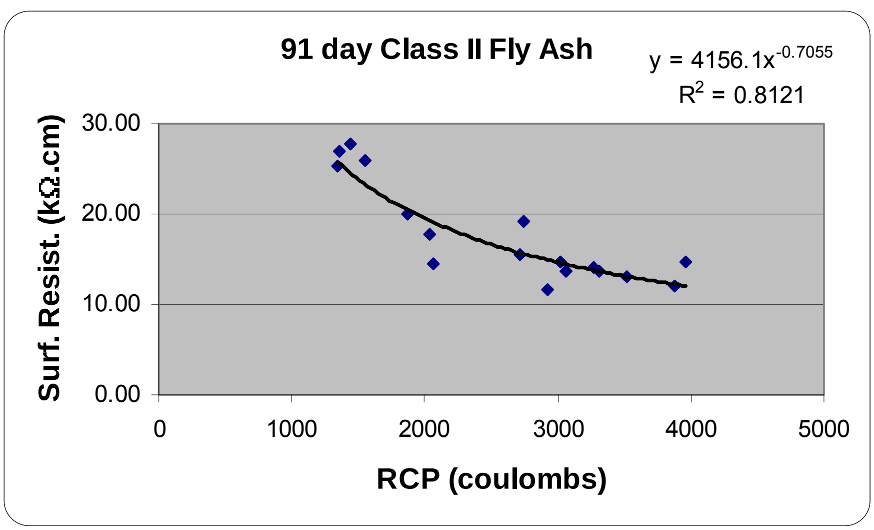

Figure 4.7 Correlation between Test Results of RCP and SR at 91-Days - Class II FA.

The relationships between RCP and Surface Resistivity for Blast Furnace Slag samples for 28 and 91 days are shown in Figures 4.8 and 4.9, respectively. The R^2 values are 0.8653 at 28 days and 0.9193 at 91 days. The associated correlation coefficients are –0.930 and –0.959, respectively. Again, both correlation coefficients are significant at the 95% level of confidence.

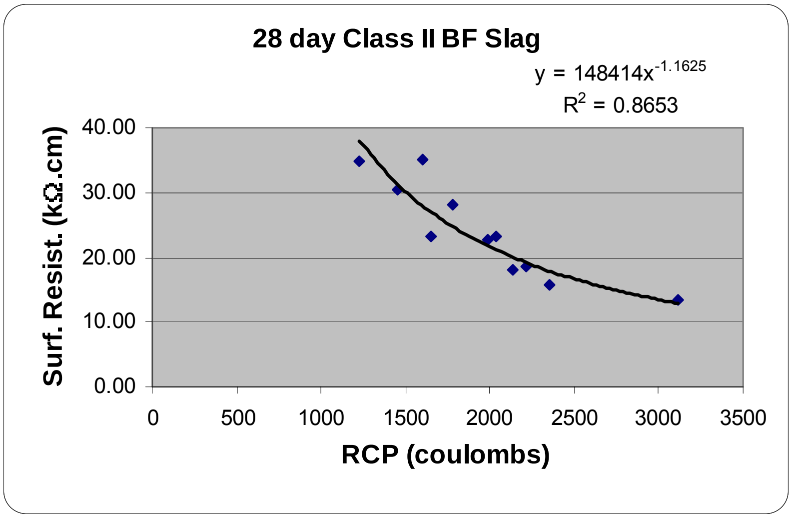

Figure 4.8 Correlation between Test Results of RCP and SR at 28-Days - Class II Slag.

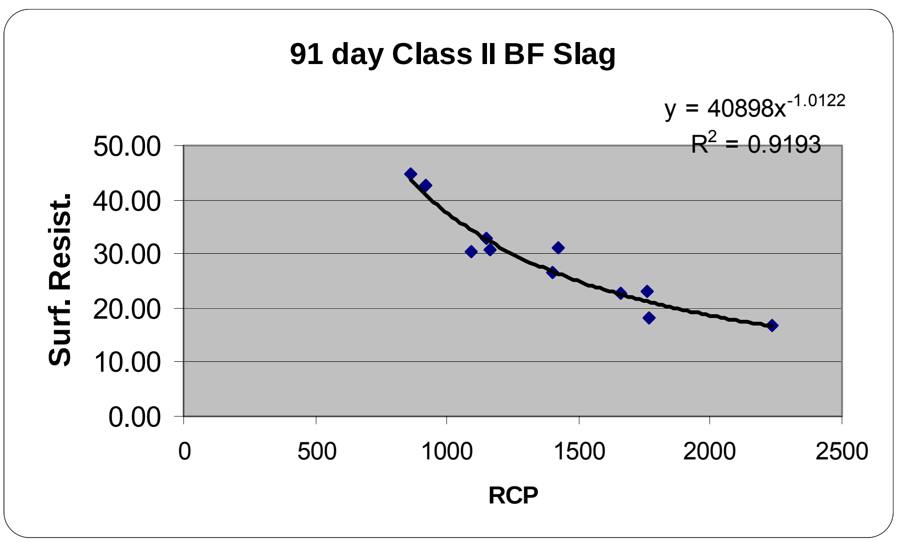

Figure 4.9 Correlation between Test Results of RCP and SR at 91-Days - Class II slag.

Class II Bridge Deck

Rapid Chloride Permeability Test

Class II Bridge Deck samples had a test population of 56 sample sets at 28 days and 52 at 91. Class II Bridge Deck results are presented in Table 4.7. The average RCP value for Class II BD samples were 5287 and 2110 coulombs for 28 and 91-day tests respectively. Their standard deviations were 2542 coulombs at 28 days and 698 coulombs at 91 days.

Table 4.7 The RCP and Surface Resistivity Results of Class II Bridge Deck.

	RCP		Surface Resistivity		
	28 Day	91 Day	28 Day	91 Day	
# Samples	56	52	56	51	# Samples
Average	5287	2110	12.0	20.6	Average
Maximum	11163	3951	33.9	41.1	Maximum
Minimum	1204	914	4.4	9.9	Minimum
Std. Dev.	2542	698	7.3	7.4	Std. Dev.
Median	5612	2101	8.9	18.8	Median
FLY ASH ONLY					
# Samples	43	40	43	40	# Samples
Average	6256	2258	8.7	18.9	Average
Maximum	11163	3490	17.6	41.1	Maximum
Minimum	2334	1015	4.4	12.5	Minimum
Std. Dev.	1983	608	2.7	6.5	Std. Dev.
Median	6210	2244	8.1	17.1	Median
BLAST FURNACE SLAG ONLY					
# Samples	12	11	12	10	# Samples
Average	1771	1405	24.6	28.6	Average
Maximum	2312	1806	33.9	35.6	Maximum
Minimum	1204	914	17.4	19.7	Minimum
Std. Dev.	353	261	5.0	5.3	Std. Dev.
Median	1820	1349	24.5	29.7	Median

(RCP in coulombs, Resistivity in ohms-cm)

Samples with Fly Ash as pozzolanic material represented the majority of the 56 total samples with 43 sample sets. Their average 28-day test result was 6256 coulombs with a standard deviation of 1983, which fell to a 91-day average of 2258 coulombs with a 608 coulomb standard deviation. Samples containing Blast Furnace Slag numbered only 12. However the 28-day average was down at 1771 and the 91-day average at 1405 coulombs. Their standard deviations were only 353 and 261 coulombs, respectively.

Surface Resistivity Test

Surface Resistivity data supports the RCP data. At 28 days the average test value was 12.0 kΩ.cm and at 91 days the value increased to 20.6 kΩ.cm. The standard deviations for these tests turned to be 7.3 and 7.4 kΩ.cm, respectively.

Broken into their pozzolanic categories Fly Ash samples displayed an average at 28 days to be 8.7 kΩ.cm and at 91 days to be 18.9 kΩ.cm. Their standard deviations were 2.7 and 6.5 kΩ.cm, respectively. For those samples containing Blast Furnace Slag, their average was higher than the Fly Ash samples at 24.6 kΩ.cm for 28 days and 28.6 kΩ.cm at 91 days. Their standard deviations were 5.0 and 5.3 kΩ.cm, respectively. The Blast Furnace Slag samples therefore performed better than the Fly Ash samples.

Correlation between RCP and Surface Resistivity Results

Class II BD test results between the Rapid Chloride Permeability test and the Surface Resistivity test correlate as well as the rest of the project. The R^2 value for 28-day testing was 0.9544 but for 91-day testing was down to 0.8749. Both associated R values are significant at the 95% level of confidence. This is a trend that has been observed in the project; that is that 28-day test data correlates more closely than 91-day data and both are significant. These trends are represented graphically in Figures 4.10 and 4.11.

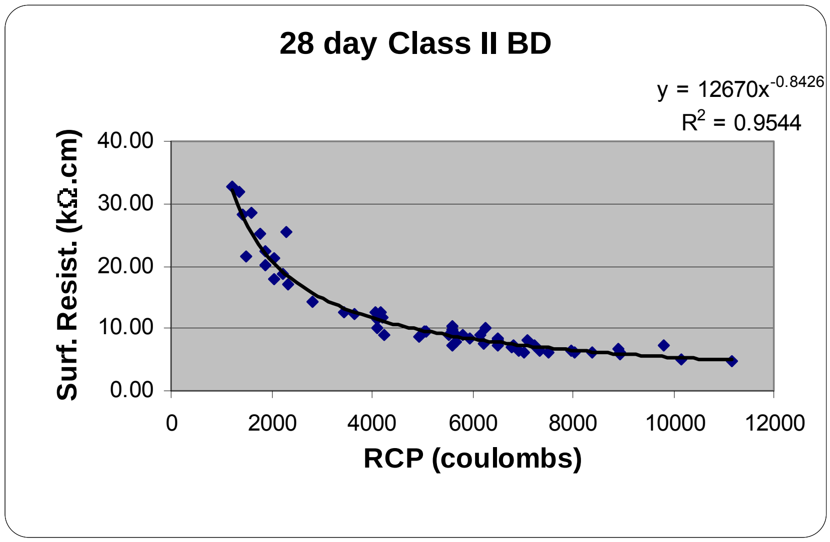

Figure 4.10 Correlation between Test Results of RCP and SR at 28-Days - Class II BD.

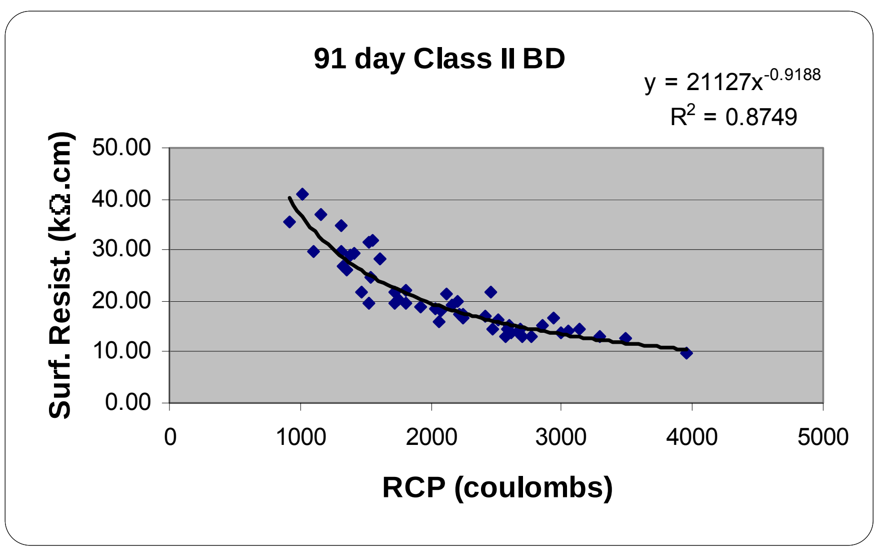

Figure 4.11 Correlation between Test Results of RCP and SR at 91-Days - Class II BD.

In the Class II Bridge Deck as in the Class II samples, those with Fly Ash seem not to correlate quite as well. The Class II Bridge Deck samples with Fly Ash had R^2 values of 0.8731 and 0.8479at 28 and 91 days, respectively. The associated correlation coefficients of –0.934 and –0.921, respectively, are both significant at the 95% level of confidence. These relationships can be found presented graphically in Figures 4.12 and 4.13.

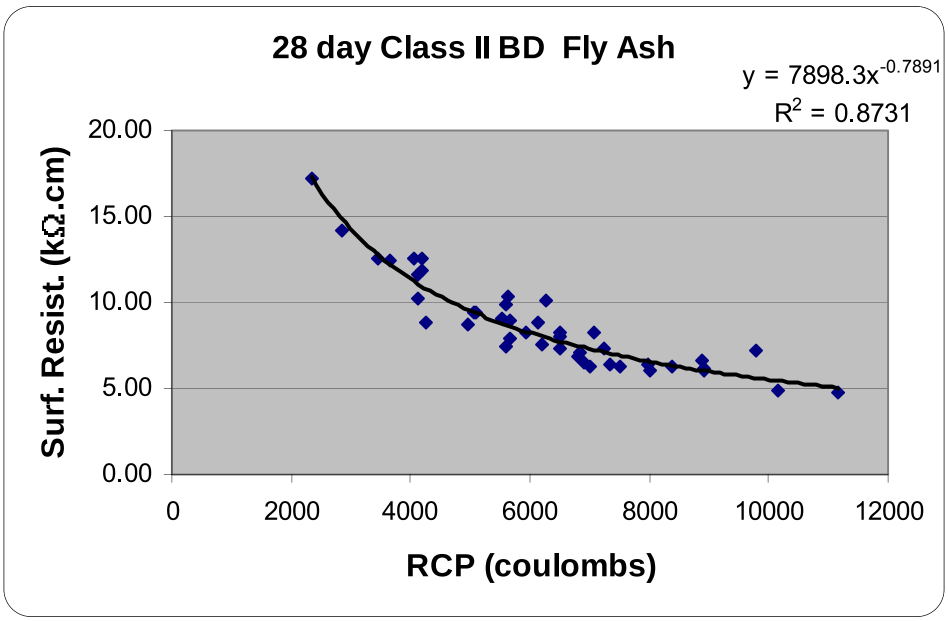

Figure 4.12 Correlation between Test Results of RCP and SR at 28-Days for Class II BD Samples with Fly Ash.

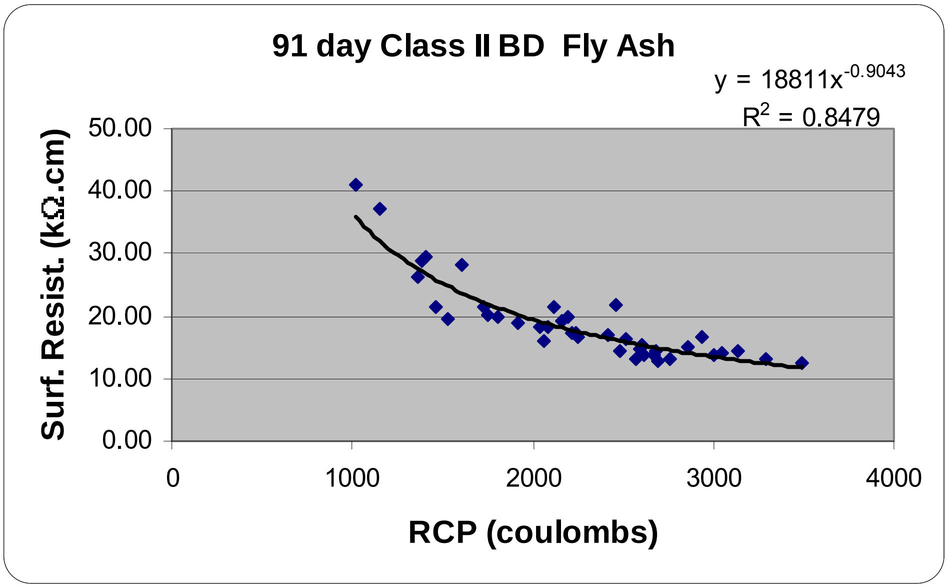

Figure 4.13 Correlation between Test Results of RCP and SR at 91-Days for Class II BD Samples with Fly Ash.

Class II Bridge Deck samples containing Blast Furnace Slag showed a lower correlation between the RCP and Surface Resistivity tests. The 28-day R^2 value was 0.5458 and the 91-day R^2 value was 0.4783. The associated correlation coefficients were –0.739 and –0.692, respectively, and both were significant at the 95% level of confidence. There were 12 Surface Resistivity readings taken at 28 days and 10 taken at 91 days to yield these values. Figures 4.14 and 4.15 graph the performance of these samples.

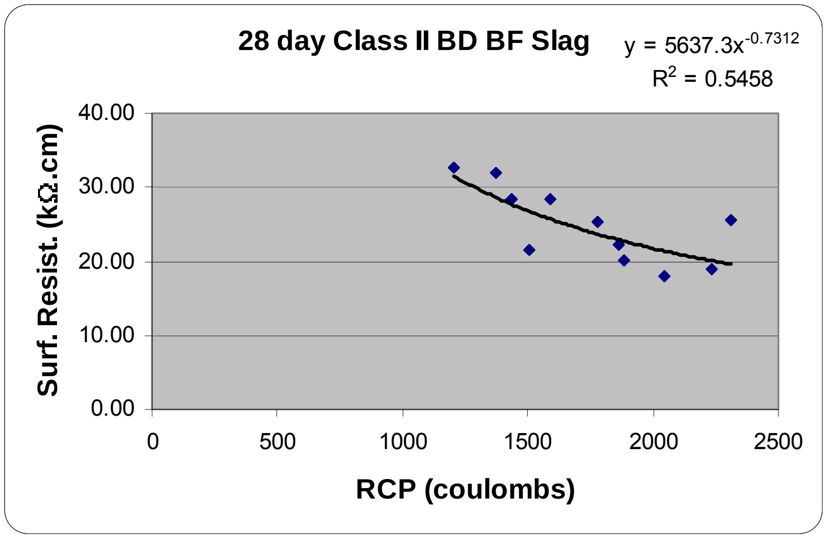

Figure 4.14 Correlation between Test Results of RCP and SR at 28-Days for Class II BD Samples with BF Slag.

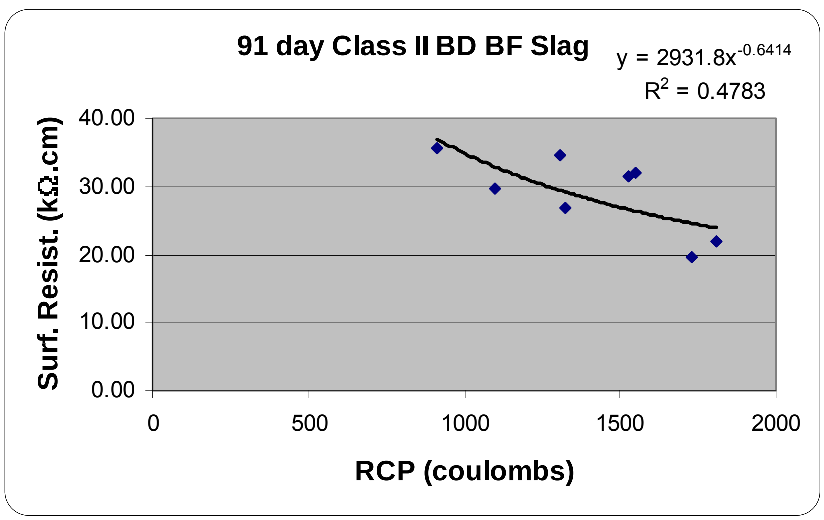

Figure 4.15 Correlation between Test Results of RCP and SR at 91-Days for Class II BD Samples with BF Slag.

Class IV

Rapid Chloride Permeability Test

Class IV samples comprise the most numerous of all Classes tested with 120 sample sets resulting in collectable data. The average results for all of the Class IV samples grouped together for the 28-day test was 2948 coulombs and for the 91-day test was 1572 coulombs. This is for all 120 sample sets before separating into the different pozzolanic categories. Their standard deviations in this configuration were 1623 coulombs at 28 days and 483 coulombs at 91 days.

There are just barely enough sample sets in each pozzolanic category to report on every one. Refer to Table 4.8 for complete data on all Class IV samples. Those samples with Fly Ash numbered 33 at the 28-day test with an average of 4886 coulombs and a standard deviation of 1837. At 91 days the sample quantity was also 33 with an average of 1823 coulombs and a standard deviation of 634.

The Blast Furnace Slag division was the largest sub-category within the Class IV samples. Its numbers at the 28-day test were 77 with an average of 2183 coulombs and a standard deviation of 643. Likewise the 91-day test had a population of 77 sample sets with an average of 1474 coulombs and a standard deviation of 383 to their credit. The Blast Furnace Slag samples display lower values at both test days and therefore have a more desirable performance than the Fly Ash samples. In addition the pattern of showing lower test results at the 91-day date is supported here as well. The data in this set in particular is quite stable though, due to the large number of samples.

Table 4.8 RCP and Surface Resistivity Test Result of Class IV Concrete Samples.
(RCP in coulomb, Resistivity in kΩ.cm)

	RCP		Surface Resistivity		
	28 Day	91 Day	28 Day	91 Day	
# Samples	120	119	121	119	# Samples
Average	2948	1572	19.0	28.8	Average
Maximum	8403	3503	49.8	115.6	Maximum
Minimum	735	425	5.5	12.0	Minimum
Std. Dev.	1623	485	7.7	13.4	Std. Dev.
Median	2413	1529	18.7	25.7	Median
FLY ASH ONLY					
# Samples	33	33	32	32	# Samples
Average	4886	1823	11.8	25.3	Average
Maximum	8403	3503	31.2	59.1	Maximum
Minimum	1301	615	5.5	14.5	Minimum
Std. Dev.	1837	634	5.4	11.0	Std. Dev.
Median	4597	1929	10.1	21.4	Median
BLAST FURNACE SLAG ONLY					
# Samples	77	77	79	78	# Samples
Average	2183	1474	22.1	30.3	Average
Maximum	4232	2277	49.8	115.6	Maximum
Minimum	735	425	12.3	12.0	Minimum
Std. Dev.	643	383	6.7	14.7	Std. Dev.
Median	2184	1472	20.5	27.4	Median
SILICA FUME WITH FLY ASH					
# Samples	10	10	10	10	# Samples
Average	1819	1101	27.4	50.7	Average
Maximum	3538	1653	49.8	115.6	Maximum
Minimum	735	425	13.5	23.9	Minimum
Std. Dev.	884	461	13.5	30.9	Std. Dev.
Median	1998	1206	19.3	32.7	Median

Class IV samples containing any amount of Silica Fume also performed well in the RCP test. There were 10 such sample sets tested at both test dates. At 28 days their average was 1819 coulombs and at 91 days it was 1101 coulombs. Their standard deviations were 884 and 461, respectively. As a general rule, samples containing Silica Fume as a partial cement replacement perform well in the RCP test. These results tend not to challenge this notion.

Surface Resistivity

All of the Surface Resistivity values for the Class IV samples conform to support the same conclusions as the RCP testing. As a group, the average reading at 28 days was 19.0 kΩ.cm and at 91 days was 28.8 Ωwith standard deviations of 7.7 and 13.4 kΩ.cm, respectively.

The results of the Fly Ash samples were averaged at 11.8 kΩ.cm at 28 days but up to 25.3 kΩ.cm by the 91-day test. Their respective standard deviations were 5.4 and 11.0 kΩ.cm.

The samples with Blast Furnace Slag also show the same disposition, as did the RCP results. The 28-day testing average was 22.1 kΩ.cm with a standard deviation of 6.7 and the 91-day average was 30.3 kΩ.cm while its standard deviation was 14.7 kΩ.cm. Here again, the samples with Blast Furnace Slag perform better than those with Fly Ash.

Samples having Silica Fume performed in a way such as to be concurrent with the RCP test also. The average 28-day yield was 27.4 kΩ.cm and at 91 days was 50.7 kΩ.cm. Their standard deviations were 13.5 and 30.9 kΩ.cm, respectively for the two testing dates. Compared with the other sub-classifications within Class IV, these values are indeed higher. This fact gives credence to statement that Silica Fume improves sample performance in this test as well as the RCP test.

There is one thing to take in account when comparing specifically the Fly Ash samples with the other sub-category's samples, the range difference in the results of the 28 and 91-day tests for each reveals a point of interest. Fly Ash seems to take approximately two months before showing its effectiveness. Taking Class IV samples as an example, notice that the range in Fly Ash samples between 28 and 91 days goes from 4886 coulombs way down to 1823, which is a 63% reduction. In contrast, the Blast Furnace Slag sample's average only went from 2183 coulombs down to 1474 coulombs, a 32% reduction. And the Silica Fume samples went from 1819 coulombs down to 1101 coulombs, a 39% reduction. The effectiveness of the Fly Ash was delayed beyond the 28-day testing date but was in fact showing its benefit by the 91-day test. The data indicate that Blast Furnace Slag out performs Fly Ash and that Silica Fume out performs both Blast Furnace Slag and Fly Ash. However it is the difference in the ranges that draws attention to the fact that Fly Ash requires a time lag before it activates and becomes effective.

Correlation between RCP and Surface Resistivity

Correlation between the Rapid Chloride Permeability test and the Surface Resistivity test in Class IV samples is similar to that of the rest of the project. As can be seen in Figures 4.16 and 4.17, all of Class IV RCP test results correlate well with Surface Resistivity test results with an R^2 value of 0.9306 at 28 days but falls to 0.8708 for the 91-day test. The associated correlation coefficients are –0.965 and –0.933, respectively, and both are significant at the 95% level of confidence.

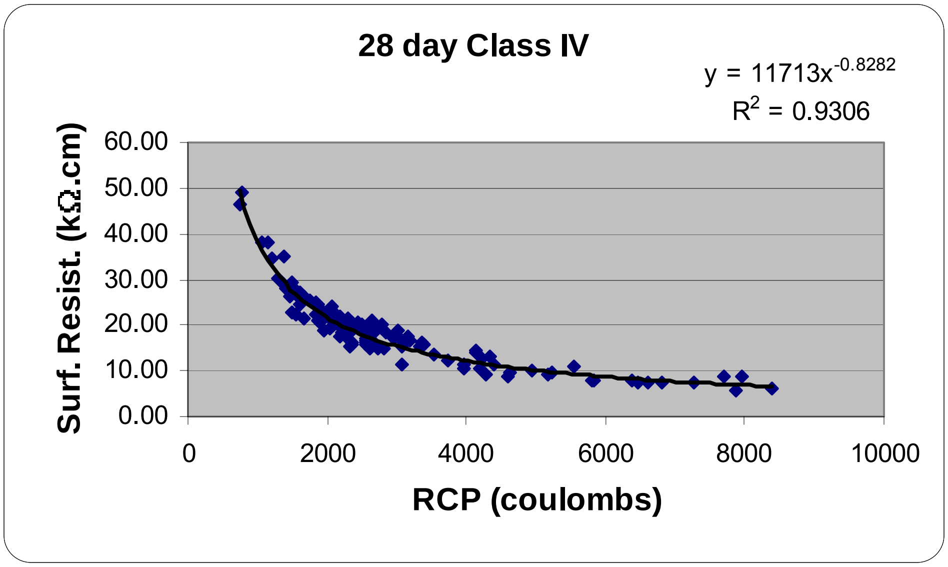

Figure 4.16 Correlation between RCP and SR at 28-Days - Class IV Samples.

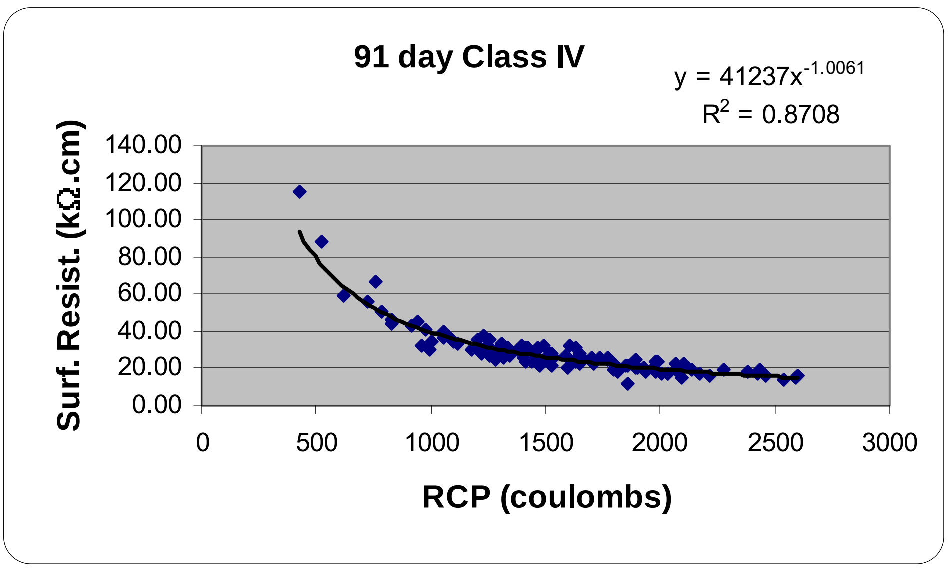

Figure 4.17 Correlation between RCP and SR at 91-Days - Class IV Samples.

Samples containing Fly Ash do not correlate quite as closely. This could be due to the smaller number of samples however the same is true of the Blast Furnace Slag samples. Analyses of the Fly Ash samples yield an R^2 value of 0.8853 with a corresponding 91 day R^2 value of 0.9115. These are expressed graphically in Figures

4.18 and 4.19. The associated correlation coefficients are –0.941 and –0.955, respectively, and are both significant at the 95% level of confidence.

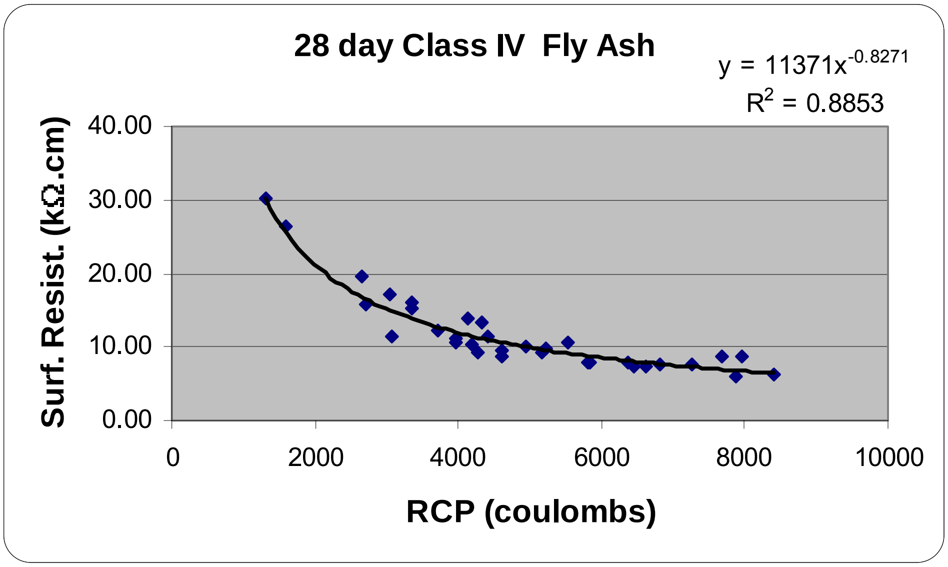

Figure 4.18 Correlation between RCP and SR at 28-Days - Class IV FA.

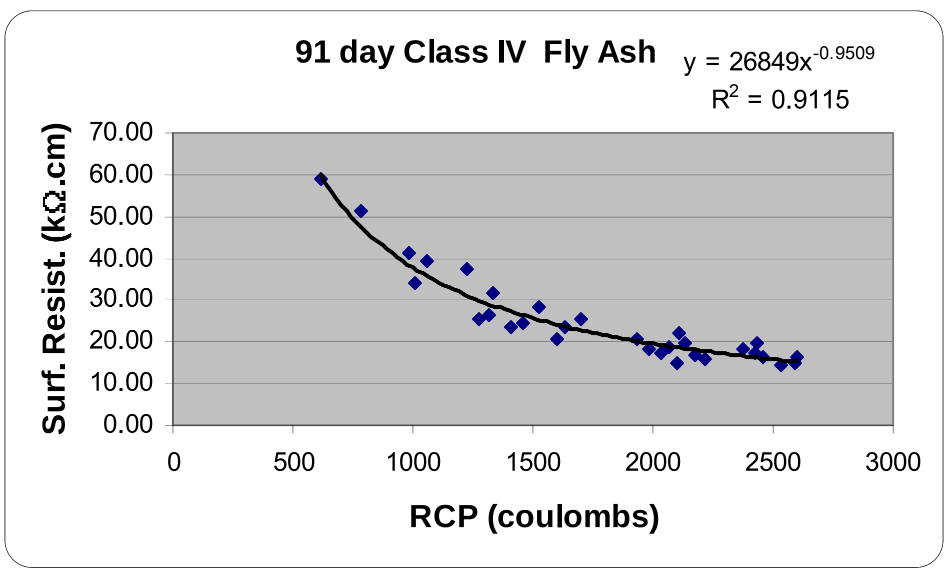

Figure 4.19 Correlation between RCP and SR at 91-Days - Class IV FA.

Blast Furnace Slag data showed an R^2 value at 28 days to be 0.8603 and at 91 days to be 0.8562. Each is shown here in Figure 4.20 and 4.21. Both associated correlation coefficients are significant at the 95% level of confidence.

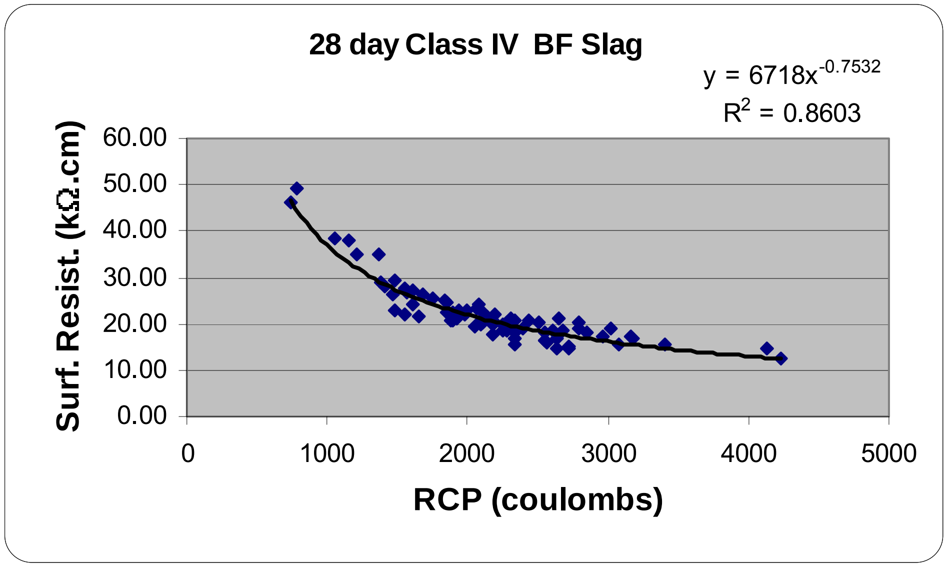

Figure 4.20 Correlation between RCP and SR at 28-Days - Class IV Slag.

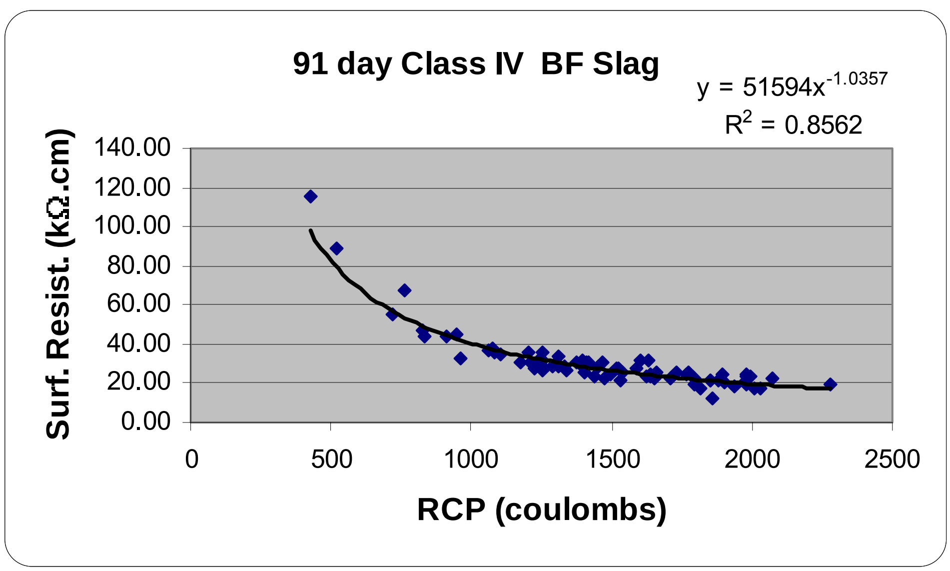

Figure 4.21 Correlation between RCP and SR at 91-Days - Class IV Slag.

Next come those samples containing any amount of Silica Fume. Although these samples are not strong in number (there are only 10) they correlate strongly with an R^2 value of 0.9674 at 28 days and 0.9649 at 91. These relationships are shown in Figures 4.22 and 4.23. In both cases the correlation coefficient is significant at the 95% level of confidence.

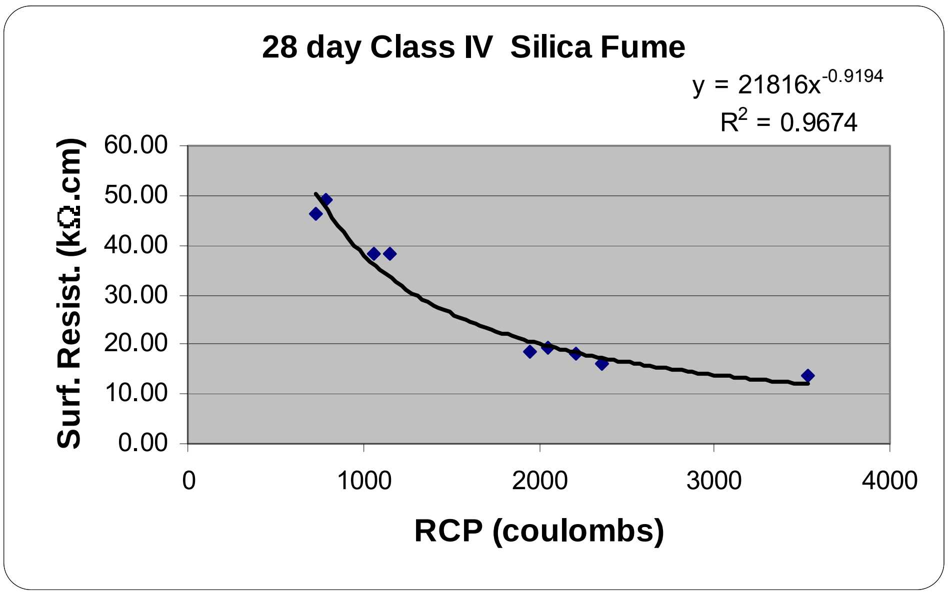

Figure 4.22 Correlation between RCP and SR at 28- Days - Class IV Silica Fume.

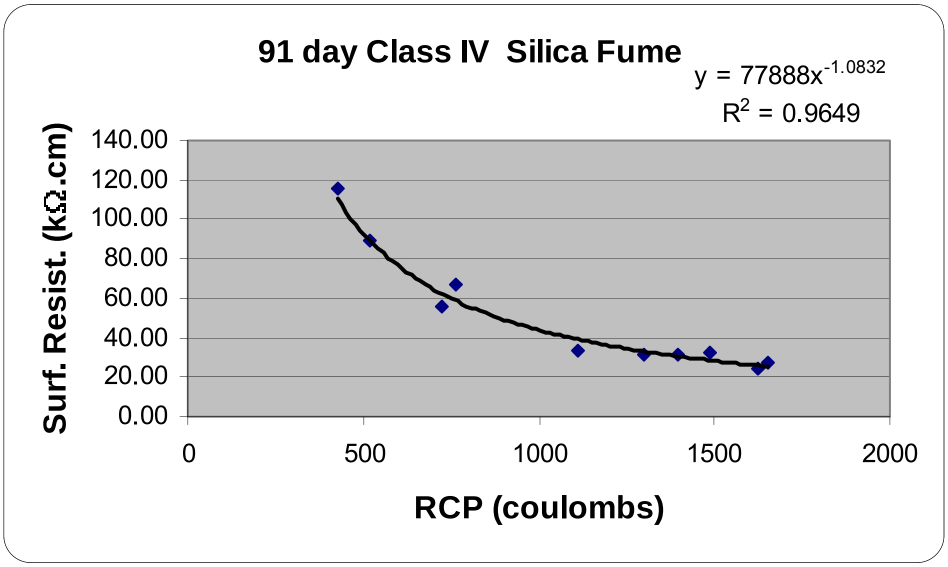

Figure 4.23 Correlation between RCP and SR at 91-Days - Class IV Silica Fume.

Class IV Drilled Shaft

Rapid Chloride Permeability Test

Samples sets of Class IV Drilled Shaft numbered 68 at 28 and 91 days. The average RCP value forged at the 28-day test was 3173 coulombs with a standard deviation of 2736 coulombs. At the 91-day test the average was 1490 coulombs with a standard deviation of 527 coulombs. All of the Class IV data has a profile concurrent with the rest of the classes as can be assessed in Table 4.9.

Table 4.9 RCP and Surface Resistivity Test Result of Class IV DS Concrete Samples.

	RCP		Surface Resistivity		
	28 Day	91 Day	28 Day	91 Day	
# Samples	68	67	68	68	# Samples
Average	3173	1490	19.3	28.4	Average
Maximum	18239	3103	49.1	91.7	Maximum
Minimum	936	465	4.5	12.7	Minimum
Std. Dev.	2736	527	7.6	10.4	Std. Dev.
Median	2004	1362	21.3	27.5	Median
FLY ASH ONLY					
# Samples	18	16	18	17	# Samples
Average	6645	1907	9.3	23.3	Average
Maximum	18239	3103	13.8	45.3	Maximum
Minimum	3323	883	4.5	12.7	Minimum
Std. Dev.	3384	780	2.6	9.4	Std. Dev.
Median	5504	1558	9.6	22.1	Median
BLAST FURNACE SLAG ONLY					
# Samples	48	49	48	49	# Samples
Average	1935	1367	22.7	29.9	Average
Maximum	3885	2466	49.1	91.7	Maximum
Minimum	936	465	9.0	15.4	Minimum
Std. Dev.	503	338	4.9	10.4	Std. Dev.
Median	1771	1336	22.3	28.4	Median

(RCP in coulombs, Resistivity in kΩ.cm)

Samples containing Fly Ash had an average of 6645 coulombs at 28 days and a standard deviation of 3384 coulombs. Then reduces down to 1907 coulombs with a standard deviation of 780 for the 91-day test date.

The Blast Furnace Slag samples on the other hand begin at 1935 coulombs average 28 day RCP value and inch down to 1367 at 91 days. Their standard deviations were 503 and 338 coulombs, respectively. These values show that Blast Furnace Slag samples out perform the Fly Ash samples in testing.

Surface Resistivity Test

Results of Surface Resistivity testing of Class IV Drilled Shaft samples proport to engage the previous relationships hereby discussed in this report. At 28 days the average reading taken was 19.3 kΩ.cm with a standard deviation of 7.6 kΩ.cm. At 91 days the average increased to 28.4 kΩ.cm with a standard deviation of 10.4 kΩ.cm.

The samples with Fly Ash averaged 9.3 kΩ.cm at 28 days and were up to 23.3 kΩ.cm by 91 days. Their respective standard deviations were 2.6 and 9.4 kΩ.cm.

The Blast Furnace Slag samples on the other hand debuted with an average of 22.7 kΩ.cm at 28 days and climbed to 29.9 kΩ.cm at 91 days. Standard deviations for the Blast Furnace Slag samples were 4.9 kΩ.cm at the 28-day test and 10.4 kΩ.cm at the 91-day test. The performance of the Blast Furnace Slag samples bests the performance of the Fly Ash samples in this test.

Correlation between RCP and Surface Resistivity Test Results

The correlation of Class IV Drilled Shaft samples between the two tests agrees with the previous classes. The 28-day tests correlate closely with an R^2 value of 0.948. However the 91-day R^2 value diminishes to 0.6860. Figures 4.24 and 4.25 show this data graphically. The 28-day correlation coefficient is –0.974 and that for the 91-day sample is –0.828. Both are significant at the 95% level of confidence.

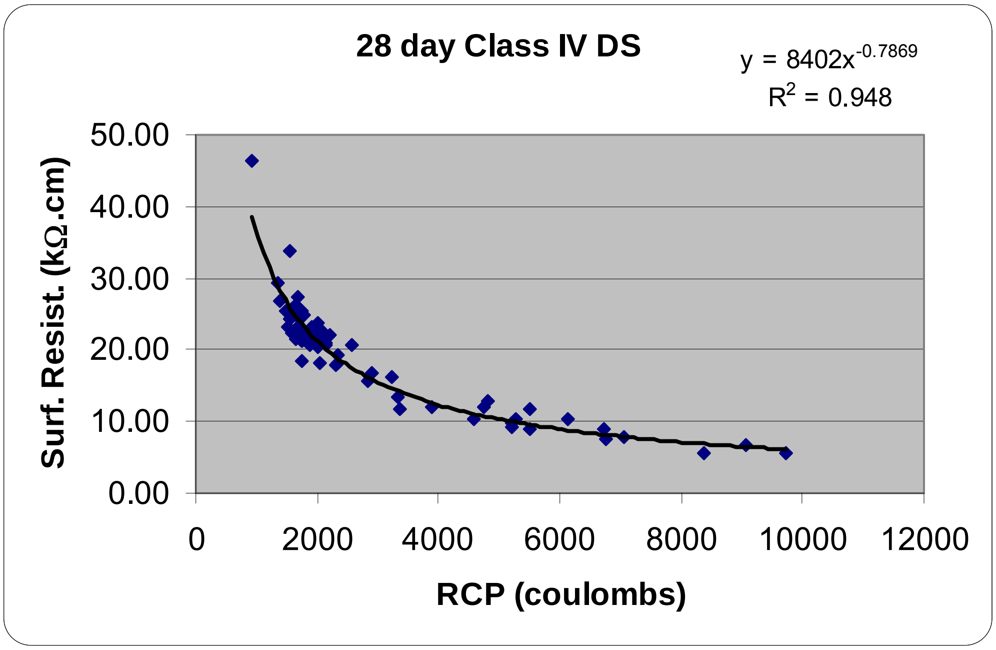

Figure 4.24 Correlation between RCP and SR at 28-Days - Class IV DS.

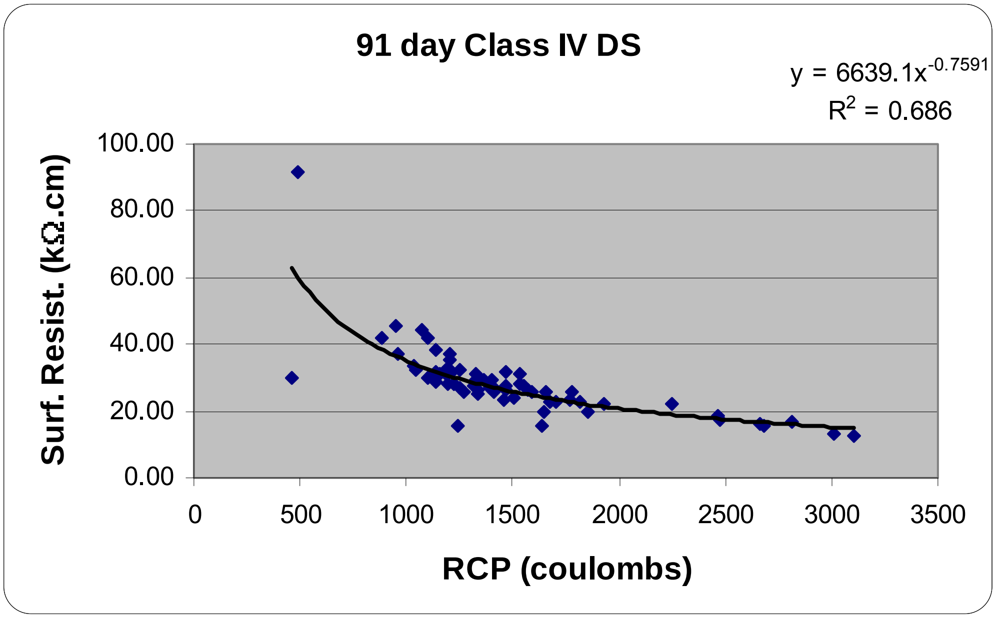

Figure 4.25 Correlation between RCP and SR at 91-Days - Class IV DS.

The Fly Ash tests correlate with an R^2 value of 0.788 at the 28-day test and 0.7279 at the 91-day test. As can be seen here in Figures 4.26 and 4.27. The associated correlation coefficients of –0.888 and –0.853, respectively, are both significant at the 95% level of confidence.

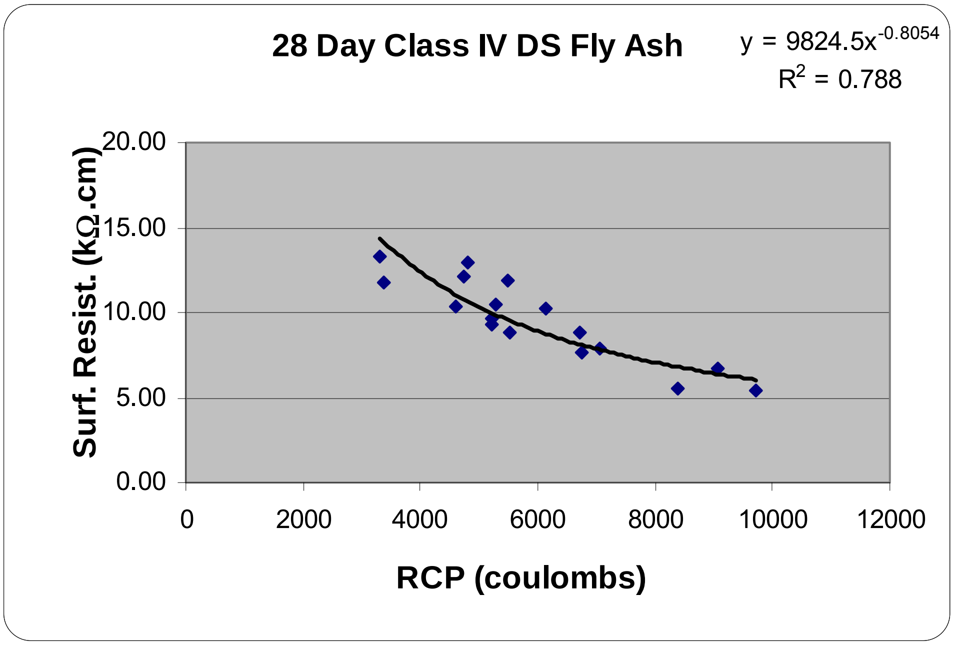

Figure 4.26 Correlation between RCP and SR at 28-Days - Class IV DS FA.

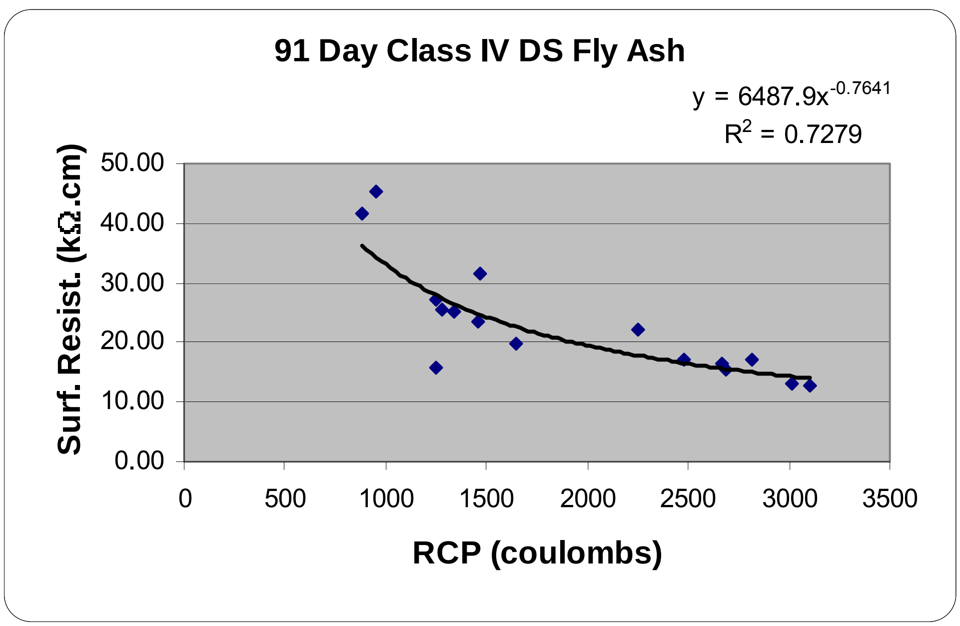

Figure 4.27 Correlation between RCP and SR at 91-Days - Class IV DS FA.

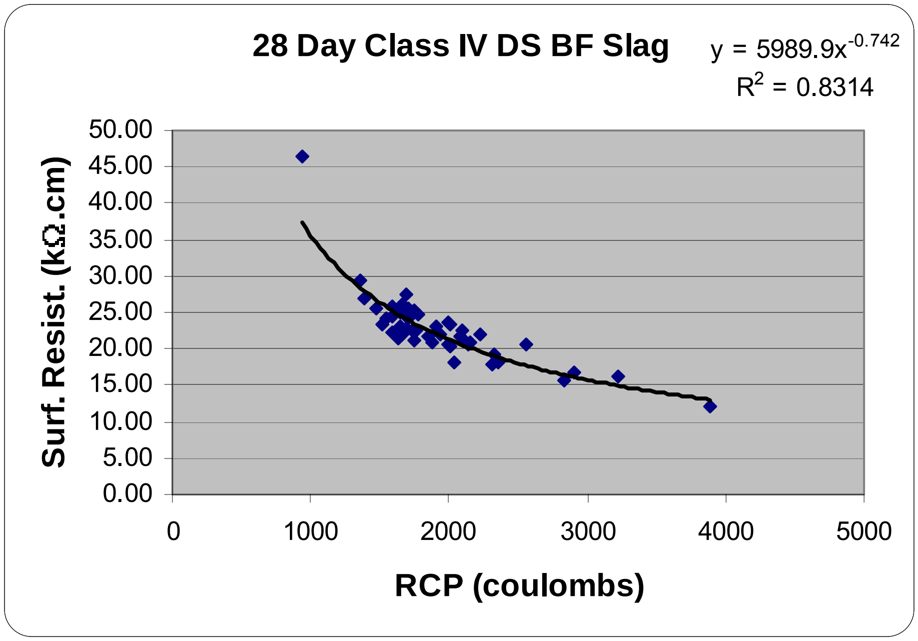

Figure 4.28 Correlation between RCP and SR at 28-Days - Class IV DS Slag.

Blast Furnace Slag sample correlation also suffers a lower R^2 value at the two testing dates. The explained variation at the 28-day test was 0.8314 but decreased to 0.5837 for the 91-day test. Figures 4.28 and 4.29 graphically represent Blast Furnace Slag relationship. Both correlation coefficients (-0.912 and –0.764, respectively) are significant at the 95% level of confidence.

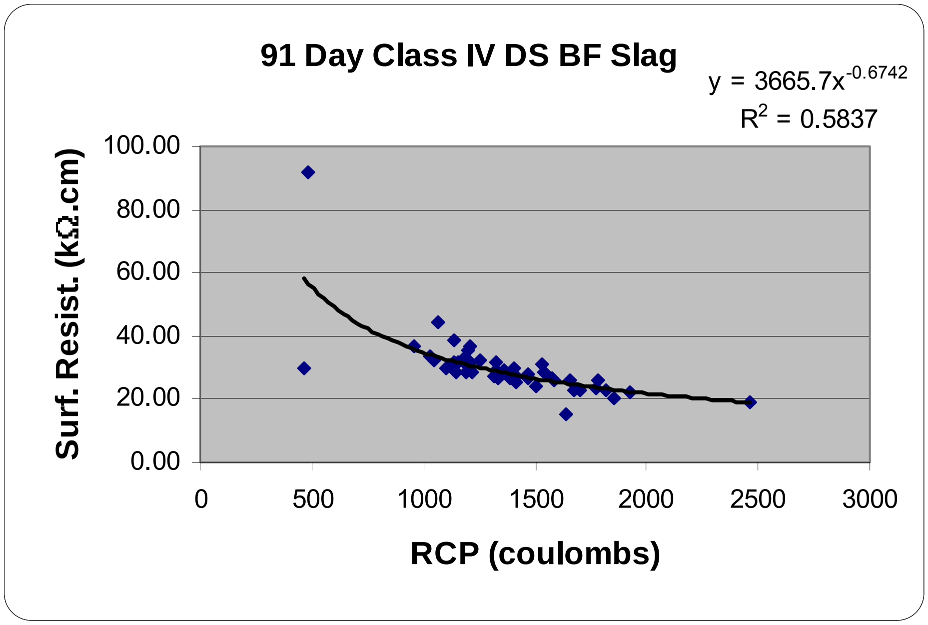

Figure 4.29 Correlation between RCP and SR at 91-Days - Class IV DS Slag.

Class V

Sample

Class V samples host the most modest number of collected and tested sample sets within this report which are presented in Table 4.10. There were only 19 samples tested.

Rapid Chloride Permeability Test

Twenty-eight day RCP results averaged 4434 coulombs with a standard deviation of 1852 coulombs. The 91-day test average was an improved 1917 coulombs with a complementary standard deviation of 984 coulombs. Sixteen of the 19 sample sets belonged to the Fly Ash sub-category. The fact that Fly Ash takes approximately two months to activate explains why there is such a large difference between the 28 day and 91 day results.

Surface Resistivity

The average 28-day test resulted in a value of 14.4 kΩ.cm and the 91-day test in 27.2 kΩ.cm. Their standard deviations were 10.9 and 25.9 kΩ.cm, respectively. These are typical of the model of improving for the 91-day test.

Table 4.10 RCP and Surface Resistivity Test Result of Class V Concrete Samples.

	RCP			Surface Resistivity		
	28 Day	91 Day		28 Day	91 Day	
# Samples	18	19		19	18	# Samples
Average	4434	1917		14.4	27.2	Average
Maximum	6571	3951		45.0	110.9	Maximum
Minimum	974	302		7.4	10.4	Minimum
Std. Dev.	1852	984		10.9	25.9	Std. Dev.
Median	4984	2000		10.4	18.4	Median

(RCP in coulombs, Resistivity in kΩ.cm)

The results of the Surface Resistivity test also indicate a large improvement from the 28-day test date to the 91-day test date, a characteristic of Fly Ash samples in this project.

Correlation between RCP and Surface Resistivity Test Results

The data for Class V samples taken from the RCP and Surface Resistivity tests and correlated shows the 91-day test correlating more closely than the 28-day test. Bear in mind that there is a small quantity of Class V samples and so the results are not as reliable. Still, as can be seen in Figure 4.30 the 28-day correlation shows an R^2 value of 0.9591. The 91-day R^2 value increases to 0.9787as can be seen in Figure 4.31, indicating a closer correlation than the 28-day test. Both correlation coefficients are significant at the 95% level of confidence.

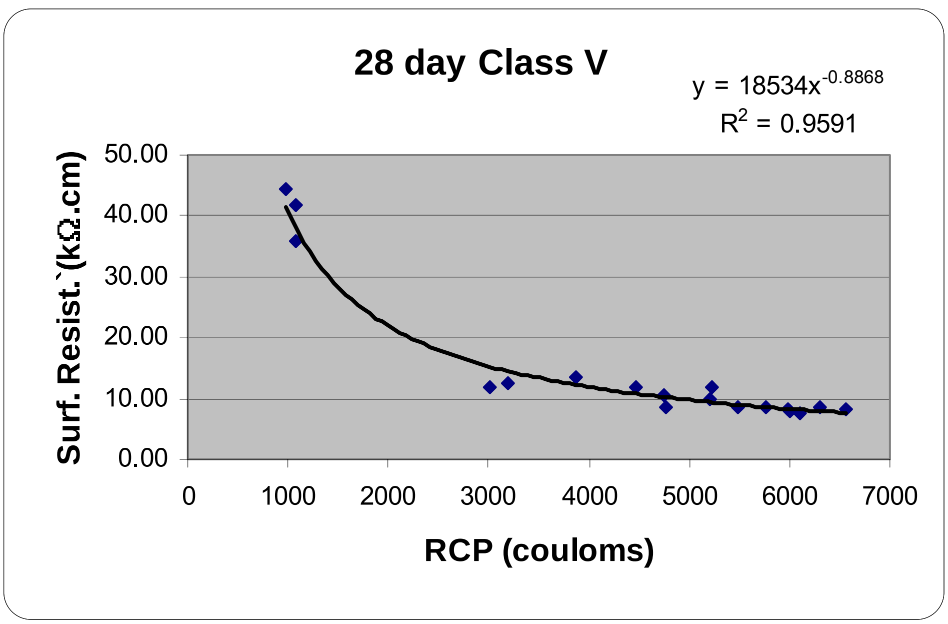

Figure 4.30 Correlation between RCP and SR at 28-Days - Class V Samples.

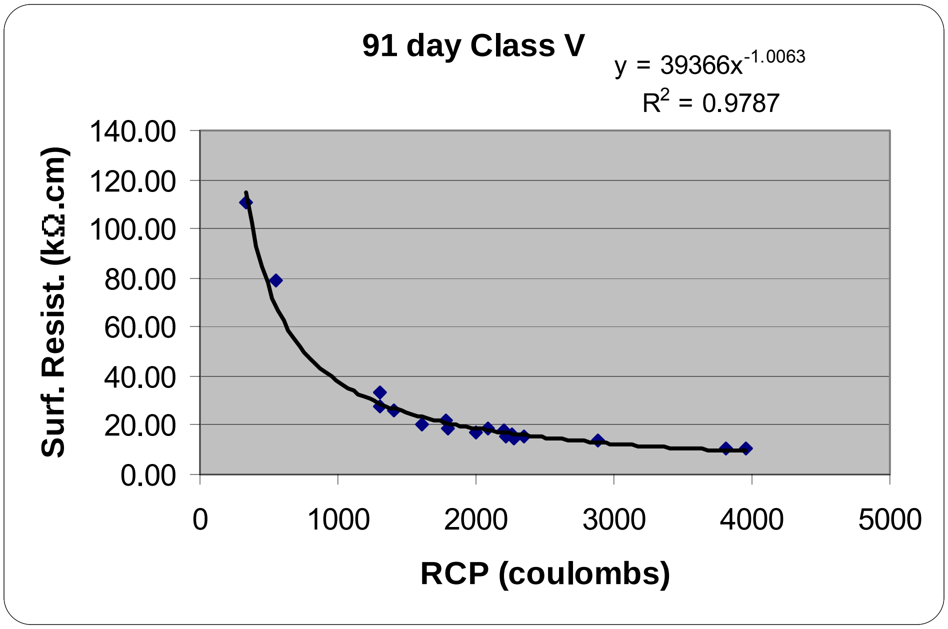

Figure 4.31 Correlation between RCP and SR at 91-Days - Class V Samples.

Class V Special

Rapid Chloride Permeability Test

Class V Specials had a good showing with 95 samples sets tested at the 28-day mark and 72 at 91 days. RCP test averages for the group as a whole were 3602 coulombs at 28 days and 1524 at 91. Their respective standard deviations were 1971 and 823 coulombs. Most of these samples contained Fly Ash. The 28-day testing average for Fly Ash samples was 4998 coulombs with a standard deviation of 1071 coulombs. The 91-day testing average was 2106 coulombs with a standard deviation of 542 coulombs. Again, a difference was observed in the Fly Ash sample results between the 28 and 91-day testing dates. Class V Special testing results are presented in Table 4.11, below.

The other category of pozzolanic material reportable in Class V Special was Silica Fume. The 28-day average result was 1376 coulombs with a standard deviation of 628 coulombs. The 91-day test averaged was an improved 709 coulombs with a complementary standard deviation of 258 coulombs. By this data Silica Fume demonstrates that it is better than all other pozzolans in its performance in the RCP test.

Surface Resistivity

The Surface Resistivity test results for the Class V Special concrete samples uphold the precedents already outlined by the previous concrete classes. The average reading at 28 days was 17.9 kΩ.cm with a standard deviation of 11.4 kΩ.cm. For the 91-day tests the average was 37.1 kΩ.cm and its standard deviation was 22.6 kΩ.cm.

The Fly Ash samples reflect this also due to the fact that most of the samples in Class V Special had Fly Ash in them. The average test for the Fly Ash-only samples at

28 days was 9.9 kΩ.cm with a standard deviation of 2.6. The 91-day average was 20.4 kΩ.cm with a standard deviation of 6.7 kΩ.cm.

The Silica Fume sample results averaged at 28 days to be 30.0 kΩ.cm with a standard deviation of 8.8 kΩ.cm and at 91 days averaged 57.0 kΩ.cm with a standard deviation of 18.2 kΩ.cm. Both support the RCP test results in that samples with Silica Fume out performed all other samples with other pozzolanic additives.

Table 4.11 RCP and Surface Resistivity Test Result of Class V S Concrete Samples.

	RCP		Surface Resistivity		
	28 Day	91 Day	28 Day	91 Day	
# Samples	95	72	96	71	# Samples
Average	3602	1524	17.9	37.1	Average
Maximum	7366	3072	48.7	92.7	Maximum
Minimum	721	403	5.7	12.6	Minimum
Std. Dev.	1971	823	11.4	22.6	Std. Dev.
Median	4184	1450	11.9	29.7	Median
FLY ASH ONLY					
# Samples	55	42	54	38	# Samples
Average	4998	2106	9.9	20.4	Average
Maximum	7366	3072	17.3	38.4	Maximum
Minimum	2549	1055	5.7	12.6	Minimum
Std. Dev.	1071	542	2.6	6.7	Std. Dev.
Median	5155	2217	9.1	17.7	Median
SILICA FUME WITH FLY ASH					
# Samples	36	30	38	33	# Samples
Average	1376	709	30.0	57.0	Average
Maximum	3520	1226	48.7	92.7	Maximum
Minimum	721	403	10.9	22.9	Minimum
Std. Dev.	628	258	8.8	18.2	Std. Dev.
Median	1160	598	28.6	61.2	Median

(RCP in coulomb, Resistivity in kΩ.cm)

Correlation between RCP and Surface Resistivity Test Results

The data for Class V Special samples conform to the findings of other concrete classes. This result is displayed in Figure 4.32 for the 28-day testing and in Figure 4.33 for the 91-day testing. The R^2 value evaluating the correlation at 28 days is 0.9726. The 91-day correlation value is R^2 equals 0.9583.

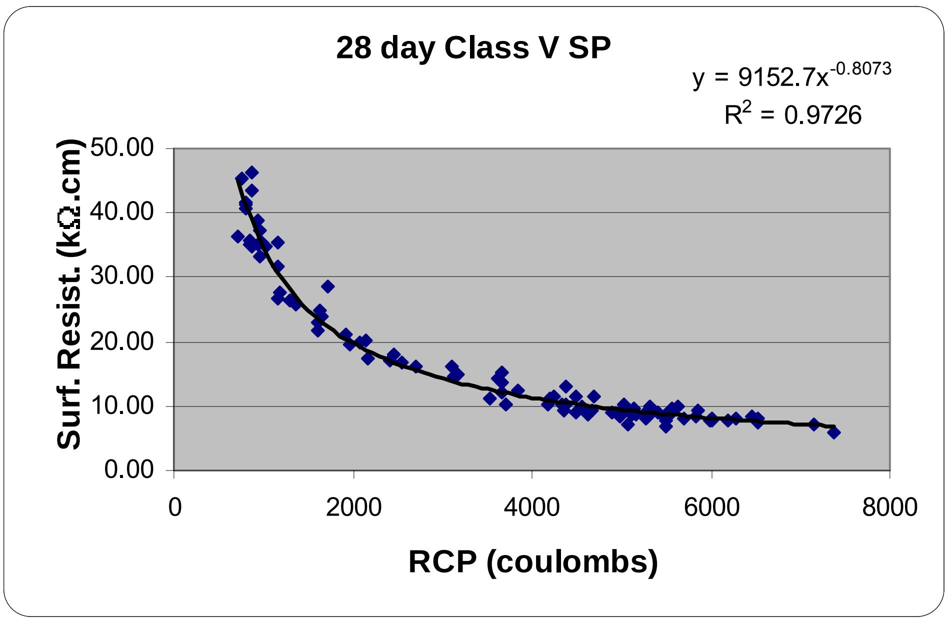

Figure 4.32 Correlation between RCP and SR at 28-Days - Class V Special.

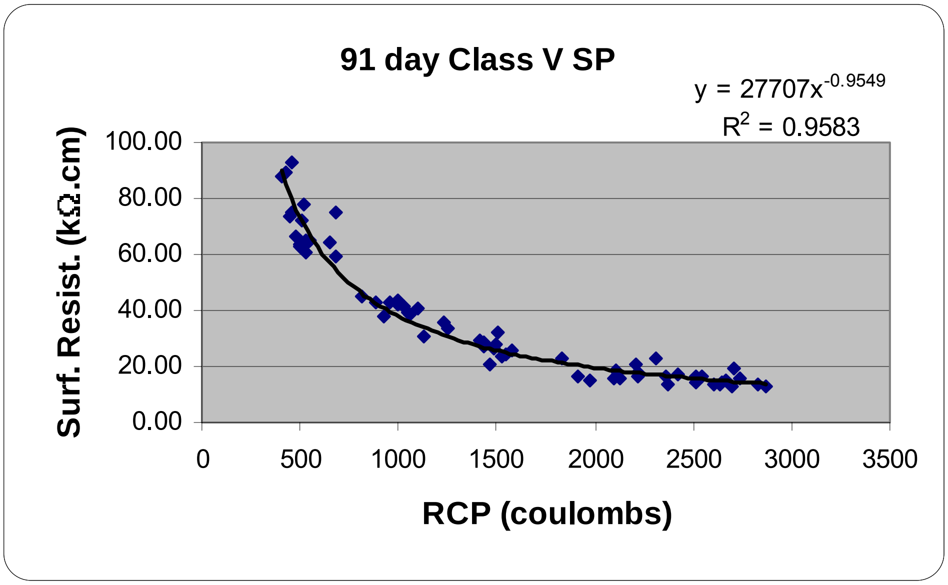

Figure 4.33 Correlation between RCP and SR at 91-Days - Class V Special.

The correlations for the Fly Ash samples diminish at the 28-day test with an R^2 value of 0.8318, as does the 91-day R^2 value of 0.8240, shown below in Figures 4.34 and 4.35.

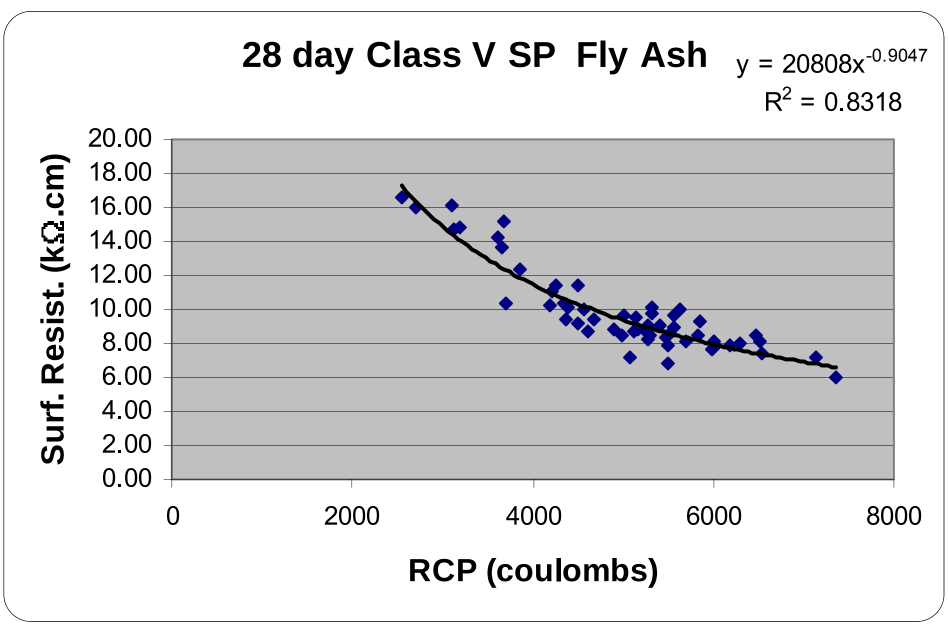

Figure 4.34 Correlation between RCP and SR at 28-Days - Class V Special FA.

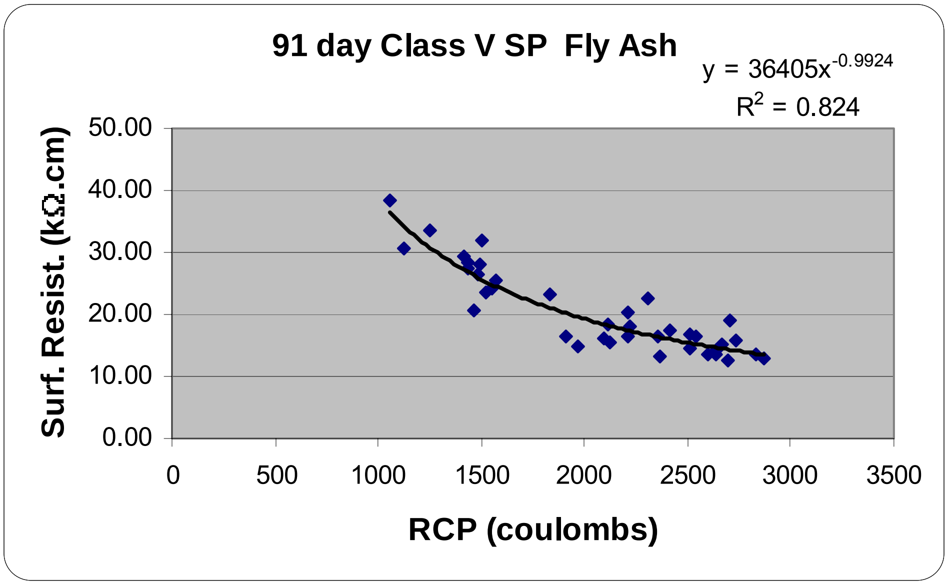

Figure 4.35 Correlation between RCP and SR at 91-Days - Class V Special FA.

The samples with Silica Fume also decline in correlation value from the Class V Special as a whole group. At 28 days it can be seen in Figure 4.36 that the R^2 value is 0.9208. This declines to a 91-day value of R^2 equals 0.8705 shown here in Figure 4.37.

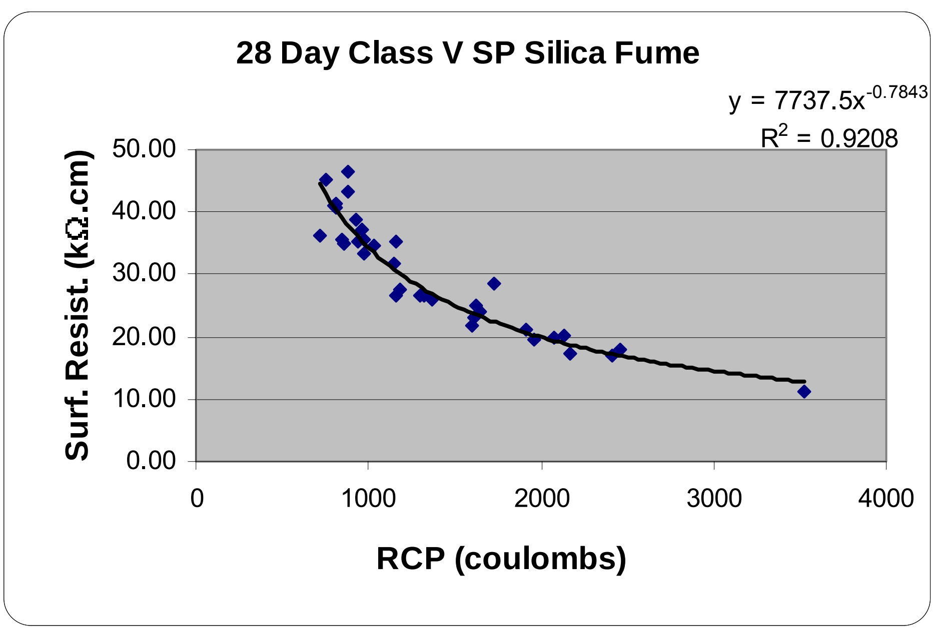

Figure 4.36 Correlation between RCP and SR at 28-Days - Class VS Silica Fume.

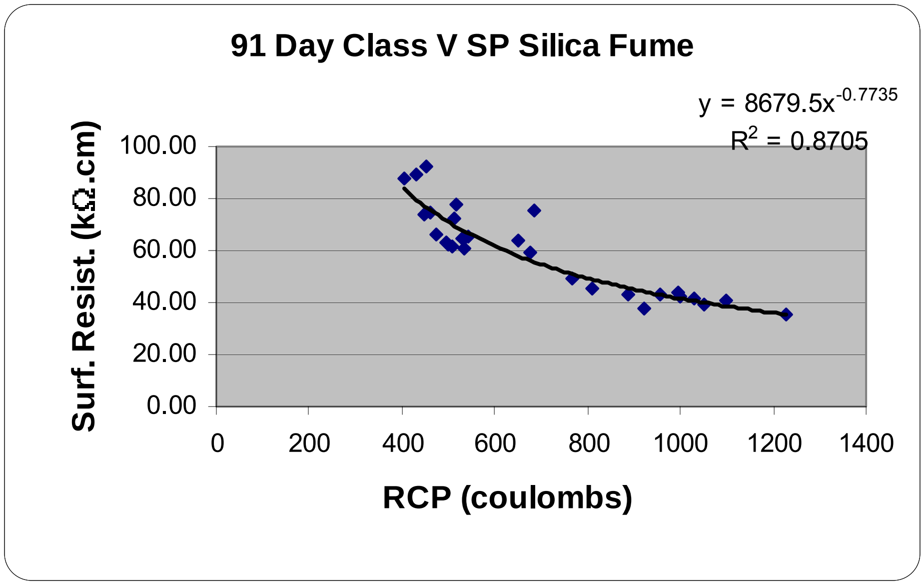

Figure 4.37 Correlation between RCP and SR at 91-Days - Class VS Silica Fume.

Class VI

Rapid Chloride Permeability Test

Class VI concrete samples are the last in which to discuss. This class holds no surprises and proves to support the trends hereby proposed. There were 53 sample sets collected and successfully tested at the 28-day mark. Their average was 3679 coulombs and their standard deviation was 938 coulombs. The 91-day test data average was 1606 coulombs with a standard deviation of 603 coulombs.

Nearly all of the Class VI samples contained Fly Ash and so the figures for that category are very similar. Therefore only the general category figures are shown in Table 4.12.

Surface Resistivity

The results of the Surface Resistivity readings are directly in line with the RCP test findings. With the same configuration of samples, the 28-day test average was 12.5 kΩ.cm and the 91-day average was 25.6 kΩ.cm. The standard deviations for the two dates were 3.1 and 9.1 kΩ.cm, respectively.

Table 4.12 RCP and Surface Resistivity Test Result of Class VI Concrete Samples.

	RCP		Surface Resistivity		
	28 Day	91 Day	28 Day	91 Day	
# Samples	53	52	54	49	# Samples
Average	3679	1606	12.5	25.6	Average
Maximum	5938	3894	28.1	63.8	Maximum
Minimum	1050	598	7.9	10.4	Minimum
Std. Dev.	938	603	3.1	9.1	Std. Dev.
Median	3498	1481	12.1	24.2	Median

(RCP in coulombs, Resistivity in kΩ.cm)

Correlation between RCP and Surface Resistivity Test Results

The Class VI samples behave differently than the other concrete classes discussed thus far. The 28-day test results correlate poorly with an R^2 value of 0.6412. The Class VI samples however proceed to increase the closeness of correlation at the 91-day test with an R^2 value of 0.8880. Figures 4.38 and 4.39 present this data graphically.

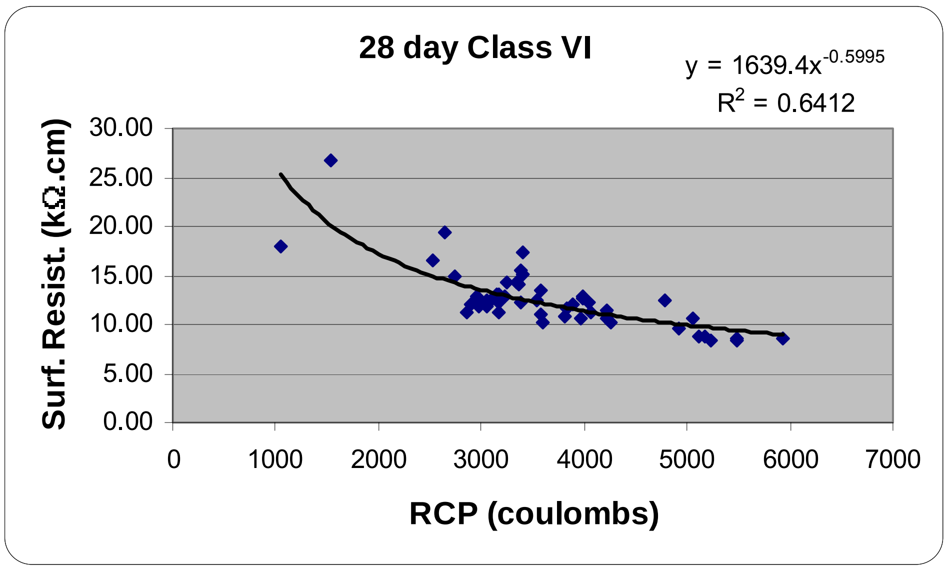

Figure 4.38 Correlation between RCP and SR at 28-Days - Class VI Samples.

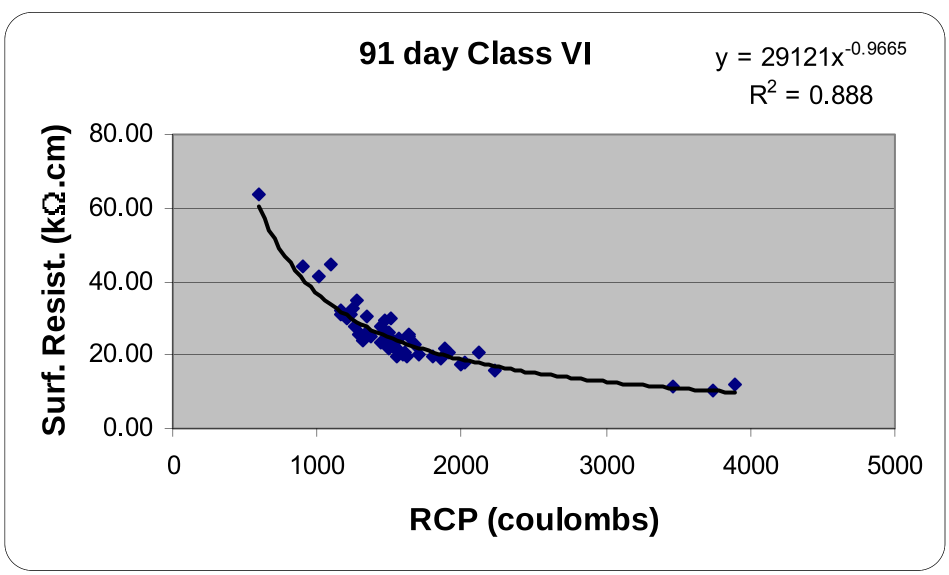

Figure 4.39 Correlation between RCP and SR at 91-Days - Class VI Samples.

Comparing Results from Two Laboratories

To demonstrate the fact that this testing is repeatable with some degree of accuracy, another FDOT laboratory in Lake City was commissioned in the beginning of the project to test more than 100 sample sets identical to those tested at the SMO. This means that on the jobsite where sampling took place, six cylinders were cast at the same time of the same concrete batch. Three of these were subsequently sent to the SMO in Gainesville while the other three went to Lake City for testing. The results of the tests were later correlated to determine reliability of this testing procedure. Table 4.13 reveals all corresponding statistical data on the sample sets common to the two facilities.

In this case, rather than relying on the R^2 value to indicate correlation, the y-intercept will be the tool of choice. Instead of the need to determine a relationship between two data sets, as was the objective in correlating the RCP test with the Surface Resistivity test, in the investigation of the two laboratory results, it is equivalency which is sought. If equal values were graphed in the cartesian plane, the slope of a line drawn through them would be 45°. Likewise, using the equation

$$y = mx$$

when m is equal to 1, the inverse tangent of x will yield a line of 45° slope and therefore indicate the equivalency of x and y values. As m approaches 1 the closer to being equivalent two data sets are. The lab results are graphed in Figure 4.40. From the equation it is seen that m = 0.9926. The two sets of data are nearly identical.

Table 4.13 Comparing Statistical Results of RCP test from Two Laboratories.

Results for Common 28 Day Testing		
	State Materials Office	Lake City Lab
Number of samples	104	104
Average	4094	4139
Maximum	9830	9180
Minimum	1070	1100
Std. Dev.	2143	2247
Median	3160	3080

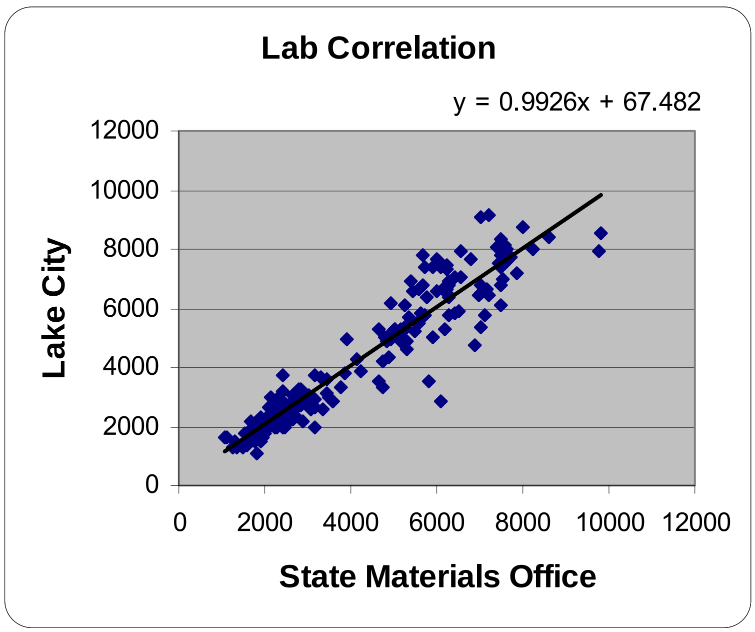

Figure 4.40 Correlating Test Results of Two Laboratories.

RCP Test Results using Alternative Methods to Seal Samples

There were two suggestions made to replace the epoxy step in the sample preparation. One was to use ordinary duct tape and the other was to use a Permatex® product available at NAPA Auto Parts stores intended for stopping leaks on automobile engines.

Spray Alternative to Seal RCP Samples

The Permatex® product is named "Form-A-Seal® 'Leak Repair'" and is applied by spraying. It takes only about one hour to dry and can be applied before or after cutting however before cutting ensures that none of the sealant gets on the testing surfaces. The spray goes on and dries clear and nearly undetectable, is durable and has excellent adhering properties for the silicone. There was no problem with the samples leaking during the testing procedures and the desiccation cycle seemed not to disturb the product.

Thirty samples were tested, cut from the remaining useless pieces of 91 day A and B samples. These were compared to the actual A and B samples run for official testing which of course had applied around their circumference the traditional epoxy. When graphed, a perfect correlation would yield a trend line of angle equal to 45°. The graph for this spray alternative's line finds its angle to be 43° as can be seen in Figure 4.41.

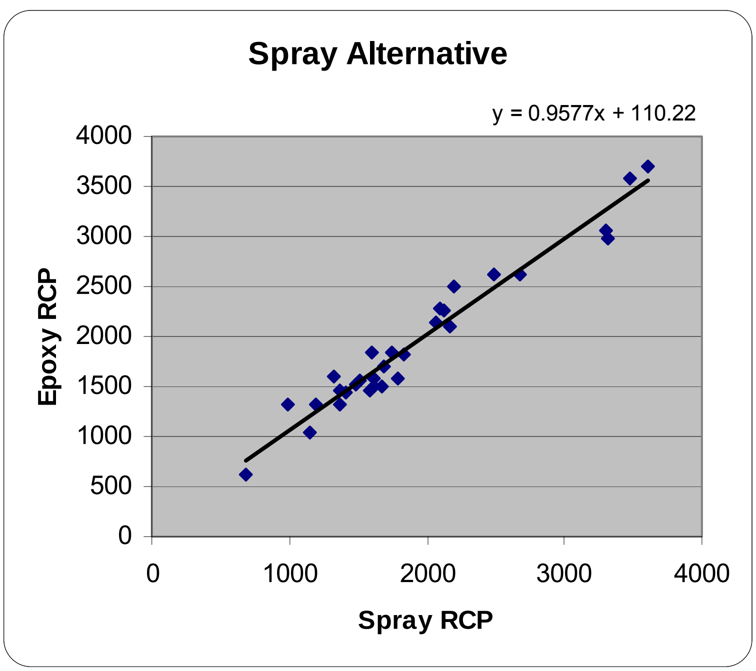

Figure 4.41 Correlation between RCP Test Results using Spray and Epoxy Methods of Sealing Samples.

Tape Alternative to Seal RCP Samples

The second suggestion for an alternative to the epoxy step was to utilize every day run-of-the-mill duct tape. Duct tape seemed a perfect solution due to its widespread use and availability. Also duct tape conveniently comes in 2-inch wide rolls, exactly the width required for the test samples. The tape was applied around the circumference of the sample after desiccation immediately prior to siliconing them into the test cells. An overlap of approximately one inch resolved the possibility of leakage from the seam of the tape. However the properties of the exterior of the duct tape made the adhesion of the silicone difficult even when special care was taken that the tape was completely dry before application. In fact, when disassembling the testing configuration at the end of the test, after the silicone had completely cured, the silicone would pull off the tape with ease. This circumstance made the testing procedure very delicate and a higher incidence of sample leakage was observed compared with either the normal epoxy or the spray sealant discussed above. In addition, as the angular degree of the trend line was stated above to be optimal at 45°, the graph of duct tape samples tested in the same manner as was described above, their angle turned only to be 40°. This is demonstrated graphically in Figure 4.42 below.

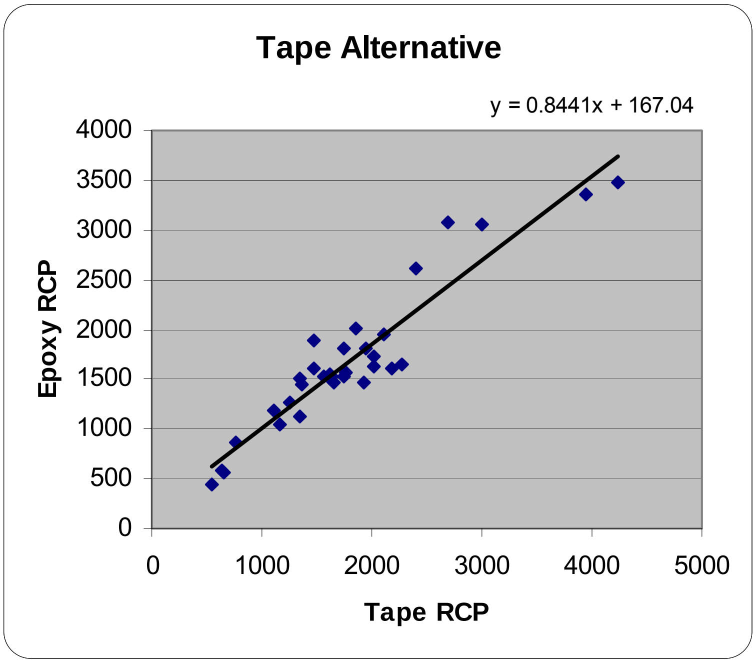

Figure 4.42 Correlation of RCP Test Results when using Tape and Epoxy Methods.

There are several other categories in which to take in account when evaluating a possible option for replacing the epoxy. The figures above show that the change in material affects the test very minimally. Table 4.14 compares the three materials in several other categories pertinent to making a judgment. Although some of the strengths and weaknesses have been discussed regarding the specific alternatives here proposed, this table allows a comprehensive comparison of the three choices and their properties.

Table 4.14 Comparing Qualities of Epoxy, Spray, and Tape Methods.

	Epoxy	Spray	Tape
Cost per Test	$1.74	$0.38	$0.03
Time:			
Labor Hours	10 min	2 min	1 min
Curing Time	8 hrs	45 min	0 min
Relationship to Current Standard	100%	96%	84%
Workability	average	good	very good
Propensity for Leaking	low	very low	high

CHAPTER 5
CONCLUSIONS

Pozzolanic content both by observation and statistical analysis proved to have the single greatest effect on the sample performance. Between Fly Ash and Blast Furnace Slag as pozzolanic materials, Blast Furnace Slag concrete performed better. However Silica Fume concrete out performed all other categories. These findings were established by the results of the RCP test and supported by the results of the Surface Resistivity test.

No other characteristic seemed to have a consistent effect on RCP or Surface Resistivity results. The two most commonly quoted factors in the literature were the water / cementitious materials ratio of the mix and the mix's type of coarse aggregate. Neither of these factors affected the results consistently, or in any other way on which to make claim, positive or negative.

The project tested but one sample set containing calcium nitrite. Calcium nitrite was stated in the review of literature to cause high test results in the RCP test. However, the one sample containing calcium nitrite did not appear to produce a coulomb value in excess of the mean.

Individual Concrete Class Recommendations

It was this project's main objective to recommend maximum allowable values for the RCP test for basis of acceptance and pay by the FDOT. Several different statistical tools were employed in the determination of these recommended values. The first and most relevant to the interpretation of the tables to follow is the confidence level or level of confidence as it is sometimes referred. The confidence level is expressed as a percent and indicates the statistical probability that the next single sample tested will fall at or below (within the acceptable range) the maximum value. For example, at an 80% level of confidence, the next sample has statistically an 80% chance of satisfying the requirement of being at or below the maximum acceptable value.

The coefficient of variation is the second statistical application used. This tool is applied when comparing two different data sets evaluated at the same level of confidence (from above). The coefficient of variation will naturally increase as the confidence level increases. If the data sets are without exceeding variation, then the coefficient of variation associated with each data set will remain comparably equal to one another in value. This will indicate the reliability of the two data sets being compared.

The third item utilized in the data analysis is the Student's t-value. The Student's t is a standardized normal variable, adjusted for sample size used to aid data interpretation.

Recommended Values at Different Confidence Levels

Directly following in Tables 5.1 through 5.7 are recommended values for the different concrete classes. Maximum allowable values have been separated by their pozzolanic identity as well as provided at several different levels of confidence. When interpreting these confidence level percentages, it must be heeded that 10% of the project's samples were deleted from analysis prior to applying these formulas (as was discussed in Chapter 4) for exceeding the cap of 4000 coulombs at the 91-day test. In other words, when looking at the 80% confidence level, it will indicate that statistically 20% of future tested sets will not attain the value, however that 20% is in addition to the 10% for the entire sample set (across all concrete classes). The specific percentage varies with each class of concrete (see Table 4.5).

Table 5.1 Recommended Allowable RCP and Surface Resistivity Values for Class II.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
	# Samples: 31			# Samples: 29			# Samples: 31			# Samples: 29		
80%	9%	0.854	**5385**	7%	0.854	**2283**	10%	0.854	**12.6**	6%	0.854	**20.5**
85%	12%	1.055	**5493**	8%	1.055	**2317**	12%	1.055	**12.2**	8%	1.055	**20.2**
90%	14%	1.31	**5631**	11%	1.311	**2361**	15%	1.31	**11.8**	10%	1.311	**19.7**
95%	19%	1.697	**5840**	14%	1.699	**2427**	20%	1.697	**11.2**	13%	1.699	**19.1**
99%	30%	2.75	**6408**	22%	2.756	**2608**	32%	2.75	**9.5**	21%	2.756	**17.3**

FLY ASH ONLY												
	# Samples: 18			# Samples: 17			# Samples: 18			# Samples: 17		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	7%	0.862	**7259**	7%	0.863	**2778**	7%	0.862	**7.4**	7%	0.863	**16.5**
85%	9%	1.067	**7374**	9%	1.069	**2822**	8%	1.067	**7.2**	8%	1.069	**16.2**
90%	11%	1.330	**7521**	11%	1.333	**2878**	10%	1.330	**7.1**	10%	1.333	**15.9**
95%	14%	1.734	**7748**	14%	1.74	**2965**	13%	1.734	**6.8**	13%	1.74	**15.4**
99%	24%	2.878	**8389**	24%	2.898	**3213**	22%	2.878	**6.1**	22%	2.898	**13.8**

BLAST FURNACE SLAG ONLY												
	# Samples: 11			# Samples: 11			# Samples: 11			# Samples: 11		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	7%	0.876	**2096**	8%	0.876	**1513**	8%	0.876	**22.0**	8%	0.876	**26.7**
85%	9%	1.088	**2129**	10%	1.088	**1540**	10%	1.088	**21.5**	10%	1.088	**26.1**
90%	11%	1.363	**2171**	12%	1.363	**1575**	12%	1.363	**20.9**	13%	1.363	**25.4**
95%	14%	1.796	**2238**	16%	1.796	**1630**	16%	1.796	**20.0**	17%	1.796	**24.2**
99%	25%	3.106	**2442**	28%	3.106	**1795**	28%	3.106	**17.1**	29%	3.106	**20.6**

(RCP in coulomb, Resistivity in kΩ.cm)

Table 5.2 Recommended Allowable RCP and SR for Class II Bridge Deck.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
		# Samples: 56			# Samples: 52			# Samples: 56			# Samples: 51	
80%	5%	0.849	**5576**	4%	0.849	**2192**	7%	0.849	**11.2**	4%	0.849	**19.8**
85%	7%	1.047	**5643**	5%	1.047	**2211**	9%	1.047	**11.0**	5%	1.047	**19.6**
90%	8%	1.297	**5728**	6%	1.298	**2236**	11%	1.297	**10.7**	7%	1.298	**19.3**
95%	11%	1.673	**5855**	8%	1.675	**2272**	14%	1.673	**10.4**	8%	1.675	**18.9**
99%	17%	2.669	**6194**	12%	2.673	**2369**	22%	2.669	**9.4**	13%	2.673	**17.9**

FLY ASH ONLY

		# Samples: 43			# Samples: 40			# Samples: 43			# Samples: 40	
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	4%	0.85	**6513**	4%	0.851	**2339**	4%	0.85	**8.3**	5%	0.851	**18.1**
85%	5%	1.049	**6573**	4%	1.05	**2359**	5%	1.049	**8.2**	6%	1.05	**17.9**
90%	6%	1.302	**6650**	6%	1.303	**2383**	6%	1.302	**8.1**	7%	1.303	**17.6**
95%	8%	1.682	**6765**	7%	1.684	**2420**	8%	1.682	**8.0**	9%	1.684	**17.2**
99%	13%	2.699	**7072**	12%	2.704	**2518**	13%	2.699	**7.6**	15%	2.704	**16.2**

BLAST FURNACE SLAG ONLY

		# Samples: 12			# Samples: 11			# Samples: 12			# Samples: 10	
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	5%	0.873	**1860**	5%	0.876	**1474**	5%	0.873	**23.3**	5%	0.879	**27.1**
85%	6%	1.083	**1882**	6%	1.088	**1491**	7%	1.083	**23.0**	6%	1.093	**26.8**
90%	8%	1.356	**1909**	8%	1.363	**1513**	8%	1.356	**22.6**	8%	1.372	**26.3**
95%	10%	1.782	**1953**	10%	1.796	**1547**	11%	1.782	**22.0**	11%	1.812	**25.6**
99%	18%	3.055	**2082**	17%	3.106	**1650**	18%	3.055	**20.1**	18%	3.169	**23.3**

(RCP in coulomb, Resistivity in kΩ.cm)

Table 5.3 Recommended Allowable RCP and SR Values for Class IV.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
	# Samples: 120			# Samples: 119			# Samples: 121			# Samples: 119		
80%	4%	0.846	**3074**	2%	0.846	**1610**	3%	0.846	**18.4**	4%	0.846	**27.7**
85%	5%	1.041	**3103**	3%	1.041	**1619**	4%	1.041	**18.3**	4%	1.041	**27.5**
90%	6%	1.289	**3139**	4%	1.289	**1630**	5%	1.289	**18.1**	6%	1.289	**27.2**
95%	8%	1.659	**3194**	5%	1.659	**1646**	6%	1.659	**17.8**	7%	1.659	**26.7**
99%	13%	2.622	**3337**	7%	2.622	**1689**	10%	2.622	**17.2**	11%	2.622	**25.5**
FLY ASH ONLY												
	# Samples: 33			# Samples: 33			# Samples: 32			# Samples: 32		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	6%	0.853	**5158**	5%	0.853	**1918**	7%	0.853	**10.9**	7%	0.853	**23.6**
85%	7%	1.054	**5223**	6%	1.054	**1940**	9%	1.054	**10.8**	8%	1.054	**23.2**
90%	9%	1.308	**5304**	8%	1.308	**1968**	11%	1.308	**10.5**	10%	1.308	**22.8**
95%	11%	1.694	**5427**	10%	1.694	**2010**	14%	1.694	**10.1**	13%	1.694	**22.0**
99%	18%	2.727	**5758**	17%	2.727	**2124**	22%	2.727	**9.2**	21%	2.727	**20.0**
BLAST FURNACE SLAG ONLY												
	# Samples: 77			# Samples: 77			# Samples: 79			# Samples: 78		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	3%	0.847	**2245**	3%	0.847	**1511**	3%	0.847	**21.5**	5%	0.847	**28.9**
85%	4%	1.044	**2260**	3%	1.044	**1520**	4%	1.044	**21.3**	6%	1.044	**28.6**
90%	4%	1.293	**2278**	4%	1.293	**1530**	4%	1.293	**21.1**	7%	1.293	**28.2**
95%	6%	1.665	**2305**	5%	1.665	**1547**	6%	1.665	**20.9**	9%	1.665	**27.6**
99%	9%	2.641	**2377**	8%	2.641	**1589**	9%	2.641	**20.1**	14%	2.641	**26.0**
SILICA FUME WITH FLY ASH												
	# Samples: 10			# Samples: 10			# Samples: 10			# Samples: 10		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	14%	0.879	**2065**	12%	0.879	**1229**	14%	0.879	**23.7**	17%	0.879	**42.1**
85%	17%	1.093	**2125**	14%	1.093	**1260**	17%	1.093	**22.7**	21%	1.093	**40.0**
90%	21%	1.372	**2203**	18%	1.372	**1301**	21%	1.372	**21.5**	26%	1.372	**37.3**
95%	28%	1.812	**2325**	24%	1.812	**1365**	28%	1.812	**19.7**	35%	1.812	**33.0**
99%	49%	3.169	**2705**	42%	3.169	**1563**	49%	3.169	**13.9**	61%	3.169	**19.7**
OTHERS												
	# Samples: 5			# Samples: 4			# Samples: 5			# Samples: 4		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	8%	0.920	**2607**	12%	0.941	**1824**	10%	0.920	**16.9**	11%	0.941	**20.2**
85%	10%	1.156	**2656**	15%	1.190	**1877**	12%	1.156	**16.5**	14%	1.190	**19.6**
90%	13%	1.476	**2724**	20%	1.533	**1949**	15%	1.476	**15.9**	18%	1.533	**18.7**
95%	18%	2.015	**2837**	28%	2.132	**2075**	21%	2.015	**14.8**	25%	2.132	**17.1**
99%	35%	4.032	**3263**	60%	4.604	**2595**	42%	4.032	**10.9**	53%	4.604	**10.6**

(RCP in coulomb, Resistivity in kΩ.cm)

Table 5.4 Recommended Allowable RCP and SR Values for Class IV Drilled Shaft.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
	# Samples: 68			# Samples: 67			# Samples: 68			# Samples: 68		
80%	9%	0.847	**3455**	4%	0.847	**1544**	4%	0.847	**18.5**	4%	0.847	**27.4**
85%	11%	1.045	**3520**	5%	1.045	**1557**	5%	1.045	**18.3**	5%	1.045	**27.1**
90%	14%	1.294	**3603**	6%	1.294	**1573**	6%	1.294	**18.1**	6%	1.294	**26.8**
95%	17%	1.668	**3727**	7%	1.668	**1597**	8%	1.668	**17.7**	7%	1.668	**26.3**
99%	28%	2.652	**4053**	11%	2.652	**1661**	13%	2.652	**16.8**	12%	2.652	**25.1**
FLY ASH ONLY												
	# Samples: 18			# Samples: 16			# Samples: 18			# Samples: 17		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	10%	0.862	**7332**	9%	0.866	**2076**	6%	0.863	**8.8**	8%	0.863	**21.4**
85%	13%	1.067	**7496**	11%	1.071	**2116**	7%	1.069	**8.7**	10%	1.069	**20.9**
90%	16%	1.330	**7705**	14%	1.337	**2168**	9%	1.333	**8.5**	13%	1.333	**20.3**
95%	21%	1.734	**8028**	18%	1.746	**2247**	11%	1.740	**8.3**	17%	1.740	**19.4**
99%	35%	2.878	**8940**	30%	2.921	**2477**	19%	2.898	**7.6**	28%	2.898	**16.8**
BLAST FURNACE SLAG ONLY												
	# Samples: 48			# Samples: 49			# Samples: 48			# Samples: 49		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	3%	0.849	**1997**	3%	0.849	**1408**	3%	0.849	**22.1**	4%	0.849	**28.7**
85%	4%	1.047	**2011**	4%	1.047	**1417**	3%	1.047	**22.0**	5%	1.047	**28.4**
90%	5%	1.299	**2030**	5%	1.299	**1429**	4%	1.299	**21.8**	6%	1.299	**28.0**
95%	6%	1.677	**2057**	6%	1.677	**1448**	5%	1.677	**21.5**	8%	1.677	**27.5**
99%	10%	2.68	**2130**	9%	2.68	**1496**	8%	2.68	**20.8**	13%	2.68	**26.0**

(RCP in coulomb, Resistivity in kΩ.cm)

Table 5.5 Recommended Allowable RCP and Surface Resistivity Values for Class V.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
	# Samples: 18			# Samples: 19			# Samples: 19			# Samples: 18		
80%	8%	0.862	**4810**	10%	0.861	**2111**	15%	0.861	**12.2**	19%	0.862	**21.9**
85%	11%	1.067	**4900**	13%	1.066	**2158**	19%	1.066	**11.7**	24%	1.067	**20.7**
90%	13%	1.330	**5015**	16%	1.328	**2217**	23%	1.328	**11.0**	30%	1.330	**19.1**
95%	17%	1.734	**5191**	20%	1.729	**2307**	30%	1.729	**10.0**	39%	1.734	**16.6**
99%	28%	2.878	**5690**	34%	2.861	**2563**	50%	2.861	**7.1**	65%	2.878	**9.6**

FLY ASH ONLY												
	# Samples: 16			# Samples: 17			# Samples: 17			# Samples: 16		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	10%	0.866	**4700**	9%	0.863	**1841**	16%	0.863	**12.6**	20%	0.866	**23.5**
85%	12%	1.071	**4798**	11%	1.069	**1878**	20%	1.069	**12.1**	25%	1.071	**22.1**
90%	15%	1.337	**4926**	14%	1.333	**1926**	25%	1.333	**11.3**	31%	1.337	**20.3**
95%	20%	1.746	**5122**	19%	1.74	**1999**	32%	1.74	**10.2**	40%	1.746	**17.6**
99%	33%	2.921	**5685**	31%	2.898	**2207**	54%	2.898	**7.0**	67%	2.921	**9.7**

(RCP in coulomb, Resistivity in kΩ.cm)

Table 5.6 Recommended Allowable RCP and SR Values for Class V Special.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
	# Samples: 95			# Samples: 72			# Samples: 96			# Samples: 71		
80%	5%	0.846	**3773**	5%	0.847	**1606**	5%	0.846	**16.9**	6%	0.847	**34.9**
85%	6%	1.042	**3813**	7%	1.045	**1625**	7%	1.042	**16.7**	8%	1.045	**34.3**
90%	7%	1.29	**3863**	8%	1.294	**1650**	8%	1.29	**16.4**	9%	1.294	**33.7**
95%	9%	1.661	**3938**	11%	1.667	**1686**	11%	1.661	**16.0**	12%	1.667	**32.7**
99%	15%	2.629	**4134**	17%	2.646	**1781**	17%	2.629	**14.9**	19%	2.646	**30.0**

FLY ASH ONLY

	# Samples: 55			# Samples: 42			# Samples: 54			# Samples: 38		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	2%	0.849	**5120**	3%	0.851	**2177**	3%	0.849	**9.6**	5%	0.851	**19.5**
85%	3%	1.047	**5149**	4%	1.050	**2194**	4%	1.047	**9.5**	6%	1.050	**19.2**
90%	4%	1.297	**5185**	5%	1.303	**2215**	5%	1.297	**9.4**	7%	1.304	**19.0**
95%	5%	1.673	**5239**	7%	1.683	**2247**	6%	1.673	**9.3**	9%	1.687	**18.5**
99%	8%	2.669	**5383**	11%	2.702	**2332**	9%	2.669	**9.0**	15%	2.710	**17.4**

SILICA FUME WITH FLY ASH

	# Samples: 36			# Samples: 30			# Samples: 38			# Samples: 33		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	6%	0.852	**1465**	6%	0.854	**749**	4%	0.851	**31**	5%	0.853	**60**
85%	8%	1.052	**1486**	7%	1.055	**759**	5%	1.050	**32**	6%	1.054	**60**
90%	10%	1.306	**1513**	9%	1.310	**771**	6%	1.304	**32**	7%	1.308	**61**
95%	13%	1.690	**1553**	11%	1.697	**789**	8%	1.687	**32**	9%	1.694	**62**
99%	21%	2.724	**1661**	18%	2.750	**839**	13%	2.710	**34**	15%	2.727	**66**

(RCP in coulomb, Resistivity in kΩ.cm)

Table 5.7 Recommended Allowable RCP and SR Values for Class VI.

	RCP						Surface Resistivity					
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
	# Samples: 53			# Samples: 52			# Samples: 54			# Samples: 49		
80%	3%	0.849	**3788**	4%	0.849	**1677**	3%	0.849	**12.2**	4%	0.849	**24.5**
85%	4%	1.047	**3813**	5%	1.047	**1694**	4%	1.047	**12.1**	5%	1.047	**24.2**
90%	5%	1.299	**3846**	7%	1.299	**1715**	4%	1.297	**12.0**	7%	1.299	**23.9**
95%	6%	1.675	**3894**	9%	1.675	**1746**	6%	1.673	**11.8**	8%	1.677	**23.4**
99%	9%	2.675	**4023**	14%	2.675	**1830**	9%	2.669	**11.4**	14%	2.68	**22.1**

FLY ASH ONLY												
	# Samples: 48			# Samples: 49			# Samples: 49			# Samples: 46		
CL	CV	Student's t	28 day	CV	Student's t	91 day	CV	Student's t	28 day	CV	Student's t	91 day
80%	3%	0.849	**3617**	3%	0.849	**1515**	3%	0.849	**12.5**	4%	0.850	**25.5**
85%	4%	1.047	**3640**	3%	1.047	**1524**	3%	1.047	**12.5**	5%	1.048	**25.2**
90%	4%	1.299	**3670**	4%	1.299	**1535**	4%	1.299	**12.4**	6%	1.301	**24.9**
95%	6%	1.677	**3715**	5%	1.677	**1552**	6%	1.677	**12.2**	8%	1.680	**24.4**
99%	9%	2.68	**3835**	8%	2.68	**1596**	9%	2.68	**11.8**	13%	2.690	**23.1**

(RCP in coulomb, Resistivity in kΩ.cm)

Maximum values at 5 different Levels of Confidence have been herein provided to lend some flexibility to this report as well as offer the Florida Department of Transportation several values in order that it may make a final decision specifically suitable to its unique experience and desire.

Recommendation

It is the author's opinion that the 90% Confidence Level figures are the optimum values to be recommended for maximum limits. There are several reasons for this designation. If the limits are chosen above this level then the criteria will be easily met and one could argue the necessity of the limits at all. However if the limits are set too low, they will be exceedingly difficult to achieve. This will produce two residual effects: first, many contractors will fail to meet the standard and therefore either have payment withheld or reduced, neither of which are desirable. The second is that it will, as a consequence of requiring more work on the part of the contractor as well as an increase in material costs, drive up the cost of construction to the Florida Department of Transportation. So a threshold that strikes a balance between a conservative value and an ambitious value is the most appropriate decision.

In addition, as was related earlier in this report, 10% of the total mixes were exempted from calculation due to non-conforming test results. This means that the 90% Confidence Level is in fact a bit more ambitious than its face value indicates as it relates to this research. Finally, the entire objective of this endeavor is to improve concrete durability. If standards were set which accepted virtually all contemporary concrete mixes, no improvement can be expected. By setting the standards at 10% below what has been tested before any changes have been applied, then an improvement in durability can be realized.

Due to the fact that there are differences between the performance of concrete samples of different pozzolanic make up, a hierarchy within each concrete Class can begin to emerge. For instance it is recommended based on observed performance that concrete placed in extremely aggressive environments should be required to contain either Silica Fume or Blast Furnace Slag. These two pozzolanic materials have demonstrated superior performance in durability testing here and would consequently extend the serviceable lifetime of a structure. For moderately aggressive environments Blast Furnace Slag or Fly Ash could be required. And for slightly aggressive environments any pozzolan or the absence there of could be acceptable.

RCP test Standard Limit Drawbacks

It must be reported that the employment of the RCP test for the purposes of acceptance and payment will not come to pass without penalty. There are several drawbacks to the RCP test. Its accuracy is questionable and there exists high variability on an individual testing basis. Also, according to the ASTM 1202, there is a high degree of variability between testing facilities. This was not the case in this project but is indeed stated in the standards. The RCP test is widely used but not universally accepted by the construction industry. It should also be noted that there has not been any recent updates or correlation to the test method to identify characteristics of concretes of lower water/cement ratios and concrete utilizing pozzolanic materials. Stiff opposition may be encountered when exercising the implications of test results.

RCP / Surface Resistivity

The second objective of this paper was to continue building a case for an RCP test alternative, which in this case is the Surface Resistivity test. In Chapter 4, correlation between the RCP test and the Surface Resistivity test were presented by individual concrete class. However, our intention is to build a case for the replacement of the RCP test entirely with the Surface Resistivity test, not class by class. Figures 5.1 and 5.2 show the correlation of the two tests over the entire sample population, regardless of class for the two testing dates. The two tests show a strong relationship at both testing dates, with the 28-day test correlating more closely than the 91-day test as did the majority of the individual classes. The 28-day test demonstrated an R^2 value of 0.9481 and the 91-day test showed at 0.9321.

If the value ranges found in the table provided in the AASHTO standard intended to guide the interpretation of RCP test results is converted using the equations revealed by these graph's trend lines, then interpretive guidelines for the Surface Resistivity test results can be ascertained. These figures are provided here in Table 5.8 both for the 28 and 91-day tests. These values have been determined by the comparison of laboratory

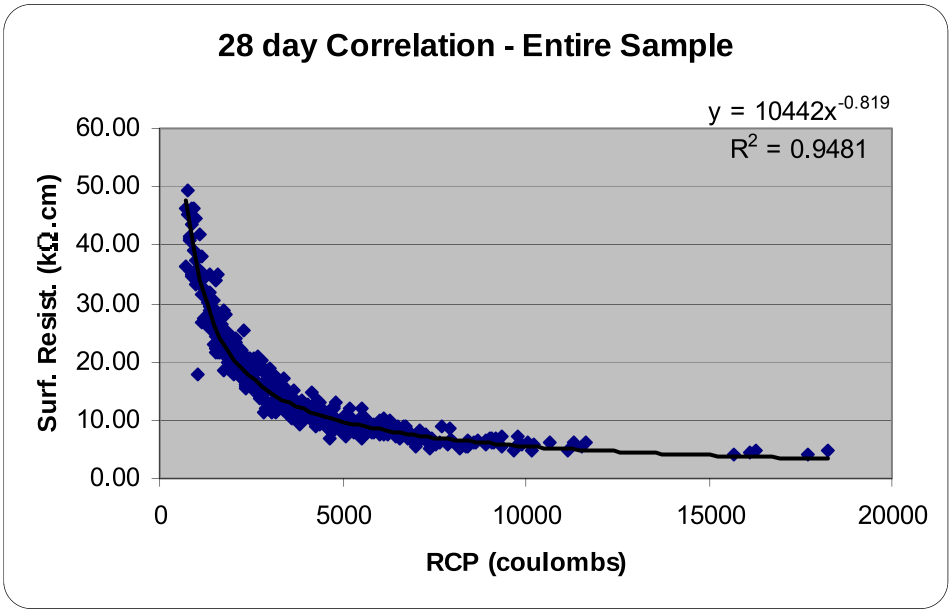

Figure 5.1 Correlation between RCP and SR at 28-Days for Entire Samples.

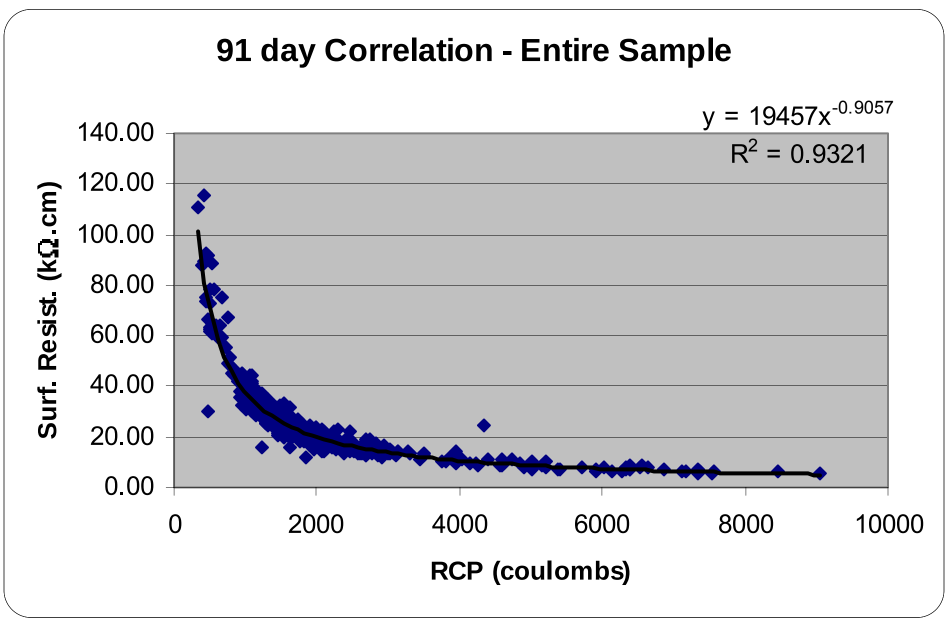

Figure 5.2 Correlation between RCP and SR at 91-Days for Entire Samples.

tests of job site samples. The data is based on the use of the Wenner 4-probe array applied to a 4 inch by 8-inch concrete cylinder. These data ranges would therefore be inappropriate for the interpretation of testing done on site on in-situ concrete placements. Localized variability such as ambient temperature, moisture content, proximity and orientation of reinforcing steel, and sample geometry all affect a Surface Resistivity reading. The values presented here are only applicable for testing done on 4 inch by 8-inch cylinders cured in a similar fashion as described in the Methodology Chapter of this report.

Table 5.8 Equivalent Surface Resistivity Values for 28 and 91-day tests.

Chloride Ion Permeability	RCP Test Charged Passed (coulombs)	Surface Resistivity test 28 day test kΩcm	91 day test kΩcm
High	> 4,000	< 11.8	< 10.6
Moderate	2,000-4,000	11.8 - 21.0	10.6 - 19.7
Low	1,000-2,000	21.0 - 37.4	19.7 - 36.9
Very Low	100-1,000	37.4 - 253.7	36.9 - 295.3
Negligible	< 100	> 253.7	> 295.3

Table 5.9 Equivalent Surface Resistivity Values Rounded for Utilization.

Chloride Ion Permeability	RCP Test Charged Passed (coulombs)	Surface Resistivity test 28 day test kΩ.cm	91 day test kΩ.cm
High	> 4,000	< 12	< 11
Moderate	2,000-4,000	12 - 21	11 - 19
Low	1,000-2,000	21 - 37	19 - 37
Very Low	100-1,000	37 - 254	37 - 295
Negligible	< 100	> 254	> 295

In addition to the above mentioned conditions, Table 5.9 is presented as a slight variation to Table 5.8 in that the Surface Resistivity values have been rounded in order to provide a more user-friendly table suitable for FDOT deployment.

Testing Procedure Improvements

Lastly, recommendations were requested for improvements to the testing procedure. Two alternatives to the epoxy step were tested here and their data presented in chapter 4. The spray sealant available at Napa Stores produced by Permatex® out performed the tape as an alternative. It also out performs the epoxy in terms of saving time, an element important in relevance to cost but particularly important when samples arrive which need to be run immediately. The significantly reduced set time of the spray (less than one hour) is quite an asset over the epoxy which takes approximately 8 hours to

Table 5.10 Comparison of Testing Procedure Alternatives.

	Epoxy	Spray	Tape
Cost per Test	$1.74	$0.38	$0.03
Time:			
Labor Hours	10 min	2 min	1 min
Curing Time	8 hrs	45 min	0 min
Relationship to Current Standard	100%	96%	84%
Workability	average	good	very good
Propensity for Leaking	low	very low	high

cure (depending on ambient conditions) enough so as not to be affected during desiccation. The spray alternative showed no signs of difficulty during the testing procedure, i.e. leaking, and has great workability. The spray seems to be a more desirable choice in all categories. See Table 5.10 for quick comparison of the three choices, it will easily demonstrate that the spray alternative is the superior choice.

APPENDIX A
MASTER LIST OF SAMPLE DATA

LAB #	SAMPLE #	CAST DATE	TEST DATE (28 D)	MIX DESIGN	DISTRICT	CLASS	Fly-Ash %	Slag %	Silica Fume (OZ)	28D RCP (not adjusted)	Average Samples A & B	28D RCP Adjusted	28D Surf. Resist.	28D Surf. Resist, Adjusted	91D RCP (not adjusted)	Average Samples A & B	91D RCP Adjusted	91D Surf. Resist.
01A	M- 21	4/24/01	5/23/01	02-0308	2	V SP	18.3			6280	6656	**5851**	10.58	**8.99**				
B						V SP	18.3			7032			10.74	**9.13**				
C						V SP	18.3						9.80	**9.80**				
02A	NR15	4/26/01	5/24/01	02-0309	2	V	18.3			7220	7175	**6307**	10.38	**8.82**				
B						V	18.3			7130			9.95	**8.46**				
C						V	18.3						8.04	**8.04**				
03A	MV-3	5/1/01	5/29/01	02-0308	2	V SP	18.3			5820	5710	**5019**	13.03	**11.08**	2540	2520	**2215**	
B						V SP	18.3			5600			11.50	**9.78**	2500			
C						V SP	18.3						8.09	**8.09**				**16.60**
04A	NR16	5/2/01	5/30/01	02-0309	2	V	18.3			6110	5915	**5199**	11.67	**9.92**	2526	2523	**2218**	
B						V	18.3			5720			12.25	**10.41**	2520			
C						V	18.3						9.22	**9.22**				**15.46**
05A	RB-3	5/3/01	5/31/01	02-0556	2	V SP	16.7		1225	1830	1830	**1609**	26.54	**22.56**	1210	1170	**1028**	
B						V SP	16.7		1225	1830			27.48	**23.36**	1130			
C						V SP	16.7		1225				23.21	**23.21**				**41.18**
06A	02-0869	5/4/01	6/1/01	02-0869	2	IV		50					34.00	**28.90**				
B						IV		50					38.24	**32.50**				
C						IV		50					35.61	**35.61**				
07A	MV 7	5/8/01	6/5/01	02-0309	2	V	18.3			5240	5080	**4465**	12.31	**10.46**	2450	2510	**2206**	
B						V	18.3			4920			14.99	**12.74**	2570			
C						V	18.3						12.26	**12.26**				**18.01**
08A	RB-6	5/8/01	6/5/01	02-0556	2	V SP	16.7		1225	1130	1100	**967**	35.76	**30.40**	770	771	**678**	
B						V SP	16.7		1225	1070			41.65	**35.40**	772			
C						V SP	16.7		1225				45.91	**45.91**				**59.29**
09A	MV-9	5/9/01	6/6/01	02-0308	2	V SP	18.3			5920	5775	**5076**	9.48	**8.06**	2460	2420	**2127**	
B						V SP	18.3			5630			6.85	**5.82**	2380			
C						V SP	18.3						7.61	**7.61**				**15.40**
10A	02-M0898	5/10/01	6/7/01	02-0898	2	II BD		50		2080	2140	**1881**	20.44	**17.37**	1830	1765	**1551**	
B						II BD		50		2200			21.76	**18.50**	1700			
C						II BD		50					24.29	**24.29**				**31.88**
11A	02-M0717	5/15/01	6/12/01	02-0717	2	IV DS	34.9			7730	7645	**6720**	9.90	**8.42**	3080	3030	**2663**	
B						IV DS	34.9			7560			11.20	**9.52**	2980			
C						IV DS	34.9						8.55	**8.55**				**16.40**
12A	NR18	5/16/01	6/13/01	02-0309	2	V	18.3			6440	5935	**5217**	15.08	**12.82**	2480	2375	**2088**	
B						V	18.3			5430			12.84	**10.91**	2270			
C						V	18.3						11.84	**11.84**				**19.10**
13A	M 23	5/16/01	6/13/01	02-0556	2	V SP	16.7		1225	1280	1315	**1156**	42.46	**36.09**	723	740.5	**651**	
B						V SP	16.7		1225	1350			40.39	**34.33**	758			
C						V SP	16.7		1225				35.46	**35.46**				**64.08**
14A	02M2042	5/16/01	6/13/01	02-2042	2	II		50		1980	2025	**1780**	35.54	**30.21**	1560	1615	**1420**	
B						II		50		2070			33.96	**28.87**	1670			
C						II		50					25.55	**25.55**				**31.25**
15A	MV13	5/17/01	6/14/01	02-0308	2	V SP	18.3			5380	5575	**4900**	11.65	**9.90**	2280	2380	**2092**	
B						V SP	18.3			5770			9.69	**8.24**	2480			
C						V SP	18.3						8.43	**8.43**				**16.05**
16A	MV-15	5/21/01	6/18/01	02-0308	2	V SP	18.3			5995	5995	**5270**	10.70	**9.10**				
B						V SP	18.3						11.43	**9.72**				
C						V SP	18.3						8.36	**8.36**				
17A	M 26	5/22/01	6/19/01	02-0556	2	V SP	16.7		1225	1830	1825	**1604**	24.51	**20.83**	1030	1050	**923**	
B						V SP	16.7		1225	1820			26.24	**22.30**	1070			
C						V SP	16.7		1225				22.16	**22.16**				**37.66**
18A	NR19	5/23/01	6/20/01	02-0309	2	V	18.3			6570	6800	**5977**	8.78	**7.46**	2590	2590	**2277**	
B						V	18.3			7030			10.11	**8.59**	2590			
C						V	18.3						8.90	**8.90**				**14.84**
19A	S 4686	5/25/01	6/22/01	06-0280	4	IV		51.1			1770	**1556**	30.28	**25.74**	1570	1490	**1310**	
B						IV		51.1		1770			33.79	**28.72**	1410			
C						IV		51.1					27.83	**27.83**				**33.75**

20A	NR20	5/31/01	6/28/01	02-0309	2	V	18.3			7000	6940	6100	8.76	7.45				
B						V	18.3			6880			9.03	7.68				
C						V	18.3						7.54	7.54				
21A	M27	6/5/01	7/3/01	02-0556	2	V SP	16.7		1225	2290	2365	2079	22.45	19.08				
B						V SP	16.7		1225	2440			24.13	20.51				
C						V SP	16.7		1225				20.14	20.14				
22A	MV18	6/5/01	7/3/01	02-0309	2	V	18.3			7470	7475	6571	9.73	8.27	2570	2575	2263	
B						V	18.3			7480			9.48	8.06	2580			
C						V	18.3						8.13	8.13				16.64
23A	I4169	6/5/01	7/3/01	04-2044	4	IV				6090	6020	5292	8.93	7.59	5120	5180	4553	
B						IV				5950			8.91	7.57	5240			
C						IV							8.44	8.44				8.79
24A	I2010	6/6/01	7/4/01	04-0409	4	II BD				6069	6616	5815	10.23	8.70	4280	4495	3951	
B						II BD				7163			11.50	9.78	4710			
C						II BD							8.74	8.74				9.86
25A	M30	6/8/01	7/6/01	02-0308	2	V SP	18.3			6980	7420	6522	9.69	8.24	2580	2680	2356	
B						V SP	18.3			7860			9.84	8.36	2780			
C						V SP	18.3						7.80	7.80				16.33
26A	M-34	6/15/01	7/13/01	02-0556	2	V SP	16.7		1225	2420	2430	2136	21.59	18.35				
B						V SP	16.7		1225	2440			25.34	21.54				
C						V SP	16.7		1225				20.85	20.85				
27A	M 036	6/19/01	7/17/01	02-0308	2	V SP	18.3			7530	7355	6465	9.89	8.41				
B						V SP	18.3			7180			9.96	8.47				
C						V SP	18.3						8.53	8.53				
28A	IX001	6/19/01	7/17/01	03-0612	3	II BD	18.1			3970	4165	3661	16.65	14.15	1520	1550	1362	
B						II BD	18.1			4360			13.83	11.76	1580			
C						II BD	18.1						11.29	11.29				26.20
29A	IX002	6/19/01	7/17/01	03-0611	3	II	19.3			6310	6280	5520	11.36	9.66	1680	1770	1556	
B						II	19.3			6250			11.21	9.53	1860			
C						II	19.3						10.49	10.49				26.01
30A	IX003	6/20/01	7/18/01	03-0881	3	IV	19.7			2980	3085	2712	17.43	14.82				
B						IV	19.7			3190			17.90	15.22				
C						IV	19.7			3040			17.48	17.48				
31A	A4001	6/21/01	7/19/01	06-0335	8	IV	19.7			7340	7350	6461	9.58	8.14	6160	6160	5415	
B						IV	19.7			7360			9.60	8.16	6160			
C						IV	19.7						8.58	8.58				7.19
32A	A4002	6/21/01	7/19/01	06-0335	8	IV	19.7			5520	5685	4997	11.45	9.73	5170	5240	4606	
B						IV	19.7			5850			12.06	10.25	5310			
C						IV	19.7						10.14	10.14				8.49
33A	02-0586	6/22/01	7/20/01	02-0586	2	I	21.9						8.58	7.29				
B						I	21.9						8.76	7.45				
C						I	21.9						8.91	8.91				
34A	M-37	6/22/01	7/20/01	02-0556	2	V SP	16.7		1225				27.09	23.03				
B						V SP	16.7		1225				26.94	22.90				
C						V SP	16.7		1225				28.69	28.69				
35A	A2001	6/22/01	7/20/01	04-0409	8	II BD							10.15	8.63	5550	5585	4909	
B						II BD							9.68	8.23	5620			
C						II BD							9.46	9.46				7.99
36A	M-40	6/26/01	7/24/01	02-0556	2	V SP	16.7		1225	2340	2225	1956	20.88	17.75				
B						V SP	16.7		1225	2110			21.88	18.60				
C						V SP	16.7		1225				21.94	21.94				
37A	02-M0860	6/26/01	7/24/01	02-0860	2	IV		50		2700	2650	2329	20.28	17.24	1850	1880	1653	
B						IV		50		2600			21.81	18.54	1910			
C						IV		50					19.08	19.08				22.35
38A	ID501	6/26/01	7/24/01	03-0845	3	IV DS	33			19600	20150	17712	5.06	4.30	7620	7430	6531	
B						IV DS	33			20700			4.69	3.99	7240			
C						IV DS	33						4.01	4.01				8.03
39A	M43	6/27/01	7/24/01	02-0308	2	V SP	18.3			6220	6140	5397	10.16	8.64				
B						V SP	18.3			6060			11.44	9.72				
C						V SP	18.3						8.80	8.80				

40A	02-0684	6/27/01	7/25/01	02-0684	2	I SP		50		3160	2790	**2452**	22.90	**19.47**	2610	2340	**2057**	
B						I SP		50		2420			25.24	**21.45**	2070			
C						I SP		50					21.00	**21.00**				**19.23**
41A	02-0869	6/28/01	7/26/01	02-0869	2	IV		50		1690	1685	**1481**	35.21	**29.93**	1390	1380	**1213**	
B						IV		50		1680			34.94	**29.70**	1370			
C						IV		50					28.03	**28.03**				**30.88**
42A	I2012	6/29/01	7/27/01	03-0854	3	II BD	19.5						5.38	**4.57**	7450	7450	**6549**	
B						II BD	19.5						5.14	**4.37**				
C						II BD	19.5											**8.39**
43A	I2013	6/29/01	7/27/01	03-0854	3	II BD	19.5						5.00	**4.25**	7200	7200	**6329**	
B						II BD	19.5						4.86	**4.13**				
C						II BD	19.5											**8.11**
44A	02-0881	7/2/01	7/30/01	02-0881	2	II BD		50										
B						II BD		50										
C						II BD		50										
45A	M-48	7/3/01	7/31/01	02-0556	2	V SP	16.7		1225	1830	1870	**1644**	26.53	**22.55**				
B						V SP	16.7		1225	1910			27.50	**23.38**				
C						V SP	16.7		1225				25.96	**25.96**				
46A	I2169	7/5/01	8/2/01	04-0424	6	II				5149	4912	**4318**	11.38	**9.67**	4850	4855	**4268**	
B						II				4675			9.63	**8.19**	4860			
C						II							15.46	**15.46**				**8.39**
47A	M51	7/6/01	8/3/01	02-0556	2	V SP	16.7		1225	1920	1970	**1732**	36.85	**31.32**				
B						V SP	16.7		1225	2020			33.60	**28.56**				
C						V SP	16.7		1225				26.11	**26.11**				
48A	I4001	7/10/01	8/7/01	05-0612	5	IV		50		3290	3435	**3019**	22.36	**19.01**	2090	2065	**1815**	
B						IV		50		3580			23.98	**20.38**	2040			
C						IV		50					17.54	**17.54**				**17.83**
49A	I4262	7/11/01	8/8/01	04-2044	4	IV				6510	6535	**5744**	9.54	**8.11**	5740	5705	**5015**	
B						IV				6560			10.20	**8.67**	5670			
C						IV							7.48	**7.48**				**6.78**
50A	I2024	7/12/01	8/9/01	04-0433	4	II BD		60		1450	1560	**1371**	35.44	**30.12**	1020	1040	**914**	
B						II BD		60		1670			39.93	**33.94**	1060			
C						II BD		60					31.88	**31.88**				**35.63**
51A	HRC01	7/12/01	8/9/01	TP-36	2	II				7440	7465	**6562**	8.84	**7.51**	6010	6115	**5375**	
B						II				7490			9.63	**8.19**	6220			
C						II							7.79	**7.79**				**6.88**
52A	SC1	7/12/01	8/9/01	02-0919	2	V SP				7640	7520	**6610**	9.84	**8.36**	5610	5525	**4856**	
B						V SP				7400			9.86	**8.38**	5440			
C						V SP							9.35	**9.35**				**9.65**
53A	RB17	7/13/01	8/10/01	02-0556	2	V SP	16.7		1225	2830	2800	**2461**	20.34	**17.29**				
B						V SP	16.7		1225	2770			21.88	**18.60**				
C						V SP	16.7		1225									
54A	02-M0717	7/16/01	8/13/01	02-0717	2	IV DS	34.9			10500	10300	**9054**	7.80	**6.63**	3660	3530	**3103**	
B						IV DS	34.9			10100			8.20	**6.97**	3400			
C						IV DS	34.9						6.59	**6.59**				**12.65**
55A	M-54	7/16/01	8/13/01	02-0308	2	V SP	18.3			5480	5320	**4676**	10.79	**9.17**	2180	2175	**1912**	
B						V SP	18.3			5160			11.25	**9.56**	2170			
C						V SP	18.3						9.58	**9.58**				**16.50**
56A	RB-18	7/18/01	8/15/01	02-0556	2	V SP	16.7		1225	1940	1845	**1622**	28.36	**24.11**				
B						V SP	16.7		1225	1750			29.54	**25.11**				
C						V SP	16.7		1225				25.60	**25.60**				
57A	I2001	7/18/01	8/15/01	02-2057	2	II		49.9		1610	1650	**1450**	35.76	**30.40**	1280	1320	**1160**	
B						II		49.9		1690			36.60	**31.11**	1360			
C						II		49.9					30.11	**30.11**				**30.61**
58A	I2004	7/19/01	8/16/01	02-0881	2	II BD		50		1720	1810	**1591**	32.44	**27.57**	1490	1505	**1323**	
B						II BD		50		1900			34.41	**29.25**	1520			
C						II BD		50					28.43	**28.43**				**26.71**
59A	I2052	7/24/01	8/21/01	04-0433	4	II BD		60		1360	1370	**1204**	37.06	**31.50**	1350	1250	**1099**	
B						II BD		60		1380			38.63	**32.84**	1150			
C						II BD		60					33.55	**33.55**				**29.79**

60A	RB24	7/25/01	8/22/01	02-0556	2	V SP	16.7		1225	2830	2740	2408	20.31	17.26	1220	1340	1178	35.51
B						V SP	16.7		1225	2650			19.98	16.98	1460			30.00
C						V SP	16.7		1225						1570			N/A
61A	IP003	7/25/01	8/22/01	02-0658	5	I				3810	3885	3415	15.14	12.87	1790	1790	1573	
B						I				3960			15.15	12.88	1790			
C						I							14.11	14.11				21.24
62A	02-M0833	7/26/01	8/23/01	02-0833	2	IV DS		60		2280	2380	2092	24.31	20.66	1820	1860	1635	
B						IV DS		60		2480			25.11	21.34	1900			
C						IV DS		60					22.08	22.08				15.43
63A	IA002	7/27/01	8/24/01	05-0621	8	II BD	19.9			5690	5750	5054	11.23	9.55	2760	2800	2461	
B						II BD	19.9			5810			11.04	9.38	2840			
C						II BD	19.9						9.39	9.39				21.84
64A	02M0688	7/31/01	8/28/01	02-0688	2	IV		50		2100	2255	1982	24.45	20.78	1810	1860	1635	
B						IV		50		2410			26.84	22.81	1910			
C						IV		50					22.40	22.40				23.40
65A	RB30	8/2/01	8/30/01	02-0556	2	V SP	16.7		1225	2480	2470	2171	19.98	16.98				
B						V SP	16.7		1225	2460			21.09	17.93				
C						V SP	16.7		1225	1860								
66A	IXD52	8/2/01	8/30/01	03-0845	3	IV DS	33			17600	18550	16305	6.26	5.32	5540	5695	5006	
B						IV DS	33			19500			5.60	4.76	5850			
C						IV DS	33						4.71	4.71				10.54
67A	IXMH1	8/3/01	8/31/01	03-0741	3	II				10800	10650	9361	6.64	5.64	10100	10300	9054	
B						II				10500			6.46	5.49	10500			
C						II							5.59	5.59				5.41
68A	I4002	8/7/01	9/4/01	05-0612	5	IV		50		3060	3180	2795	22.78	19.36	1990	2035	1789	
B						IV		50		3300			21.55	18.32	2080			
C						IV		50					19.51	19.51				23.25
69A	I2002	8/8/01	9/5/01	05-0786	5	II BD	20			7000	7120	6258	11.75	9.99	2530	2455	2158	
B						II BD	20			7240			12.61	10.72	2380			
C						II BD	20						9.55	9.55				19.19
70A	SC 5	8/8/01	9/5/01	02-0919	2	V SP				7200	7605	6685	9.59	8.15	7380	7260	6382	
B						V SP				8010			10.13	8.61	7140			
C						V SP							7.70	7.70				7.49
71A	G5001	8/9/01	9/6/01	07-0130	1	V SP	18			3100	3070	2699	17.60	14.96	1300	1280	1125	
B						V SP	18			3040			19.15	16.28	1260			
C						V SP	18						16.83	16.83				30.56
72A	G4002	8/10/01	9/7/01	01-0494	1	IV		50		2680	2655	2334	16.53	14.05	2410	2310	2030	
B						IV		50		2630			19.73	16.77	2210			
C						IV		50					15.45	15.45				17.01
73A	G4001	8/10/01	9/7/01	01-0494	1	IV		50		3090	3005	2641	19.69	16.74	2220	2285	2009	
B						IV		50		2920			19.54	16.61	2350			
C						IV		50					17.04	17.04				17.39
74A	G2001	8/12/01	9/9/01	07-0511	7	II BD	21.9			7310	8060	7085	10.19	8.66				
B						II BD	21.9			8810			8.90	7.57				
C						II BD	21.9						8.48	8.48				
75A	G2003	8/13/01	9/10/01	07-0511	7	II BD	21.9			10900	10120	8895	7.66	6.51	3130	3250	2857	
B						II BD	21.9			9340			7.29	6.20	3370			
C						II BD	21.9						7.26	7.26				15.13
76A	G2002	8/13/01	9/10/01	07-0511	7	II BD	21.9			11300	11150	9801	8.78	7.46	2870	3050	2681	
B						II BD	21.9			11000			8.55	7.27	3230			
C						II BD	21.9						6.76	6.76				14.49
77A	IX008	8/14/01	9/11/01	03-0858	3	VI	18			1660	1750	1538	29.85	25.37	692	680.5	598	
B						VI	18			1840			31.24	26.55	669			
C						VI	18						28.13	28.13				63.84
78A	G2001	8/14/01	9/11/01	01-0514	1	II BD		50		2310	2330	2048	20.74	17.63	1820	1965	1727	
B						II BD		50		2350			22.06	18.75	2110			
C						II BD		50					17.49	17.49				19.66
79A	02-0688	8/15/01	9/12/01	02-0688	2	IV		50		2420	2390	2101	23.61	20.07	2170	2110	1855	
B						IV		50		2360			25.59	21.75	2050			
C						IV		50					19.93	19.93				21.83

80A	I4001	8/15/01	9/12/01	03-0876	3	IV	19.7			2970	3025	2659	22.86	19.43	875	888	781	
B						IV	19.7			3080			23.08	19.62	901			
C						IV	19.7						19.64	19.64				51.11
81A	G2001	8/15/01	9/12/01	07-0550	7	II BD		50		2630	2540	2233	21.16	17.99	2060	2055	1806	
B						II BD		50		2450			21.15	17.98	2050			
C						II BD		50					20.59	20.59				22.06
82A	I4079	8/15/01	9/12/01	06-0280	6	IV		51.1		1700	1675	1472	32.10	27.29	1360	1415	1244	
B						IV		51.1		1650			28.73	24.42	1470			
C						IV		51.1					27.51	27.51				29.78
83A	02-M0717	8/16/01	9/13/01	02-0717	2	IV DS	34.9			7880	8040	7067	9.49	8.07	3060	3055	2685	
B						IV DS	34.9			8200			9.40	7.99	3050			
C						IV DS	34.9						7.55	7.55				15.35
84A	A4138	8/16/01	9/13/01	03-0436	3	IV	18.4			6240	5945	5226	11.44	9.72	2330	2255	1982	
B						IV	18.4			5650			9.91	8.42	2180			
C						IV	18.4						11.10	11.10				18.21
85A	I4009	8/16/01	9/13/01	06-0280	6	IV		51.1		1640	1570	1380	34.39	29.23	1470	1420	1248	
B						IV		51.1		1500			35.25	29.96	1370			
C						IV		51.1					27.58	27.58				28.35
86A	MC2	8/17/01	9/14/01	02-0308	2	V SP	18.3			5190	5190	4562	11.68	9.93				
B						V SP	18.3						11.94	10.15				
C						V SP	18.3						10.01	10.01				
87A	SC7	8/21/01	9/18/01	02-0919	2	V SP				7610	7560	6645	10.76	9.15	6210	5930	5212	
B						V SP				7510			10.23	8.70	5650			
C						V SP							9.24	9.24				10.20
88A	I2004	8/21/01	9/18/01	05-0786	5	II BD	20			5990	6390	5617	12.65	10.75	2220	2180	1916	
B						II BD	20			6790			13.45	11.43	2140			
C						II BD	20						8.83	8.83				18.80
89A	02-M0856	8/22/01	9/19/01	02-0856	2	II		50		1860	1875	1648	27.70	23.55	1560	1590	1398	
B						II		50		1890			27.26	23.17	1620			
C						II		50					23.19	23.19				26.65
90A	G2001	8/22/01	9/19/01	07-0511	7	II BD	21.9			4680	4685	4118	12.65	10.75	1790	1670	1468	
B						II BD	21.9			4690			12.31	10.46	1550			
C						II BD	21.9						9.40	9.40				21.60
91A	T4002	8/28/01	9/25/01	06-0280	6	IV		51.1		1870	1785	1569	32.19	27.36	1450	1415	1244	
B						IV		51.1		1700			30.56	25.98	1380			
C						IV		51.1					26.74	26.74				32.75
92A	I4249	8/29/01	9/26/01	06-0280	6	IV		51.1		1890	1880	1653	25.50	21.68	1560	1525	1340	
B						IV		51.1		1870			25.74	21.88	1490			
C						IV		51.1					21.16	21.16				26.39
93A	ID503	8/29/01	9/26/01	03-0845	3	IV DS	33			18400	17850	15690	4.74	4.03	4870	4950	4351	
B						IV DS	33			17300			4.95	4.21	5030			
C						IV DS	33						3.95	3.95				24.19
94A	02-0688	8/29/01	9/26/01	02-0688	2	IV		50		2610	2585	2272	21.19	18.01	2030	2115	1859	
B						IV		50		2560			22.48	19.11	2200			
C						IV		50					18.71	18.71				11.99
95A	IA002	8/30/01	9/27/01	01-0538	8	II BD	18			6630	6750	5933	9.73	8.27	2400	2370	2083	
B						II BD	18			6870			10.30	8.76	2340			
C						II BD	18						7.80	7.80				18.20
96A	G4002	8/30/01	9/27/01	01-2038	1	IV	18.7		30 mL	2200	2215	1947	20.59	17.50	1560	1480	1301	
B						IV	18.7		30 mL	2230			22.29	18.95	1400			
C						IV	18.7		30 mL				19.58	19.58				31.58
97A	G4001	8/30/01	9/27/01	01-2038	1	IV	18.7		30 mL	2450	2510	2206	20.80	17.68	1270	1265	1112	
B						IV	18.7		30 mL	2570			21.38	18.17	1260			
C						IV	18.7		30 mL				18.76	18.76				33.05
98A	I4002	8/30/01	9/27/01	05-0451	5	IV	18			8000	7745	6808	9.55	8.12	3040	2960	2602	
B						IV	18			7490			8.53	7.25	2880			
C						IV	18						7.14	7.14				16.15
99A	IA003	8/31/01	9/28/01	01-0538	8	II BD	18			6180	6365	5595	8.96	7.62	2250	2320	2039	
B						II BD	18			6550			8.56	7.28	2390			
C						II BD	18						7.33	7.33				18.35

100A	IX501	9/4/01	10/2/01	03-0907	3	V SP	19.9			4210	4215	**3705**	12.29	**10.45**	1450	1425	**1253**	
B						V SP	19.9			4220			12.25	**10.41**	1400			
C						V SP	19.9						10.05	**10.05**				**33.45**
101A	A2035	9/5/01	10/3/01	04-0420	4	II				8100	7980	**7014**	6.46	**5.49**	7140	6965	**6122**	
B						II				7860			6.94	**5.90**	6790			
C						II							5.25	**5.25**				**6.55**
102A	IB003	9/5/01	10/3/01	05-0662	5	IV	18			3610	3485	**3063**	13.91	**11.82**	1640	1655	**1455**	
B						IV	18			3360			13.48	**11.46**	1670			
C						IV	18						10.99	**10.99**				**24.69**
103A	I2005	9/5/01	10/3/01	05-0786	5	II BD	20			4960	4840	**4254**	9.95	**8.46**	2040	1965	**1727**	
B						II BD	20			4720			10.75	**9.14**	1890			
C						II BD	20						8.85	**8.85**				**21.56**
104A	IA004	9/5/01	10/3/01	01-0538	8	II BD	18			8640	8560	**7524**	7.21	**6.13**	3210	3340	**2936**	
B						II BD	18			8480			7.34	**6.24**	3470			
C						II BD	18						6.49	**6.49**				**16.56**
105A	I2016	9/6/01	10/4/01	03-0857	3	II	20.4			7890	8375	**7362**	6.75	**5.74**	3430	3330	**2927**	
B						II	20.4			8860			5.95	**5.06**	3230			
C						II	20.4						4.86	**4.86**				**11.65**
106A	02-0688	9/6/01	10/4/01	02-0688	2	IV			50	3030	2925	**2571**	17.25	**14.66**	2390	2355	**2070**	
B						IV			50	2820			18.50	**15.73**	2320			
C						IV			50				17.40	**17.40**				**22.95**
107A	G2002	9/6/01	10/4/01	07-0549	7	II			50	2820	2680	**2356**	19.04	**16.18**	1950	2010	**1767**	
B						II			50	2540			18.86	**16.03**	2070			
C						II			50				14.65	**14.65**				**18.01**
108A	G5002	9/6/01	10/4/01	07-0130	7	V SP	18			4510	4785	**4206**	13.21	**11.23**	1680	1635	**1437**	
B						V SP	18			5060			13.24	**11.25**	1590			
C						V SP	18						10.61	**10.61**				**27.28**
109-1	02-M0923	9/10/01	10/8/01	02-0923	2	IV DS				8140	8567	**7530**	6.73	**5.72**	6740	6862	**6031**	
109-2						IV DS				8170			6.98	**5.93**	6820			
109-3						IV DS				8080			7.00	**7.00**	6850			
109-4													5.99	**5.09**				**7.46**
109-5													6.34	**5.39**				**7.83**
109-6													5.90	**5.90**				**7.61**
109-7										8960			7.06	**6.00**	6890			
109-8										8760			6.86	**5.83**	6900			
109-9										9290			6.95	**6.95**	6970			
109-10													5.58	**4.74**				**7.60**
109-11													5.80	**4.93**				**7.68**
109-12													5.81	**5.81**				**7.30**
110A	IA003	9/10/01	10/8/01	05-0621	8	II BD	19.9			6150	6450	**5670**	9.30	**7.91**	2810	2820	**2479**	
B						II BD	19.9			6750			9.81	**8.34**	2830			
C						II BD	19.9						7.39	**7.39**				**14.43**
111A	IX201	9/11/01	10/9/01	03-0842	3	II	19.5			10700	11000	**9669**	5.73	**4.87**	4160	4405	**3872**	
B						II	19.5			11300			5.80	**4.93**	4650			
C						II	19.5						4.76	**4.76**				**12.10**
112A	I2017	9/11/01	10/9/01	03-0857	3	II	20.4			4990	5315	**4672**	7.99	**6.79**	2310	2310	**2030**	
B						II	20.4			5640			8.45	**7.18**	2310			
C						II	20.4						7.04	**7.04**				**17.75**
113-1	SC8	9/11/01	10/9/01	02-0919	2	V SP				4950	5393	**4741**	11.19	**9.51**	4670	5222	**4590**	
113-2	SC8					V SP				5180			10.95	**9.31**	5190			
113-3	SC8					V SP				5010			11.44	**11.44**	4820			
113-4	SC8												9.70	**8.25**				**12.40**
113-5	SC8												8.79	**7.47**				**11.16**
113-6	SC8												7.66	**7.66**				**9.58**
113-7	SC8									6180			8.99	**7.64**	5610			
113-8	SC8									5490			9.45	**8.03**	5610			
113-9	SC8									5550			9.31	**9.31**	5430			
113-10	SC8												7.65	**6.50**				**10.09**
113-11	SC8												7.16	**6.09**				**9.38**
113-12	SC8												8.60	**8.60**				**11.54**

114A	SC8	9/11/01	10/9/01	02-0919	2	V SP				5670	5715	**5023**	12.13	**10.31**				
B						V SP				5760			13.43	**11.42**				
C						V SP							8.73	**8.73**				
115A	02-M0869	9/12/01	10/10/01	02-0869	2	IV		50		2150	2155	**1894**	24.48	**20.81**	1700	1740	**1529**	
B						IV		50		2160			25.04	**21.28**	1780			
C						IV		50					19.71	**19.71**				**21.59**
116A	SW 2	9/17/01	10/15/01	02-0308	2	V SP	18.3			4880	5115	**4496**	10.68	**9.08**				
B						V SP	18.3			5350			10.85	**9.22**				
C						V SP	18.3						9.14	**9.14**				
117A	02-M0833	9/18/01	10/16/01	02-0833	2	IV DS		60		2380	2320	**2039**	21.10	**17.94**	2070	2015	**1771**	
B						IV DS		60		2260			21.99	**18.69**	1960			
C						IV DS		60					17.90	**17.90**				**23.29**
118A	SC-9	9/18/01	10/16/01	02-0919	2	V SP				4150	4180	**3674**	14.49	**12.32**				
B						V SP				4210			14.00	**11.90**				
C						V SP							11.70	**11.70**				
119A	I2005	9/18/01	10/16/01	04-0424	8	II				5770	5670	**4984**	9.14	**7.77**	5270	5260	**4624**	
B						II				5570			8.96	**7.62**	5250			
C						II							7.80	**7.80**				**9.21**
120A	IX201	9/18/01	10/16/01	03-0477	3	II				8520	8720	**7665**	7.55	**6.42**	6590	6725	**5911**	
B						II				8920			7.28	**6.19**	6860			
C						II							6.10	**6.10**				**7.33**
121A	I4370	9/19/01	10/17/01	04-0434	4	IV DS		60		2360	2390	**2101**	27.26	**23.17**	1840	1805	**1587**	
B						IV DS		60		2420			26.13	**22.21**	1770			
C						IV DS		60					21.84	**21.84**				**25.98**
122A	02-0692	9/19/01	10/17/01	02-0692	2	IV		70.1		1650	1600	**1406**	31.86	**27.08**	1400	1370	**1204**	
B						IV		70.1		1550			31.86	**27.08**	1340			
C						IV		70.1					29.81	**29.81**				**35.64**
123A	G2004	9/23/01	10/21/01	07-0511	7	II BD	21.9			10400	10155	**8926**	7.38	**6.27**				
B						II BD	21.9			9910			6.69	**5.69**				
C						II BD	21.9						6.41	**6.41**				
124A	G2005	9/23/01	10/21/01	07-0511	7	II BD	21.9			9350	9125	**8021**	6.80	**5.78**				
B						II BD	21.9			8900			7.48	**6.36**				
C						II BD	21.9						6.14	**6.14**				
125A	IX502	9/24/01	10/22/01	03-0907	3	V SP	19.9			5100	4985	**4382**	12.00	**10.20**	1610	1610	**1415**	
B						V SP	19.9			4870			11.26	**9.57**				
C						V SP	19.9						10.63	**10.63**				**29.38**
126A	G2006	9/24/01	10/22/01	07-0511	7	II BD	21.9			9250	9065	**7968**	7.75	**6.59**	2800	2960	**2602**	
B						II BD	21.9			8880			7.60	**6.46**	3120			
C						II BD	21.9						6.14	**6.14**				**15.30**
127A	IX011	9/24/01	10/22/01	03-0638	3	IV DS	33			5940	5940	**5221**	11.39	**9.68**	1710	1675	**1472**	
B						IV DS	33						11.43	**9.72**	1640			
C						IV DS	33						9.65	**9.65**				**31.71**
128A	I2023	9/25/01	10/23/01	04-2050	4	II BD		51.2		1760	1715	**1507**	26.90	**22.87**				
B						II BD		51.2		1670			27.35	**23.25**				
C						II BD		51.2					18.85	**18.85**				
129A	I4001	9/25/01	10/23/01	04-0420	4	II				2310	2220	**1951**	23.63	**20.09**				
B						II				2130			23.60	**20.06**				
C						II							22.16	**22.16**				
130A	I4082	9/26/01	10/24/01	06-0280	6	IV		51.1		2090	2100	**1846**	26.23	**22.30**	1760	1725	**1516**	
B						IV		51.1		2110			28.06	**23.85**	1690			
C						IV		51.1					21.23	**21.23**				**27.89**
131A	G4004	9/27/01	10/25/01	01-2038	1	IV	18.7		30 mL	4410	4025	**3538**	15.85	**13.47**	1800	1880	**1653**	
B						IV	18.7		30 mL	3640			16.40	**13.94**	1960			
C						IV	18.7		30 mL				13.68	**13.68**				**27.63**
132A	G4003	9/27/01	10/25/01	01-2038	1	IV	18.7		30 mL	2820	2685	**2360**	19.23	**16.35**	1550	1590	**1398**	
B						IV	18.7		30 mL	2550			17.11	**14.54**	1630			
C						IV	18.7		30 mL				16.95	**16.95**				**31.21**
133A	I4001	9/27/01	10/25/01	07-0470	7	IV DS	36.5			11700	11050	**9713**	6.56	**5.58**	3060	3205	**2817**	
B						IV DS	36.5			10400			6.01	**5.11**	3350			
C						IV DS	36.5						5.71	**5.71**				**17.01**

134A	IX012	9/27/01	10/25/01	03-0859	3	V SP	18			2860	2900	**2549**	19.84	**16.86**	1220	1200	**1055**	
B						V SP	18			2940			20.36	**17.31**	1180			
C						V SP	18						15.73	**15.73**				**38.39**
135A	G2001	9/28/01	10/26/01	01-0214	1	II				12200	11650	**10240**	6.64	**5.64**	10100	9625	**8460**	
B						II				11100			6.85	**5.82**	9150			
C						II							5.73	**5.73**				**6.49**
136A	I2006	10/1/01	10/29/01	04-0424	8	II				5200	5370	**4720**	9.48	**8.06**	5480	5850	**5142**	
B						II				5540			9.19	**7.81**	6220			
C						II							7.75	**7.75**				**8.63**
137A	SW6	10/2/01	10/30/01	02-0308	2	V SP	18.3			4620	4930	**4333**	11.70	**9.95**				
B						V SP	18.3			5240			11.74	**9.98**				
C						V SP	18.3			5020			11.20	**11.20**				
138A	ID504	10/2/01	10/30/01	03-0845	3	IV DS	33			21600	20750	**18239**	5.76	**4.90**				
B						IV DS	33			19900			6.04	**5.13**				
C						IV DS	33						4.49	**4.49**				
139A	IA006	10/2/01	10/30/01	01-0537	8	II	22			8480	8410	**7392**	7.85	**6.67**				
B						II	22			8340			7.13	**6.06**				
C						II	22						6.36	**6.36**				
140A	G4001	10/3/01	10/31/01	07-0590	7	IV	19.2			7630	7520	**6610**	8.86	**7.53**	2610	2470	**2171**	
B						IV	19.2			7410			8.74	**7.43**	2330			
C						IV	19.2						6.99	**6.99**				**16.71**
141A	A4024	10/3/01	10/31/01	05-0451	5	IV	18			6760	6615	**5815**	9.38	**7.97**	2750	2755	**2422**	
B						IV	18			6470			9.34	**7.94**	2760			
C						IV	18						8.09	**8.09**				**17.41**
142A	IA008	10/3/01	10/31/01	01-0537	8	II	22			8540	9620	**8456**	7.78	**6.61**	3370	3770	**3314**	
B						II	22			10700			6.14	**5.22**	4170			
C						II	22						6.34	**6.34**				**13.60**
143A	DC-1	10/3/01	10/31/01	02-0308	2	V SP	18.3			4660	4760	**4184**	10.95	**9.31**				
B						V SP	18.3			4860			12.79	**10.87**				
C						V SP	18.3			5040			10.70	**10.70**				
144A	IA007	10/3/01	10/31/01	01-0537	8	II	22			7910	8460	**7436**	8.64	**7.34**	3300	3440	**3024**	
B						II	22			9010			7.80	**6.63**	3580			
C						II	22						7.01	**7.01**				**14.70**
145A	I4001	10/4/01	11/1/01	03-0937	3	IV DS	35			9110	9530	**8377**	6.38	**5.42**	3870	3430	**3015**	
B						IV DS	35			9950			6.51	**5.53**	2990			
C						IV DS	35						5.46	**5.46**				**13.25**
146A	IX202	10/4/01	11/1/01	03-0842	3	II	19.5			7560	7450	**6549**	7.73	**6.57**	3120	3120	**2742**	
B						II	19.5			7340			8.38	**7.12**	3120			
C						II	19.5						6.95	**6.95**				**19.25**
147A	I2001	10/8/01	11/5/01	05-0786	5	II BD	20			7170	7395	**6500**	10.38	**8.82**	2700	2745	**2413**	
B						II BD	20			7620			9.50	**8.08**	2790			
C						II BD	20						7.16	**7.16**				**16.98**
148A	I2002	10/9/01	11/6/01	05-2057	5	II BD	19.9			6630	6460	**5678**	10.45	**8.88**	2430	2500	**2198**	
B						II BD	19.9			6290			10.79	**9.17**	2570			
C						II BD	19.9						8.68	**8.68**				**20.00**
149A	I4005	10/9/01	11/6/01	03-0386	3	I	20			4710	4790	**4210**	12.94	**11.00**	1980	1990	**1749**	
B						I	20			4870			12.35	**10.50**	2000			
C						I	20						10.46	**10.46**				**26.64**
150A	02-M2061	10/9/01	11/6/01	02-2061	2	IV		60		2170	2110	**1855**	29.00	**24.65**	1380	1390	**1222**	
B						IV		60		2050			28.63	**24.34**	1400			
C						IV		60					24.35	**24.35**				**27.53**
151A	G2001	10/10/01	11/7/01	07-2063	7	II		50		2630	2520	**2215**	22.94	**19.50**	1910	1890	**1661**	
B						II		50		2410			20.88	**17.75**	1870			
C						II		50					18.46	**18.46**				**22.69**
152A	IA001	10/10/01	11/7/01	05-0457	8	I SP	21.9			7320	7210	**6338**	9.04	**7.68**	2340	2380	**2092**	
B						I SP	21.9			7100			9.44	**8.02**	2420			
C						I SP	21.9						7.86	**7.86**				**20.10**
153A	A4001	10/11/01	11/8/01	07-0590	5	IV	19.2			4600	4510	**3964**	14.65	**12.45**	2390	2430	**2136**	
B						IV	19.2			4420			12.14	**10.32**	2470			
C						IV	19.2						11.05	**11.05**				**19.68**

154A	G4001	10/12/01	11/9/01	01-0520	1	IV		50		2120	2210	1943	26.31	22.36	1600	1755	1543	32.11
B						IV		50		2300			27.20	23.12	1910			33.28
C						IV		50										
155A	G4001	10/12/01	11/9/01	07-0470	7	IV DS	36.5			3710	3780	3323	15.91	13.52	1380	1420	1248	
B						IV DS	36.5			3850			16.21	13.78	1460			
C						IV DS	36.5						12.69	12.69				27.20
156A	SB1	10/12/01	11/9/01	02-0308	2	V SP	18.3			6300	6265	5507	10.55	8.97				
B						V SP	18.3			6230			9.64	8.19				
C						V SP	18.3						8.53	8.53				
157A	02-M0898	10/16/01	11/13/01	02-0898	2	II BD		50		2020	2020	1776	30.09	25.58	1720	1735	1525	
B						II BD		50		2020			28.81	24.49	1750			
C						II BD		50					25.86	25.86				31.45
158A	I2001	10/17/01	11/14/01	03-2038	3	II BD	20			5040	4765	4188	16.45	13.98	1730	1830	1609	
B						II BD	20			4490			13.75	11.69	1930			
C						II BD	20						11.85	11.85				28.27
159A	IA002	10/22/01	11/19/01	05-0602	8	IV DS	34.9			7810	7685	6755	8.79	7.47	2910	2815	2474	
B						IV DS	34.9			7560			9.14	7.77	2720			
C						IV DS	34.9						7.66	7.66				17.20
160A	I4001	10/24/01	11/21/01	03-0865	3	IV	19.7			3900	3800	3340	17.95	15.26	1430	1395	1226	
B						IV	19.7			3700			18.46	15.69	1360			
C						IV	19.7						14.86	14.86				37.20
161A	IDX503	10/24/01	11/21/01	03-0907	3	V SP	19.9			4280	4160	3657	16.44	13.97	1660	1710	1503	
B						V SP	19.9			4040			15.64	13.29	1760			
C						V SP	19.9						13.81	13.81				31.84
162A	I2001	10/25/01	11/21/01	03-0936	3	II	19			7950	7910	6953	8.41	7.15	3290	3720	3270	
B						II	19			7870			7.58	6.44	4150			
C						II	19						7.09	7.09				14.14
163A	G4005	10/24/01	11/21/01	01-2032	1	IV	18.7			5610	6650	5845	10.10	8.59	2810	2800	2461	
B						IV	18.7			7690			8.69	7.39	2790			
C						IV	18.7						7.94	7.94				16.36
164A	02-0308	10/30/01	11/27/01	02-0308	2	V SP	18.3			5540	5250	4615	10.15	8.63				
B						V SP	18.3			4960			10.74	9.13				
C						V SP	18.3						8.35	8.35				
165A	02-0308	10/30/01	11/27/01	02-0308	2	V SP	18.3			6170	5865	5155	9.98	8.48				
B						V SP	18.3			5560			10.95	9.31				
C						V SP	18.3						8.71	8.71				
166A	G4001	10/30/01	11/27/01	07-2066	7	IV DS		60.3		2490	2635	2316	19.94	16.95	2170	2105	1850	
B						IV DS		60.3		2780			21.48	18.26	2040			
C						IV DS		60.3					18.73	18.73				19.95
167A	RCP01	10/31/01	11/28/01	02-0688	2	IV		50		2480	2585	2272	24.38	20.72	1980	2010	1767	
B						IV		50		2690			22.38	19.02	2040			
C						IV		50					19.10	19.10				24.28
168A	ID505	11/1/01	11/29/01	03-0845	3	IV DS	33			19900	18350	16130	5.53	4.70	5490	5400	4747	
B						IV DS	33			16800			5.65	4.80	5310			
C						IV DS	33						4.09	4.09				10.96
169A	I4002	11/1/01	11/29/01	03-0844	3	IV	20			6270	6305	5542	12.49	10.62	1910	1930	1696	
B						IV	20			6340			13.33	11.33	1950			
C						IV	20						10.25	10.25				25.53
170A	02-0748	11/1/01	11/29/01	02-0748	2	IV DS		60		3360	3230	2839	18.73	15.92	2180	2190	1925	
B						IV DS		60		3100			18.31	15.56	2200			
C						IV DS		60					15.73	15.73				22.41
171A	SC10	11/5/01	12/3/01	02-0919	2	V SP				4670	4985	4382	16.28	13.84				
B						V SP				5300			14.94	12.70				
C						V SP							12.79	12.79				
172A	SB15	11/5/01	12/3/01	02-0308	2	V SP	18.3			6590	6830	6004	10.09	8.58				
B						V SP	18.3			7070			9.33	7.93				
C						V SP	18.3						7.80	7.80				
173A	I4001	11/5/01	12/3/01	03-0898	3	IV	19.7			6650	7260	6382	9.61	8.17	2480	2705	2378	
B						IV	19.7			7870			9.08	7.72	2930			
C						IV	19.7						7.75	7.75				18.34

174A	IX001	11/6/01	12/4/01	03-0836	3	IV	19.7			4500	4505	**3960**	11.84	**10.06**	1790	1735	**1525**	
B						IV	19.7			4510			12.65	**10.75**	1680			
C						IV	19.7						11.09	**11.09**				**28.10**
175A	I2005	11/6/01	12/4/01	05-2057	5	II BD	19.9			6420	6380	**5608**	12.16	**10.34**	2340	2410	**2118**	
B						II BD	19.9			6340			11.29	**9.60**	2480			
C						II BD	19.9						9.69	**9.69**				**21.34**
176A	SC10	11/5/01	12/3/01	02-0919	2	V SP				5010	5335	**4689**	14.33	**12.18**				
B						V SP				5660			13.44	**11.42**				
C						V SP							11.10	**11.10**				
177A	3341	11/6/01	12/4/01	02-3341	2	II				8590	8075	**7098**	8.00	**6.80**	7740	7545	**6632**	
B						II				7560			8.74	**7.43**	7350			
C						II							6.86	**6.86**				**7.70**
178A	3341	11/6/01	12/4/01	02-3341	2	II				8210	7850	**6900**	8.78	**7.46**	7540	7250	**6373**	
B						II				7490			8.65	**7.35**	6960			
C						II							7.38	**7.38**				**8.46**
179A	SB16	11/7/01	12/5/01	02-0308	2	V SP	18.3											
B						V SP	18.3											
C						V SP	18.3											
180A	SB16(A)	11/7/01	12/5/01	02-0308	2	V SP	18.3			4780	4960	**4360**	11.49	**9.77**				
B						V SP	18.3			5140			11.20	**9.52**				
C						V SP	18.3						8.85	**8.85**				
181A	IC401	11/7/01	12/5/01	03-0844	3	IV	20			8230	9045	**7951**	10.40	**8.84**	2410	2395	**2105**	
B						IV	20			9860			10.48	**8.91**	2380			
C						IV	20						8.44	**8.44**				**22.26**
182A	G4001	11/8/01	12/6/01	07-0470	7	IV DS	36.5			4030	3840	**3375**	13.78	**11.71**	1550	1520	**1336**	
B						IV DS	36.5			3650			14.26	**12.12**	1490			
C						IV DS	36.5						11.41	**11.41**				**25.20**
183A	G4006	11/8/01	12/6/01	01-2038	1	IV	18.7		30 mL	2820	2685	**2360**	19.15	**16.28**	1460	1695	**1490**	
B						IV	18.7		30 mL	2550			17.40	**14.79**	1930			
C						IV	18.7		30 mL				17.25	**17.25**				**32.39**
184A	BREP 4	11/8/01	12/6/01	02-0688	2	IV		50		3050	2905	**2553**	20.11	**17.09**				
B						IV		50		2760			18.68	**15.88**				
C						IV		50					15.94	**15.94**				
185A	I2001	11/8/01	12/6/01	06-0276	8	II BD		51		1580	1630	**1433**	33.55	**28.52**	1500	1490	**1310**	
B						II BD		51		1680			33.19	**28.21**	1480			
C						II BD		51					28.20	**28.20**				**34.70**
186A	I2001	11/10/01	12/8/01	05-0621	8	II BD	19.9			3140	3225	**2835**	18.60	**15.81**	1860	1740	**1529**	
B						II BD	19.9			3310			17.98	**15.28**	1620			
C						II BD	19.9						11.63	**11.63**				**19.53**
187A	I2012	11/10/01	12/8/01	05-0621	8	II BD	19.9			4690	3925	**3450**	12.80	**10.88**	2600	2060	**1811**	
B						II BD	19.9			3160			16.70	**14.20**	1520			
C						II BD	19.9						12.63	**12.63**				**19.74**
188A	I5004	11/13/01	12/11/01	03-0905	3	V SP	18.1			6090	6405	**5630**	11.85	**10.07**	2410	2510	**2206**	
B						V SP	18.1			6720			10.99	**9.34**	2610			
C						V SP	18.1						10.45	**10.45**				**20.48**
189A	G4001	11/15/01	12/13/01	07-0481	7	IV		50		3140	3095	**2721**	16.64	**14.14**	1110	1095	**963**	
B						IV		50		3050			17.36	**14.76**	1080			
C						IV		50					15.65	**15.65**				**32.70**
190A	G2001	11/15/01	12/13/01	07-0511	7	II BD	21.9			8100	8240	**7243**	9.19	**7.81**	2680	2945	**2589**	
B						II BD	21.9			8380			8.96	**7.62**	3210			
C						II BD	21.9						6.68	**6.68**				**14.66**
191A	SB22	11/15/01	12/13/01	02-0940	2	V SP	18.3			6210	6235	**5481**	10.05	**8.54**	2710	2855	**2510**	
B						V SP	18.3			6260			9.81	**8.34**	3000			
C						V SP	18.3						8.20	**8.20**				**14.46**
192A	SB23	11/15/01	12/13/01	02-0940	2	V SP	18.3			6530	6255	**5498**	9.53	**8.10**	3170	2995	**2633**	
B						V SP	18.3			5980			9.50	**8.08**	2820			
C						V SP	18.3						7.56	**7.56**				**13.61**
193A	02-0688	11/15/01	12/13/01	02-0688	2	IV		50		2350	2395	**2105**	28.84	**24.51**	1640	1655	**1455**	
B						IV		50		2440			24.28	**20.64**	1670			
C						IV		50					21.75	**21.75**				**28.90**

194A	IX015	11/16/01	12/14/01	03-2038	3	II BD	20			2760	2655	2334	20.11	17.09	1150	1155	1015	
B						II BD	20			2550			20.65	17.55	1160			
C						II BD	20						16.90	16.90				41.10
195A	I2013	11/17/01	12/15/01	05-0621	8	II BD	19.9			5860	5795	5094	11.14	9.47	3010	2970	2611	
B						II BD	19.9			5730			11.94	10.15	2930			
C						II BD	19.9						8.69	8.69				13.90
196A	I2014	11/17/01	12/15/01	05-0621	8	II BD	19.9			6010	5635	4953	10.09	8.58	2940	2925	2571	
B						II BD	19.9			5260			11.48	9.76	2910			
C						II BD	19.9						7.69	7.69				13.11
197A	SB24	11/19/01	12/17/01	02-0940	2	V SP	18.3			6550	6490	5705	9.85	8.37	3240	3260	2866	
B						V SP	18.3			6430			9.46	8.04	3280			
C						V SP	18.3						8.00	8.00				12.86
198A	SB24(A)	11/19/01	12/17/01	02-0940	2	V SP	18.3			7010	6635	5832	10.14	8.62	3230	3220	2830	
B						V SP	18.3			6260			10.04	8.53	3210			
C						V SP	18.3						8.24	8.24				13.41
199A	TA-71	11/19/01	12/17/01	?	2	IV				2900	2770	2435	22.48	19.11				
B						IV				2640			24.58	20.89				
C						IV							17.80	17.80				
200A	G4001	11/20/01	12/18/01	07-0470	1	IV DS	36.5			5980	5915	5199	10.54	8.96	1840	1870	1644	
B						IV DS	36.5			5850			11.00	9.35	1900			
C						IV DS	36.5						9.50	9.50				19.90
201A	02-M0840	11/20/01	12/18/01	02-0840	2	II		50		2310	2430	2136	21.05	17.89	2050	2005	1762	
B						II		50		2550			21.18	18.00	1960			
C						II		50					18.60	18.60				23.00
202A	I2002	11/20/01	12/18/01	06-0276	8	II BD		51		2680	2630	2312	29.76	25.30	1510	1493.5	1313	
B						II BD		51		2580			29.66	25.21	1477			
C						II BD		51					26.11	26.11				29.60
203A	I2001	11/20/01	12/18/01	04-0555	8	II		59.9		1750	1820	1600	37.73	32.07	974	979	861	
B						II		59.9		1890			43.80	37.23	984			
C						II		59.9					35.64	35.64				44.79
204A	IX016	11/20/01	12/18/01	03-0882	3	VI	18			1160	1195	1050	20.81	17.69	1110	1150	1011	
B						VI	18			1230			20.73	17.62	1190			
C						VI	18						18.53	18.53				41.24
205A	IX017	11/20/01	12/18/01	03-0882	3	VI	18			2910	3005	2641	22.11	18.79	1030	1020	897	
B						VI	18			3100			22.61	19.22	1010			
C						VI	18						20.00	20.00				44.35
206A	H-01	11/21/01	12/19/01	02-0940	2	V SP	18.3			5500	5855	5147	10.85	9.22	2900	2890	2540	
B						V SP	18.3			6210			11.38	9.67	2880			
C						V SP	18.3						9.66	9.66				16.35
207A	H-02A	11/28/01	12/26/01	02-0940	2	V SP	18.3			7120	7030	6179	9.09	7.73	3090	2960	2602	
B						V SP	18.3			6940			9.38	7.97	2830			
C						V SP	18.3						7.99	7.99				13.60
208A	H-02A	11/28/01	12/26/01	02-0940	2	V SP	18.3			7020	6840	6012	8.45	7.18	3080	3005	2641	
B						V SP	18.3			6660			9.51	8.08	2930			
C						V SP	18.3						8.01	8.01				14.23
209A	IX018	11/28/01	12/26/01	03-0612	3	II BD	18.1			4750	4785	4206	13.21	11.23	1580	1575	1384	
B						II BD	18.1			4820			14.25	12.11	1570			
C						II BD	18.1						12.16	12.16				28.86
210A	IX019	11/28/01	12/26/01	03-0612	3	II BD	18.1			4740	4680	4114	13.83	11.76	1631	1600.5	1407	
B						II BD	18.1			4620			12.94	11.00	1570			
C						II BD	18.1						12.06	12.06				29.39
211A	DC-10	11/29/01	12/27/01	02-0940	2	V SP	18.3			6170	6020	5292	9.71	8.25	3190	3110	2734	
B						V SP	18.3			5870			9.71	8.25	3030			
C						V SP	18.3						8.83	8.83				15.80
212A	DC-9	11/29/01	12/27/01	02-0940	2	V SP	18.3			5910	5990	5265	9.86	8.38	3050	3030	2663	
B						V SP	18.3			6070			9.64	8.19	3010			
C						V SP	18.3						8.09	8.09				15.21
213A	IX020	11/29/01	12/27/01	03-0638	3	IV DS	33			5570	5395	4742	14.03	11.93	1465	1417.5	1246	
B						IV DS	33			5220			14.78	12.56	1370			
C						IV DS	33						11.86	11.86				15.85

214A	DC12A	11/30/01	12/28/01	02-0940	2	V SP	18.3		5700	5680	**4993**	9.74	**8.28**	2510	2570	**2259**	
B						V SP	18.3		5660			9.83	**8.36**	2630			
C						V SP	18.3					8.65	**8.65**				
215A	DC12A	11/30/01	12/28/01	02-0940	2	V SP	18.3		5980	5825	**5120**	10.19	**8.66**	2740	2795	**2457**	
B						V SP	18.3		5670			9.69	**8.24**	2850			
C						V SP	18.3					9.06	**9.06**				
216A	DC-13	12/3/01	12/31/01	02-0940	2	V SP	18.3		6770	7150	**6285**	9.91	**8.42**	2300	2240	**1969**	
B						V SP	18.3		7530			8.99	**7.64**	2180			
C						V SP	18.3					7.83	**7.83**				**14.91**
217A	IX505	12/5/01	1/2/02	03-0905	3	V SP	18.1		5900	6325	**5560**	11.38	**9.67**	3070	3075	**2703**	
B						V SP	18.1		6750			11.06	**9.40**	3080			
C						V SP	18.1					9.93	**9.93**				**18.94**
218A	A4033	12/3/01	12/31/01	02-2060	2	IV		50	3330	3365	**2958**	20.38	**17.32**	1630	1640	**1442**	
B						IV		50	3400			19.95	**16.96**	1650			
C						IV		50				17.38	**17.38**				**23.64**
219A	IX402	12/6/01	1/3/02	03-0865	3	IV	19.7		4960	4925	**4329**	15.15	**12.88**				
B						IV	19.7		4890			16.71	**14.20**				
C						IV	19.7					12.83	**12.83**				**36.93**
220A	A4034	12/7/01	1/4/02	02-2060	2	IV		50	2520	2485	**2184**	25.31	**21.51**	1580	1615	**1420**	
B						IV		50	2450			24.09	**20.48**	1650			
C						IV		50				20.60	**20.60**				**31.00**
221A	G4001	12/6/01	1/3/02	01-0475	1	IV DS	33.8		6290	5995	**5270**	12.84	**10.91**				
B						IV DS	33.8		5700			12.34	**10.49**				
C						IV DS	33.8					9.85	**9.85**				**26.89**
222A	I4001	12/10/01	1/7/02	03-0638	3	IV DS	33		5330	5470	**4808**	15.66	**13.31**	1020	1005	**883**	
B						IV DS	33		5610			15.34	**13.04**	990			
C						IV DS	33					12.34	**12.34**				**41.77**
223A	I2015	12/12/01	1/9/02	05-0621	8	II BD	19.9		6530	6280	**5520**	11.70	**9.95**	3270	3145	**2764**	
B						II BD	19.9		6030			10.16	**8.64**	3020			
C						II BD	19.9					8.69	**8.69**				**13.22**
224A	I2016	12/12/01	1/9/02	05-0621	8	II BD	19.9		7210	7385	**6491**	9.30	**7.91**	3450	3410	**2997**	
B						II BD	19.9		7560			9.96	**8.47**	3370			
C						II BD	19.9					8.56	**8.56**				**13.70**
225A	G2001	12/17/01	1/14/02	07-0403	7	II	22		9550	10275	**9032**	8.10	**6.89**	3300	3490	**3068**	
B						II	22		11000			7.94	**6.75**	3680			
C						II	22					6.73	**6.73**				**13.70**
226A	G2002	12/17/01	1/14/02	07-0403	7	II	22		10500	10400	**9142**	6.88	**5.85**	3890	3995	**3512**	
B						II	22		10300			7.15	**6.08**	4100			
C						II	22					6.39	**6.39**				**13.10**
227A	A2003	12/19/01	1/16/02	02-2057	2	II		49.9	2270	2265	**1991**	25.74	**21.88**	1293	1306.5	**1148**	
B						II		49.9	2260			26.00	**22.10**	1320			
C						II		49.9				23.88	**23.88**				**32.80**
228A	02-M0860	12/20/01	1/17/02	02-0860	2	IV		50	3420	3500	**3077**	18.44	**15.67**	1900	1945	**1710**	
B						IV		50	3580			17.53	**14.90**	1990			
C						IV		50				16.04	**16.04**				**22.70**
229A	02-M2057	12/21/01	1/18/02	02-2057	2	II		49.9	2230	2315	**2035**	28.14	**23.92**	1200	1245	**1094**	
B						II		49.9	2400			26.93	**22.89**	1290			
C						II		49.9				22.68	**22.68**				**30.55**
230A	G5004	12/21/01	1/18/02	07-0130	7	V SP	18		6220	6050	**5318**	11.25	**9.56**	1650	1665	**1464**	
B						V SP	18		5880			11.93	**10.14**	1680			
C						V SP	18					9.60	**9.60**				**20.73**
231A	E4376	12/26/01	1/23/02	02-0948	2	IV		50	4670	4700	**4131**	17.78	**15.11**	1690	1700	**1494**	
B						IV		50	4730			17.96	**15.27**	1710			
C						IV		50				13.36	**13.36**				**24.51**
232A	E4377	12/28/01	1/25/02	02-0748	2	IV DS		60	3590	3670	**3226**	18.76	**15.95**	1370	1345	**1182**	
B						IV DS		60	3750			19.68	**16.73**	1320			
C						IV DS		60				16.01	**16.01**				**32.62**
233A	E4378	1/3/02	1/31/02	02-0692	2	IV		70.1	2100	2095	**1842**	29.30	**24.91**	1045	1037.5	**912**	
B						IV		70.1	2090			30.15	**25.63**	1030			
C						IV		70.1				24.84	**24.84**				**43.57**

234A	E4380	1/4/02	2/1/02	02-0748	2	IV DS		60		3160	3310	2909	19.25	16.36	1910	1765	1551	
B						IV DS		60		3460			19.33	16.43	1620			
C						IV DS		60					17.14	17.14				27.55
235A	E4382	1/5/02	2/2/02	02-0692	2	IV		70.1		2410	2270	1995	25.31	21.51	1209	1254.5	1103	
B						IV		70.1		2130			27.58	23.44	1300			
C						IV		70.1					23.49	23.49				34.57
236A	E4381	1/5/02	2/2/02	02-0948	2	IV		50		3840	3870	3402	18.14	15.42	1960	1885	1657	
B						IV		50		3900			18.21	15.48	1810			
C						IV		50					15.96	15.96				25.65
237A	02-M0787	1/10/02	2/7/02	02-0787	2	IV DS	35			5300	5230	4597	12.29	10.45	1640	1655	1455	
B						IV DS	35			5160			12.41	10.55	1670			
C						IV DS	35						9.96	9.96				23.46
238A	G4001	1/14/02	2/11/02	01-0577	1	IV				12900	13250	11647	7.41	6.30	6160	6710	5898	
B						IV				13600			7.45	6.33	7260			
C						IV							5.64	5.64				6.26
239A	G2001	1/15/02	2/12/02	01-0472	1	II	20			6410	6165	5419	8.96	7.62	2480	2355	2070	
B						II	20			5920			9.93	8.44	2230			
C						II	20						7.46	7.46				14.53
240A	E4403	1/15/02	2/12/02	02-0948	2	IV		50		2450	2400	2110	24.19	20.56	1280	1335	1173	
B						IV		50		2350			24.51	20.83	1390			
C						IV		50					19.51	19.51				30.58
241A	E4413	1/19/02	2/16/02	02-0692	2	IV		70.1		1510	1555	1367	40.16	34.14	886	943	829	
B						IV		70.1		1600			40.88	34.75	1000			
C						IV		70.1					35.85	35.85				46.51
242A	G2001	1/23/02	2/20/02	01-0396	1	II				11200	11250	9889	7.45	6.33	7740	8160	7173	
B						II				11300			6.70	5.70	8580			
C						II							5.73	5.73				6.56
243A	IX007	1/23/02	2/20/02	03-0903	3	I SP	20.2			4820	4925	4329	13.73	11.67	1850	1870	1644	
B						I SP	20.2			5030			13.48	11.46	1890			
C						I SP	20.2						11.35	11.35				24.56
244A	ID401	1/24/02	2/21/02	03-2008	3	IV DS	34.9			6370	6250	5494	13.89	11.81	1090	1080	949	
B						IV DS	34.9			6130			14.48	12.31	1070			
C						IV DS	34.9						11.50	11.50				45.26
245A	I5002	1/25/02	2/22/02	05-0800	5	V	21.8			1190	1225	1077	50.60	43.01	364	376.5	331	
B						V	21.8			1260			50.86	43.23	389			
C						V	21.8						39.45	39.45				110.93
246A	I5001	1/25/02	2/22/02	05-0800	5	V	21.8			1180	1108.5	974	52.94	45.00	345	343.5	302	
B						V	21.8			1037			51.76	44.00	342			
C						V	21.8											
247A	G2001	1/28/02	2/25/02	01-0575	1	II				11400	9585	8425	6.69	5.69	8560	8360	7348	
B						II				7770			6.48	5.51	8160			
C						II							5.64	5.64				5.78
248A	G5005	1/29/02	2/26/02	07-0578	1	IV	17.7			5030	5255	4619	11.53	9.80	2380	2520	2215	
B						IV	17.7			5480			11.34	9.64	2660			
C						IV	17.7						9.54	9.54				15.95
249A	I2001	1/30/02	2/27/02	03-0842	3	II	19.5			11100	12100	10636	6.39	5.43	5000	4500	3956	
B						II	19.5			13100			7.71	6.55	4000			
C						II	19.5						6.53	6.53				14.63
250A	G2007	1/30/02	2/27/02	07-0511	7	II BD	21.9			7170	6990	6144	10.66	9.06	2073	1996.5	1755	
B						II BD	21.9			6810			10.50	8.93	1920			
C						II BD	21.9						8.68	8.68				20.32
251A	G2002	1/30/02	2/27/02	01-0575	1	II				13100	13100	11515	6.06	5.15	8530	8085	7107	
B						II				13100			6.55	5.57	7640			
C						II							5.50	5.50				5.96
252A	G2003	1/31/02	2/28/02	01-0575	1	II				10200	10350	9098	6.88	5.85	8370	8605	7564	
B						II				10500			7.34	6.24	8840			
C						II							6.33	6.33				6.68
253A	G2004	1/31/02	2/28/02	01-0575	1	II				11300	11450	10065	6.83	5.81	8762	8391	7376	
B						II				11600			7.55	6.42	8020			
C						II							6.40	6.40				6.50

254A	G2005	1/31/02	2/28/02	01-0575	1	II				9350	9775	8592	6.60	5.61	7690	7800	6856	
B						II				10200			7.16	6.09	7910			
C						II							6.65	6.65				7.22
255A	G2006	2/1/02	3/1/02	01-0575	1	II				14400	12850	11295	6.89	5.86	7930	8345	7335	
B						II				11300			6.73	5.72	8760			
C						II							6.96	6.96				6.76
256A	G2007	2/4/02	3/4/02	01-0575	1	II				8170	9335	8205	6.18	5.25	8220	8560	7524	
B						II				10500			6.00	5.10	8900			
C						II							5.48	5.48				5.73
257A	G2008	2/5/02	3/5/02	01-0575	1	II				7870	7850	6900	8.81	7.49	6530	6500	5714	
B						II				7830			9.05	7.69	6470			
C						II							6.63	6.63				7.75
258A	I4008	2/6/02	3/6/02	01-0575	1	II				8670	8135	7151	7.66	6.51	3176	2793	2455	
B						II				7600			8.64	7.34	2410			
C						II							6.95	6.95				14.81
259A	G2009	2/6/02	3/6/02	01-0575	1	II				10800	10450	9186	8.33	7.08	7050	7270	6390	
B						II				10100			7.78	6.61	7490			
C						II							6.50	6.50				7.05
260A	G4001	2/6/02	3/6/02	07-0590	7	IV	19.2			8290	8265	7265	8.85	7.52	2320	2315	2035	
B						IV	19.2			8240			9.21	7.83	2310			
C						IV	19.2						7.23	7.23				17.41
261A	I2001	2/6/02	3/6/02	05-0741	5	II	22			10400	10650	9361	8.65	7.35	2840	3095	2721	
B						II	22			10900			8.91	7.57	3350			
C						II	22						6.61	6.61				15.53
262A	G4001	2/7/02	3/7/02	01-0561	1	IV		50					25.34	21.54	2070	2045	1798	
B						IV		50					24.88	21.15	2020			
C						IV		50					18.84	18.84				19.01
263A	G4002	2/12/02	3/12/02	01-0561	1	IV		50		3780	3600	3164	21.10	17.94	2310	2255	1982	
B						IV		50		3420			18.75	15.94	2200			
C						IV		50					18.08	18.08				19.82
264A	J5037A	2/12/02	3/12/02	07-0130	1	V SP	18			4160	4180	3674	18.28	15.54	1650	1635	1437	
B						V SP	18			4200			19.16	16.29	1620			
C						V SP	18						13.75	13.75				28.23
265A	J5038A	2/13/02	3/13/02	07-0130	1	V SP	18											
B						V SP	18											
C						V SP	18											
266A	J5039A	2/14/02	3/14/02	07-0223	1	V	19.6			4380	4410	3876	16.36	13.91	1880	2025	1780	
B						V	19.6			4440			16.56	14.08	2170			
C						V	19.6						12.08	12.08				22.15
267A	J6026A	2/15/02	3/15/02	07-0587	1	VI	18.1			5260	5435	4777	13.60	11.56	2380	2275	2000	
B						VI	18.1			5610			16.00	13.60	2170			
C						VI	18.1						12.20	12.20				17.46
268A	G5006	2/15/02	3/15/02	07-0587	1	VI	18.1			5880	5750	5054	13.60	11.56	2640	2535	2228	
B						VI	18.1			5620			12.50	10.63	2430			
C						VI	18.1						9.60	9.60				15.57
269A	G2010	2/15/02	3/15/02	01-0575	1	II				6910	7350	6461	8.60	7.31	5970	5915	5199	
B						II				7790			9.00	7.65	5860			
C						II							6.80	6.80				7.72
270A	G2011	2/15/02	3/15/02	01-0575	1	II				9550	9005	7915	7.50	6.38	7520	7135	6272	
B						II				8460			7.95	6.76	6750			
C						II							6.50	6.50				6.46
271A	I4002	2/15/02	3/15/02	03-0898	3	IV	19.7			8540	8745	7687	10.70	9.10	2780	2950	2593	
B						IV	19.7			8950			10.59	9.00	3120			
C						IV	19.7						8.15	8.15				14.67
272A	J6030A	2/16/02	3/16/02	07-0587	1	VI	18.1											
B						VI	18.1											
C						VI	18.1											
273A	J6031	2/18/02	3/18/02	07-0587	1	VI	18.1			3971	3850.5	3385	17.20	14.62	1680	1720	1512	
B						VI	18.1			3730			19.30	16.41	1760			
C						VI	18.1						15.30	15.30				29.85

274A	J5045	2/19/02	3/19/02	07-0130	1	V SP	18			3330	3535	3107	19.80	16.83	1610	1700	1494	
B						V SP	18			3740			19.60	16.66	1790			
C						V SP	18						14.90	14.90				27.95
275A	J5046	2/20/02	3/20/02	07-0130	1	V SP	18			3990	4120	3621	18.70	15.90	1680	1790	1573	
B						V SP	18			4250			16.20	13.77	1900			
C						V SP	18						12.90	12.90				25.48
276A	J6032A	2/21/02	3/21/02	07-0587	1	VI	18.1			4000	4080	3586	13.10	11.14	2100	2045	1798	
B						VI	18.1			4160			13.60	11.56	1990			
C						VI	18.1						10.60	10.60				19.40
277A	J5049	2/25/02	3/25/02	07-0130	1	V SP	18			4850	4830	4246	14.16	12.04	2450	2525	2219	
B						V SP	18			4810			13.91	11.82	2600			
C						V SP	18						10.31	10.31				17.93
278A	G4001	2/19/02	3/19/02	01-0561	1	IV		50		2920	2660	2338	19.50	16.58	2260	2245	1973	
B						IV		50		2400			18.80	15.98	2230			
C						IV		50					17.60	17.60				20.67
279A	G5001	2/20/02	3/20/02	07-0645	1	V				6730	6770	5951	10.20	8.67	4840	4810	4228	
B						V				6810			10.30	8.76	4780			
C						V							8.00	8.00				9.45
280A	G4001	2/22/02	3/22/02	01-0475	1	IV DS	33.8			6517	6273.5	5514	10.92	9.28	1470	1450	1275	
B						IV DS	33.8			6030			10.48	8.91	1430			
C						IV DS	33.8						8.23	8.23				25.45
281A	A2032	2/26/02	3/26/02	06-0276	4	II BD		51		2090	2120	1863	26.91	22.87	1550	1535	1349	
B						II BD		51		2150			25.60	21.76	1520			
--						II BD		51										
282A	J6035	2/26/02	3/26/02	07-0587	1	VI	18.1			4160	4075	3582	17.17	14.59	2200	2170	1907	
B						VI	18.1			3990			16.30	13.86	2140			
C						VI	18.1						12.21	12.21				20.87
283A	G4002	2/26/02	3/26/02	07-0590	7	IV	19.2			5050	4860	4272	11.21	9.53	1850	1820	1600	
B						IV	19.2			4670			11.71	9.95	1790			
C						IV	19.2						8.30	8.30				20.62
284A	J5051	2/28/02	3/28/02	07-0130	1	V SP	18			3630	3620	3182	17.60	14.96	1760	1760	1547	
B						V SP	18			3610			18.48	15.71	1760			
C						V SP	18						13.85	13.85				24.35
285A	J6038A	3/1/02	3/29/02	07-0587	1	VI	18.1			4850	4810	4228	13.30	11.31	2050	2115	1859	
B						VI	18.1			4770			13.21	11.23	2180			
C						VI	18.1						10.63	10.63				19.31
286A	J6041A	3/4/02	4/1/02	07-0587	1	VI	18.1			3880	3870	3402	17.53	14.90	1760	1665	1464	
B						VI	18.1			3860			17.87	15.19	1570			
C						VI	18.1						14.96	14.96				29.21
287A	J5053A	3/5/02	4/2/02	07-0130	1	V SP	18			4580	4385	3854	14.71	12.50	1700	1735	1525	
B						V SP	18			4190			15.28	12.99	1770			
C						V SP	18						11.57	11.57				23.61
288A	I2001	2/22/02	3/22/02	03-0867	3	II BD	18			4490	4615	4057	15.32	13.02	1290	1310	1151	
B						II BD	18			4740			14.48	12.31	1330			
C						II BD	18						12.42	12.42				37.08
289A	G4003	2/19/02	3/19/02	?	1	IV				3037	3018.5	2653	18.90	16.07	2100	2055	1806	
B						IV				3000			18.70	15.90	2010			
C						IV							16.50	16.50				20.40
290A	G4004	2/25/02	3/25/02	?	1	IV				2840	2920	2567	22.27	18.93	1980	2055	1806	
B						IV				3000			20.03	17.03	2130			
C						IV							15.65	15.65				19.56
291A	G4003	3/1/02	3/29/02	07-0590	7	IV	19.2			5330	5630	4949	12.80	10.88	1410	1495	1314	
B						IV	19.2			5930			11.21	9.53	1580			
C						IV	19.2						9.90	9.90				26.36
292A	G4005	3/5/02	4/2/02	?	1	IV				3120	3190	2804	15.36	13.06	2190	2155	1894	
B						IV				3260			17.16	14.59	2120			
C						IV							16.61	16.61				20.26
293A	J5056A	3/6/02	4/3/02	07-0130	1	V SP	18			5070	5120	4500	13.81	11.74	2000	2085	1833	
B						V SP	18			5170			13.98	11.88	2170			
C						V SP	18						10.48	10.48				23.11

294A	G4004	3/7/02	4/4/02	07-0590	7	IV	19.2			6030	5880	5169	11.33	9.63	1850	1855	1631	
B						IV	19.2			5730			11.13	9.46	1860			
C						IV	19.2						9.05	9.05				23.35
295A	J6044	3/7/02	4/4/02	07-0587	1	VI	18.1			6660	6845	6017	11.90	10.12	5150	5015	4408	
B						VI	18.1			7030			11.87	10.09	4880			
C						VI	18.1						9.27	9.27				11.17
296A	G4006	3/8/02	4/5/02	01-0587	1	IV		50										
B						IV		50										
C						IV		50										
297A	J6047A	3/9/02	4/6/02	07-0587	1	VI	18.1			4820	4790	4210	14.42	12.26	2270	2305	2026	
B						VI	18.1			4760			13.56	11.53	2340			
C						VI	18.1						10.53	10.53				18.21
298A	J5059A	3/11/02	4/8/02	07-0130	7	V SP	18			5681	6060.5	5327	12.63	10.74	2350	2400	2110	
B						V SP	18			6440			11.53	9.80	2450			
C						V SP	18						9.65	9.65				18.51
299A	J5060A	3/12/02	4/9/02	07-0130	7	V SP	18			3710	3550	3120	18.61	15.82	1710	1690	1486	
B						V SP	18			3390			17.23	14.65	1670			
C						V SP	18						13.57	13.57				26.60
300A	J5061A	3/13/02	4/10/02	07-0223	7	V	19.6			1120	1235	1086	42.91	36.47	649	629.5	553	
B						V	19.6			1350			43.01	36.56	610			
C						V	19.6						34.22	34.22				78.70
301A	J5063A	3/14/02	4/11/02	07-0130	7	V SP	18			6040	5975	5252	10.30	8.76	2740	2855	2510	
B						V SP	18			5910			10.38	8.82	2970			
C						V SP	18						8.56	8.56				16.70
302A	J5053A	3/15/02	4/12/02	07-0587	7	VI	18.1			4390	4535	3986	16.00	13.60	2070	2150	1890	
B						VI	18.1			4680			14.70	12.50	2230			
C						VI	18.1						11.70	11.70				21.90
303A	E4489	2/26/02	3/26/02	02-0948	2	IV		50		3310	3235	2844	24.52	20.84	1560	1600	1406	
B						IV		50		3160			22.18	18.85	1640			
C						IV		50					15.33	15.33				27.88
304A	E4500	3/1/02	3/29/02	02-0948	2	IV		50		3760	3620	3182	22.26	18.92	1570	1600	1406	
B						IV		50		3480			19.66	16.71	1630			
C						IV		50					14.90	14.90				25.67
305A	E4501	3/1/02	3/29/02	02-0692	2	IV		70.1		2320	2345	2061	28.98	24.63	1200	1220	1072	
B						IV		70.1		2370			25.66	21.81	1240			
C						IV		70.1					23.52	23.52				38.10
306A	E4512	3/6/02	4/3/02	02-0692	2	IV		70.1		1940	1830	1609	31.67	26.92	1060	1075	945	
B						IV		70.1		1720			31.77	27.00	1090			
C						IV		70.1					27.32	27.32				45.00
307A	E4521	3/11/02	4/8/02	02-0948	2	IV		50		3160	3040	2672	21.77	18.50	1440	1490	1310	
B						IV		50		2920			22.46	19.09	1540			
C						IV		50					17.68	17.68				28.38
308A	E4527	3/14/02	411/02	02-0692	2	IV		70.1		1944	1987	1747	30.40	25.84	1240	1235	1086	
B						IV		70.1		2030			30.46	25.89	1230			
C						IV		70.1					24.85	24.85				36.20
309A	02-0924	3/20/02	4/17/02	02-0924	2	II BD				9830	9800	8614	7.08	6.02	7060	7215	6342	
B						II BD				9770			7.57	6.43	7370			
C						II BD							5.71	5.71				6.78
310A	set 1	3/15/02	4/12/02	05-0481	5	V SP	17.3		1280	1270	1310	1151	40.71	34.60	876	921	810	
B						V SP	17.3		1280	1350			35.38	30.07	966			
C						V SP	17.3		1280				30.43	30.43				45.20
311A	G4008	3/19/02	4/15/02	01-0587	1	IV		50										
B						IV		50										
C						IV		50										
312A	G4009	3/21/02	4/18/02	01-0587	1	IV		50		2930	2990	2628	15.18	12.90	2390	2200	1934	
B						IV		50		3050			19.23	16.35	2010			
C						IV		50					14.90	14.90				18.70
313A	G4010	3/25/02	4/20/02	01-0587	1	IV		50		3070	3095	2721	16.80	14.28	2080	2105	1850	
B						IV		50		3120			19.77	16.80	2130			
C						IV		50					14.38	14.38				21.02

314A	R0001	3/25/02	4/20/02	07-0511	7	II BD	21.9			8370	7980	**7014**	7.52	**6.39**	2880	2860	**2514**	
B						II BD	21.9			7590			7.53	**6.40**	2840			
C						II BD	21.9						6.07	**6.07**				**16.21**
315A	R0002	3/25/02	4/20/02	07-0511	7	II BD	21.9			8020	7730	**6795**	8.02	**6.82**	2700	2550	**2241**	
B						II BD	21.9			7440			8.51	**7.23**	2400			
C						II BD	21.9						6.61	**6.61**				**17.25**
316A	R0003	3/25/02	4/20/02	07-0511	7	II BD	21.9			12800	12700	**11163**	5.77	**4.90**	4090	3970	**3490**	
B						II BD	21.9			12600			5.93	**5.04**	3850			
C						II BD	21.9						4.36	**4.36**				**12.53**
317A	R0004	3/25/02	4/20/02	07-0511	7	II BD	21.9			11700	11550	**10152**	5.81	**4.94**	3800	3749.5	**3296**	
B						II BD	21.9			11400			5.62	**4.78**	3699			
C						II BD	21.9						4.97	**4.97**				**13.12**
318A	R2005	3/27/02	4/24/02	07-0511	7	II BD	21.9			7330	7385	**6491**	8.77	**7.45**	2730	2555	**2246**	
B						II BD	21.9			7440			8.75	**7.44**	2380			
C						II BD	21.9						7.15	**7.15**				**16.75**
319A	R2006	3/27/02	4/24/02	07-0511	7	II BD	21.9			7350	7065	**6210**	9.18	**7.80**	2460	2520	**2215**	
B						II BD	21.9			6780			8.76	**7.45**	2580			
C						II BD	21.9						7.28	**7.28**				**17.36**
320A	G4011	3/27/02	4/24/02	01-0587	1	IV		50		2827	2898.5	**2548**	19.63	**16.69**	2130	2160	**1899**	
B						IV		50		2970			18.77	**15.95**	2190			
C						IV		50					16.78	**16.78**				**20.05**
321A	G4012	3/29/02	4/26/02	01-0587	1	IV		50		2540	2565	**2255**	24.01	**20.41**	1860	1865	**1639**	
B						IV		50		2590			23.91	**20.32**	1870			
C						IV		50					18.96	**18.96**				**24.67**
322A	E4560	3/28/02	4/25/02	02-0948	2	IV		50		4900	4815	**4232**	15.15	**12.88**	2620	2590	**2277**	
B						IV		50		4730			14.51	**12.33**	2560			
C						IV		50					12.50	**12.50**				**19.68**
323A	E4561	3/29/02	4/26/02	02-0692	2	IV		70.1		1910	1905	**1674**	30.70	**26.10**	1170	1205	**1059**	
B						IV		70.1		1900			31.71	**26.95**	1240			
C						IV		70.1					26.17	**26.17**				**36.56**
324A	G4004	4/10/02	5/8/02	07-0596	7	IV DS		60.3		1610	1730	**1521**	31.32	**26.62**		529	**465**	
B						IV DS		60.3		1850			25.17	**21.39**	529			
C						IV DS		60.3					21.65	**21.65**				**29.80**
325A	G4005	4/10/02	5/8/02	07-0596	7	IV DS		60.3		1580	1680	**1477**	29.07	**24.71**	1270	1365	**1200**	
B						IV DS		60.3		1780			30.21	**25.68**	1460			
C						IV DS		60.3					26.10	**26.10**				**32.32**
326A	G4006	4/10/02	5/8/02	07-0596	7	IV DS		60.3		2410	2435	**2140**	25.11	**21.34**	1420	1580	**1389**	
B						IV DS		60.3		2460			25.22	**21.44**	1740			
C						IV DS		60.3					19.13	**19.13**				**26.68**
327A	G4007	4/10/02	5/8/02	07-0596	7	IV DS		60.3		2320	2270	**1995**	23.78	**20.21**	1780	1675	**1472**	
B						IV DS		60.3		2220			24.60	**20.91**	1570			
C						IV DS		60.3					21.01	**21.01**				**27.71**
328A	G4008	4/12/02	5/10/02	07-0596	7	IV DS		60.3		1940	1930	**1696**	27.93	**23.74**	1370	1360	**1195**	
B						IV DS		60.3		1920			28.77	**24.45**	1350			
C						IV DS		60.3					20.45	**20.45**				**28.25**
329A	E4572	4/2/02	4/30/02	02-0692	2	IV		70.1		1270	1385	**1217**	41.47	**35.25**	920	945.5	**831**	
B						IV		70.1		1500			43.11	**36.64**	971			
C						IV		70.1					32.46	**32.46**				**43.95**
330A	E4582	4/13/02	5/11/02	02-0948	2	IV		50		2640	2665	**2343**	25.48	**21.66**	1380	1425	**1253**	
B						IV		50		2690			26.26	**22.32**	1470			
C						IV		50					18.23	**18.23**				**26.90**
331A	R2008	4/16/02	5/14/02	07-0511	7	II BD	21.9			7620	7770	**6830**	8.37	**7.11**	2230	2350	**2066**	
B						II BD	21.9			7920			8.78	**7.46**	2470			
C						II BD	21.9						6.85	**6.85**				**16.03**
332A	R2007	4/12/02	5/10/02	07-0590	7	IV	19.2			9020	8955	**7871**	7.61	**6.47**	2300	2385	**2096**	
B						IV	19.2			8890			6.48	**5.51**	2470			
C						IV	19.2						5.65	**5.65**				**14.63**
333A	G4011	4/15/02	5/13/02	07-0596	7	IV DS		60.3		2290	2280	**2004**	26.77	**22.75**	1370	1295	**1138**	
B						IV DS		60.3		2270			29.35	**24.95**	1220			
C						IV DS		60.3					22.12	**22.12**				**31.73**

334A	G4010	4/15/02	5/13/02	07-0596	7	IV DS		60.3	2390	2365	2079	26.35	22.40	1640	1675	1472	
B						IV DS		60.3	2340			18.83	16.01	1710			
C						IV DS		60.3				26.85	26.85				26.30
335A	G4009	4/15/02	5/13/02	07-0596	7	IV DS		60.3	2186	2133	1875	26.63	22.64	1560	1495	1314	
B						IV DS		60.3	2080			20.55	17.47	1430			
C						IV DS		60.3				22.31	22.31				27.50
336A	G4012	4/16/02	5/14/02	07-0596	7	IV DS		60.3	1870	1805	1587	32.26	27.42	1240	1175	1033	
B						IV DS		60.3	1740			28.50	24.23	1110			
C						IV DS		60.3				21.72	21.72				33.70
337A	G4013	4/16/02	5/14/02	07-0596	7	IV DS		60.3	2020	2112.5	1857	25.42	21.61	1290	1360	1195	
B						IV DS		60.3	2205			26.36	22.41	1430			
C						IV DS		60.3				21.40	21.40				32.22
338A	G4014	4/16/02	5/14/02	07-0596	7	IV DS		60.3	2080	2195	1929	27.71	23.55	1390	1390	1222	
B						IV DS		60.3	2310			26.85	22.82	1390			
C						IV DS		60.3				19.22	19.22				28.38
339A	G4015	4/16/02	5/14/02	07-0596	7	IV DS		60.3	1840	1880	1653	28.16	23.94	1310	1350	1187	
B						IV DS		60.3	1920			27.06	23.00	1390			
C						IV DS		60.3				21.96	21.96				31.18
340A	G4019	4/18/02	5/16/02	07-0596	7	IV DS		60.3	1980	2025	1780	28.96	24.62	1290	1255	1103	
B						IV DS		60.3	2070			30.33	25.78	1220			
C						IV DS		60.3				24.03	24.03				29.85
341A	G4018	4/18/02	5/16/02	07-0596	7	IV DS		60.3	1990	1920	1688	34.47	29.30	1150	1090	958	
B						IV DS		60.3	1850			29.12	24.75	1030			
C						IV DS		60.3				27.97	27.97				36.86
342A	G4017	4/18/02	5/16/02	07-0596	7	IV DS		60.3	1870	1845	1622	31.98	27.18	1270	1300	1143	
B						IV DS		60.3	1820			29.81	25.34	1330			
C						IV DS		60.3				23.37	23.37				28.77
343A	R1001	4/22/02	5/20/02	07-0466	7	I SP	22.2		4620	4380	3850	11.10	9.44	2330	2250	1978	
B						I SP	22.2		4140			11.31	9.61	2170			
C						I SP	22.2					9.13	9.13				18.52
344A	G4020	4/23/02	5/21/02	07-0596	7	IV DS		60.3	1900	1980	1740	27.98	23.78	1500	1600	1406	
B						IV DS		60.3	2060			26.53	22.55	1700			
C						IV DS		60.3				21.62	21.62				29.46
345A	G4021	4/23/02	5/21/02	07-0596	7	IV DS		60.3	1870	1900	1670	25.91	22.02	1570	1580	1389	
B						IV DS		60.3	1930			28.22	23.99	1590			
C						IV DS		60.3				20.56	20.56				27.40
346A	R4005	4/24/02	5/22/02	07-0590	7	IV	19.2		4910	5230	4597	9.85	8.37	2220	2355	2070	
B						IV	19.2		5550			10.87	9.24	2490			
C						IV	19.2					8.21	8.21				18.86
347A	G4025	4/25/02	5/23/02	07-0596	7	IV DS		60.3	1890	1805	1587	24.95	21.21	1430	1380	1213	
B						IV DS		60.3	1720			26.93	22.89	1330			
C						IV DS		60.3				23.06	23.06				31.74
348A	G4024	4/25/02	5/23/02	07-0596	7	IV DS		60.3	1480	1580	1389	31.90	27.12	1250	1215	1068	
B						IV DS		60.3	1680			31.10	26.44	1180			
C						IV DS		60.3				27.26	27.26				44.04
349A	G4023	4/25/02	5/23/02	07-0596	7	IV DS		60.3	2090	1935	1701	26.28	22.34	1420	1375	1209	
B						IV DS		60.3	1780			32.43	27.57	1330			
C						IV DS		60.3				26.37	26.37				37.01
350A	G4022	4/25/02	5/23/02	07-0596	7	IV DS		60.3	1890	1990	1749	29.15	24.78	1340	1365	1200	
B						IV DS		60.3	2090			29.48	25.06	1390			
C						IV DS		60.3				26.26	26.26				35.56
351A	G4016	4/18/02	5/16/02	07-0596	7	IV DS		60.3	1780	1945	1710	29.16	24.79	1350	1315	1156	
B						IV DS		60.3	2110			29.42	25.01	1280			
C						IV DS		60.3				22.86	22.86				31.37
352A	G4013	-	-	-	-	-											
B																	
C																	
353A	G4014	-	-	-	-	-											
B																	
C																	

354A	G4015	4/16/02	5/14/02	01-0587	1	IV	50		2590	2560	2250	21.10	17.94	1890	1971	1733	
B						IV	50		2530			21.43	18.22	2052			
C						IV	50					19.20	19.20				25.72
355A	G4016	4/18/02	5/16/02	01-0587	1	IV	50		2200	2140	1881	24.00	20.40	1730	1750	1538	
B						IV	50		2080			26.50	22.53	1770			
C						IV	50					19.62	19.62				25.60
356A	G4017	4/23/02	5/21/02	01-0587	1	IV	50		2500	2388	2099	27.00	22.95	1680	1730	1521	
B						IV	50		2276			20.11	17.09	1780			
C						IV	50					19.92	19.92				27.16
357A	G4018	4/24/02	5/22/02	01-0587	1	IV	50		3200	3175	2791	24.60	20.91	2190	2155	1894	
B						IV	50		3150			23.22	19.74	2120			
C						IV	50					20.02	20.02				24.26
358A	G4019	4/29/02	5/27/02	01-0587	1	IV	50		2463	2486.5	2186	20.09	17.08	1650	1675	1472	
B						IV	50		2510			20.98	17.83	1700			
C						IV	50					17.56	17.56				22.05
359A	G4021	5/1/02	5/29/02	01-0587	1	IV	50		2590	2720	2391	21.72	18.46	2200	2250	1978	
B						IV	50		2850			22.78	19.36	2300			
C						IV	50					19.68	19.68				23.30
360A	G4020	5/1/02	5/29/02	01-0587	1	IV	50		2740	3020	2655	24.41	20.75	2220	2250	1978	
B						IV	50		3300			26.20	22.27	2280			
C						IV	50					19.81	19.81				24.10
361A	E4586	4/20/02	5/18/02	02-0948	2	IV	50		2670	2585	2272	24.63	20.94	1570	1565	1376	
B						IV	50		2500			22.66	19.26	1560			
C						IV	50					20.03	20.03				30.55
362A	G4022	5/3/02	5/31/02	01-0587	1	IV	50		2760	2860	2514	25.63	21.79	1950	2140	1881	
B						IV	50		2960			23.85	20.27	2330			
C						IV	50					18.58	18.58				21.70
363A	G4023	5/8/02	6/5/02	01-0587	1	IV	50		3040	2895	2545	20.66	17.56	2020	2045	1798	
B						IV	50		2750			21.23	18.05	2070			
C						IV	50					18.30	18.30				22.40
364A	G4024	5/8/02	6/5/02	01-0587	1	IV	50		2620	2595	2281	21.83	18.56	2370	2265	1991	
B						IV	50		2570			22.05	18.74	2160			
C						IV	50					18.67	18.67				23.70
365A	G4026	5/8/02	6/5/02	07-0596	7	IV DS	60.3		1970	1865	1639	27.30	23.21	1480	1510	1327	
B						IV DS	60.3		1760			25.32	21.52	1540			
C						IV DS	60.3					22.80	22.80				29.10
366A	G4027	5/8/02	6/5/02	07-0596	7	IV DS	60.3		2122	1986	1746	24.91	21.17	1540	1520	1336	
B						IV DS	60.3		1850			24.70	21.00	1500			
C						IV DS	60.3					21.30	21.30				26.30
367A	G4028	5/11/02	6/8/02	07-0596	7	IV DS	60.3		2350	2280	2004	25.11	21.34	1720	1710	1503	
B						IV DS	60.3		2210			23.88	20.30	1700			
C						IV DS	60.3					19.25	19.25				23.85
368A	G4029	5/11/02	6/8/02	07-0596	7	IV DS	60.3		2050	1865	1639	26.25	22.31	1650	1750	1538	
B						IV DS	60.3		1680			25.08	21.32	1850			
C						IV DS	60.3					20.97	20.97				28.26
369A	G4030	5/11/02	6/8/02	07-0594	7	IV	50		1890	1760	1547	26.17	22.24	1470	1470	1292	
B						IV	50		1630			25.72	21.86				
C						IV	50					22.36	22.36				29.09
370A	G4031	5/14/02	6/11/02	07-0664	7	IV	54.1	50	817	889.5	782	57.70	49.05	563	590.5	519	
B						IV	54.1	50	962			57.60	48.96	618			
C						IV	54.1	50				49.80	49.80				88.81
371A	G4032	5/14/02	6/11/02	07-0594	7	IV	50		1680	1685	1481	25.40	21.59	1620	1605	1411	
B						IV	50		1690			28.20	23.97	1590			
C						IV	50					23.00	23.00				31.05
372A	G4033	5/16/02	6/13/02	07-0666	7	IV DS	60.3		1500	1540	1354	31.80	27.03	1320	1295	1138	
B						IV DS	60.3		1580			35.80	30.43	1270			
C						IV DS	60.3					30.50	30.50				38.54
373A	G4034	5/16/02	6/13/02	07-0594	7	IV	50		1750	1835	1613	28.10	23.89	1830	1855	1631	
B						IV	50		1920			30.40	25.84	1880			
C						IV	50					23.20	23.20				31.61

374A	I2007	5/17/02	6/14/02	04-0438	8	II		60		1380	1400	**1231**	38.40	**32.64**	1050	1045	**919**	
B						II		60		1420			44.20	**37.57**	1040			
C						II		60					34.00	**34.00**				**42.56**
375A	G4035	5/20/02	6/17/02	07-0594	7	IV		50		2380	2195	**1929**	25.16	**21.39**	1840	1825	**1604**	
B						IV		50		2010			23.05	**19.59**	1810			
C						IV		50					23.12	**23.12**				**31.81**
376A	G4025	5/22/02	6/19/02	01-0591	1	IV		54.1	50	1430	1315	**1156**	43.17	**36.69**	792	822	**723**	
B						IV		54.1	50	1200			49.96	**42.47**	852			
C						IV		54.1	50				35.41	**35.41**				**55.60**
377A	G4036	5/23/02	6/20/02	07-0666	7	IV DS		60.3		1770	1870	**1644**	31.26	**26.57**	1130	1190	**1046**	
B						IV DS		60.3		1970			27.70	**23.55**	1250			
C						IV DS		60.3					25.11	**25.11**				**32.18**
378A	G4037	5/24/02	6/21/02	07-0664	7	IV		54.1	50	2390	2330	**2048**	21.90	**18.62**	1810	1850	**1626**	
B						IV		54.1	50	2270			23.15	**19.68**	1890			
C						IV		54.1	50				19.62	**19.62**				**23.89**
379A	G4026	5/28/02	6/25/02	01-0587	1	IV		50		2270	2425	**2132**	26.42	**22.46**	1520	1590	**1398**	
B						IV		50		2580			23.33	**19.83**	1660			
C						IV		50					22.75	**22.75**				**32.13**
380A	G4038	5/28/02	6/25/02	07-0666	7	IV DS		60.3		1860	1815	**1595**	30.21	**25.68**	1540	1505	**1323**	
B						IV DS		60.3		1770			29.21	**24.83**	1470			
C						IV DS		60.3					26.60	**26.60**				**31.33**
381A	G4039	5/28/02	6/25/02	07-0666	7	IV DS		60.3		1080	1065	**936**	53.17	**45.19**	583	552.5	**486**	
B						IV DS		60.3		1050			57.76	**49.10**	522			
C						IV DS		60.3					44.65	**44.65**				**91.74**
382A	G4027	5/29/02	6/26/02	01-0591	1	IV		54.1	50	1240	1205	**1059**	42.21	**35.88**	867	867	**762**	
B						IV		54.1	50	1170			45.26	**38.47**				
C						IV		54.1	50				40.55	**40.55**				**67.30**
383A	G4040	5/30/02	6/27/02	07-0664	7	IV		54.1	50	878	836	**735**	54.67	**46.47**	449	483	**425**	
B						IV		54.1	50	794			53.65	**45.60**	517			
C						IV		54.1	50				47.00	**47.00**				**115.63**
384A	G4028	5/31/02	6/28/02	01-0587	1	IV		50		2860	2970	**2611**	25.73	**21.87**	1940	2015	**1771**	
B						IV		50		3080			19.02	**16.17**	2090			
C						IV		50					18.18	**18.18**				**25.35**
385A	G4029	5/31/02	6/28/02	01-0587	1	IV		50		2610	2480	**2180**	23.47	**19.95**	1600	1810	**1591**	
B						IV		50		2350			22.50	**19.13**	2020			
C						IV		50					20.22	**20.22**				**27.34**
386A	G4030	5/31/02	6/28/02	01-0587	1	IV		50		2150	2160	**1899**	26.50	**22.53**	1570	1670	**1468**	
B						IV		50		2170			27.23	**23.15**	1770			
C						IV		50					22.31	**22.31**				**31.15**
387A	G4033	6/6/02	7/4/02	01-0587	1	IV		50		2780	2770	**2435**	26.88	**22.85**	1520	1515	**1332**	
B						IV		50		2760			23.06	**19.60**	1510			
C						IV		50					19.33	**19.33**				**28.91**
388A	G4034	6/6/02	7/4/02	01-0587	1	IV		50		2460	2625	**2307**	28.30	**24.06**	1450	1475	**1297**	
B						IV		50		2790			22.40	**19.04**	1500			
C						IV		50					20.82	**20.82**				**30.06**
389A	G4039	6/6/02	7/4/02	01-0587	1	IV		50		2750	2495	**2193**	23.47	**19.95**	1530	1430	**1257**	
B						IV		50		2240			30.67	**26.07**	1330			
C						IV		50					20.33	**20.33**				**31.66**
390A	02-1015	6/12/02	7/10/02	02-1015	2	IV DS	35.1			6770	6980	**6135**	12.11	**10.29**	2610	2555	**2246**	
B						IV DS	35.1			7190			12.55	**10.67**	2500			
C						IV DS	35.1						9.80	**9.80**				**22.13**
391A	02-M2028	6/4/02	7/2/02	02-2028	2	IV DS				1780	1745	**1534**	40.81	**34.69**	1180	1255	**1103**	
B						IV DS				1710			40.15	**34.13**	1330			
C						IV DS							32.51	**32.51**				**41.94**
392A	J-5152A	6/12/02	7/10/02	07-0625	1	V	18			3820	3620	**3182**	14.57	**12.38**	1530	1485	**1305**	
B						V	18			3420			15.26	**12.97**	1440			
C						V	18						12.10	**12.10**				**27.66**
393A	J6125A	6/14/02	7/12/02	07-0621	1	VI	18.1						15.91	**13.52**	1470	1535	**1349**	
B						VI	18.1						16.55	**14.07**	1600			
C						VI	18.1						12.80	**12.80**				**30.51**

394A	J5156A	6/14/02	7/12/02	07-0625	1	V	18						15.46	13.14	1500	1480	1301	
B						V	18						15.11	12.84	1460			
C						V	18						12.65	12.65				33.14
395A	UB-010	5/30/02	6/27/02	02-0882	2	VI	20			4260	4350	3824	14.23	12.10	1550	1470	1292	
B						VI	20			4440			13.75	11.69	1390			
C						VI	20						11.33	11.33				25.46
396A	02-0833	6/6/02	7/4/02	02-0833	2	IV DS		60		2300	2165	1903	28.26	24.02	1640	1609.5	1415	
B						IV DS		60		2030			27.51	23.38	1579			
C						IV DS		60					21.85	21.85				25.46
397A	UB-14	6/8/02	7/6/02	02-0882	2	VI	20			4470	4595	4039	14.71	12.50	1500	1535	1349	
B						VI	20			4720			14.53	12.35	1570			
C						VI	20						11.80	11.80				26.31
398A	IA001	6/10/02	7/8/02	05-0447	8	II BD	18.1			10100	10150	8922	6.86	5.83	3420	3565	3134	
B						II BD	18.1			10200			6.68	5.68	3710			
C						II BD	18.1						6.47	6.47				14.38
399A	IA002	6/10/02	7/8/02	05-0447	8	II BD	18.1			8060	8360	7348	7.91	6.72	3060	3065	2694	
B						II BD	18.1			8660			7.45	6.33	3070			
C						II BD	18.1						5.97	5.97				12.95
400A	IA003	6/10/02	7/8/02	05-0447	8	II BD	18.1			9220	9535	8381	7.07	6.01	3350	3470	3050	
B						II BD	18.1			9850			7.76	6.60	3590			
C						II BD	18.1						6.23	6.23				13.95
401A	IA004	6/10/02	7/8/02	05-0447	8	II BD	18.1			7730	7855	6905	7.83	6.66	3080	3035	2668	
B						II BD	18.1			7980			7.68	6.53	2990			
C						II BD	18.1						6.25	6.25				13.73
402A	J6127	6/22/02	7/20/02	07-0621	1	VI	18.1			4010	4015	3529	14.89	12.66	1460	1510	1327	
B						VI	18.1			4020			14.53	12.35	1560			
C						VI	18.1						12.18	12.18				25.41
403A	J6129A	6/25/02	7/23/02	07-0621	1	VI	18.1			3860	3980	3498			1520	1565	1376	
B						VI	18.1			4100					1610			
C						VI	18.1											24.89
404A	I1001	6/24/02	7/22/02	02-0992	2	V SP	18.3			6410	6340	5573	10.46	8.89	2620	2620	2303	
B						V SP	18.3			6270			10.70	9.10	2620			
C						V SP	18.3											
405A	J5176	6/26/02	7/24/02	07-0625	1	V	18			7250	6835	6008	9.24	7.85	2290	2275	2000	
B						V	18			6420			9.48	8.06	2260			
C						V	18						7.80	7.80				16.71
406A	J6131	6/27/02	7/25/02	07-0621	1	VI	18.1			4710	4802	4221	12.56	10.68	1800	1735	1525	
B						VI	18.1			4894			13.29	11.30	1670			
C						VI	18.1						10.86	10.86				23.79
407A	J5181	6/29/02	7/27/02	07-0625	1	V	18			3340	3435	3019	15.20	12.92	1590	1600	1406	
B						V	18			3530			12.94	11.00	1610			
C						V	18						11.29	11.29				26.25
408A	J6133A	6/29/02	7/27/02	07-0621	1	VI	18.1			3600	3615	3178	13.73	11.67	1780	1755	1543	
B						VI	18.1			3630			13.46	11.44	1730			
C						VI	18.1						10.56	10.56				21.93
409A	J6135A	7/2/02	7/30/02	07-0621	1	VI	18.1			3570	3600	3164	15.70	13.35	1560	1705	1499	
B						VI	18.1			3630			15.20	12.92	1850			
C						VI	18.1						12.90	12.90				26.06
410A	J5185A	7/3/02	7/31/02	07-0625	1	V	18			5150	5390	4738	13.20	11.22	1740	1830	1609	
B						V	18			5630			12.00	10.20	1920			
C						V	18						10.40	10.40				20.38
411A	J6137A	7/5/02	8/2/02	07-0621	1	VI	18.1			5740	5895	5182	10.10	8.59	2330	2415	2123	
B						VI	18.1			6050			10.30	8.76	2500			
C						VI	18.1						9.20	9.20				20.58
412A	J5194A	7/6/02	8/3/02	07-0625	1	V	18			5410	5425	4769	10.50	8.93	1920	2045	1798	
B						V	18			5440			10.10	8.59	2170			
C						V	18						8.20	8.20				18.81
413A	J6140A	7/8/02	8/5/02	07-0621	1	VI	18.1			3810	3835	3371	15.50	13.18	1420	1420	1248	
B						VI	18.1			3860			16.90	14.37	1420			
C						VI	18.1						14.90	14.90				32.88

414A	02-0588	6/19/02	7/17/02	02-0588	2	II	22			4670	4525	**3977**	12.27	**10.43**	2110	2130	**1872**	
B						II	22			4380			12.52	**10.64**	2150			
C						II	22						9.30	**9.30**				**19.96**
415A	UB21	6/25/02	7/22/02	02-0882	2	VI	20			4560	4625	**4065**	12.83	**10.91**	1720	1695	**1490**	
B						VI	20			4690			13.11	**11.14**	1670			
C						VI	20						11.60	**11.60**				**21.75**
416A	02-M1021	7/2/02	7/30/02	02-1021	2	IV	18			6960	7345	**6456**	8.80	**7.48**	3000	2885	**2536**	
B						IV	18			7730			9.00	**7.65**	2770			
C						IV	18						7.10	**7.10**				**14.46**
417A	UB24	7/5/02	8/2/02	02-0882	2	VI	20			6620	6755	**5938**	10.10	**8.59**	1670	1760	**1547**	
B						VI	20			6890			10.20	**8.67**	1850			
C						VI	20						8.30	**8.30**				**19.74**
418A	J6143A	7/11/02	8/8/02	07-0621	1	VI	18.1			3700	3815	**3353**	16.80	**14.28**	1450	1450	**1275**	
B						VI	18.1			3930			16.30	**13.86**				
C						VI	18.1						14.80	**14.80**				**34.84**
419A	J6144A	7/13/02	8/10/02	07-0621	1	VI	18.1			3060	3110	**2734**	17.34	**14.74**	1420	1405	**1235**	
B						VI	18.1			3160			16.94	**14.40**	1390			
C						VI	18.1						15.46	**15.46**				**30.85**
420A	J6145A	7/15/02	8/12/02	07-0621	1	VI	18.1			3560	3870	**3402**	19.54	**16.61**	1250	1245	**1094**	
B						VI	18.1			4180			20.74	**17.63**	1240			
C						VI	18.1						17.61	**17.61**				**44.43**
421A	G5051	7/5/02	8/2/02	07-0665	7	V SP	17.8			7670	8380	**7366**	7.50	**6.38**	2810	2695	**2369**	
B						V SP	17.8			9090			7.00	**5.95**	2580			
C						V SP	17.8						5.70	**5.70**				**13.34**
422A	G4052	7/8/02	8/5/02	07-0666	7	IV DS		60.3		2680	2655	**2334**	22.30	**18.96**	1830	1910	**1679**	
B						IV DS		60.3		2630			22.60	**19.21**	1990			
C						IV DS		60.3					19.80	**19.80**				**22.53**
423A	G4053	7/11/02	8/8/02	07-0666	7	IV DS		60.3		1770	1765	**1551**	28.60	**24.31**	1560	1550	**1362**	
B						IV DS		60.3		1760			29.20	**24.82**	1540			
C						IV DS		60.3					23.80	**23.80**				**29.26**
424A	G4054	7/12/02	8/9/02	07-0666	7	IV DS		60.3		2500	2445	**2149**	25.73	**21.87**	2050	2025	**1780**	
B						IV DS		60.3		2390			21.60	**18.36**	2000			
C						IV DS		60.3					22.24	**22.24**				**25.69**
425A	G4055	7/16/02	8/13/02	07-0666	7	IV DS		60.3		3010	2915	**2562**	24.38	**20.72**	1900	2070	**1820**	
B						IV DS		60.3		2820			23.31	**19.81**	2240			
C						IV DS		60.3					21.18	**21.18**				**22.59**
426A	G4056	7/17/02	8/14/02	07-0666	7	IV DS		60.3		2420	2270	**1995**	27.38	**23.27**	1600	1740	**1529**	
B						IV DS		60.3		2120			25.86	**21.98**	1880			
C						IV DS		60.3					25.78	**25.78**				**31.08**
427A	G5057	7/18/02	8/15/02	07-0665	7	V SP	17.8			6810	6810	**5986**	8.95	**7.61**	2670	2625	**2307**	
B						V SP	17.8			6810			8.90	**7.57**	2580			
C						V SP	17.8						7.94	**7.94**				**22.68**
428A	J6148-A	7/23/02	8/20/02	07-0621	1	VI	18.1			3580	3695	**3248**	16.38	**13.92**	1350	1330	**1169**	
B						VI	18.1			3810			17.03	**14.48**	1310			
C						VI	18.1						14.64	**14.64**				**31.84**
429A	J6151A	7/25/02	8/22/02	07-0621	1	VI	18.1				2880	**2532**	18.65	**15.85**	1350	1325	**1165**	
B						VI	18.1			2880			21.89	**18.61**	1300			
C						VI	18.1						15.36	**15.36**				**31.11**
430A	J6154A	7/29/02	8/26/02	07-0621	1	VI	18.1			3860	3840	**3375**	14.44	**12.27**	1660	1675	**1472**	
B						VI	18.1			3820			14.23	**12.10**	1690			
C						VI	18.1						12.66	**12.66**				**23.73**
431A	J6156A	7/30/02	8/27/02	07-0621	1	VI	18.1			4528	4509	**3963**	12.43	**10.57**	1640	1665	**1464**	
B						VI	18.1			4490			11.74	**9.98**	1690			
C						VI	18.1						11.08	**11.08**				**23.24**
432A	J6157A	8/5/02	9/2/02	07-0621	1	VI	18.1			3730	3800	**3340**	17.93	**15.24**	1330	1365	**1200**	
B						VI	18.1			3870			16.89	**14.36**	1400			
C						VI	18.1						13.09	**13.09**				**30.05**
433A	M-1	7/16/02	8/13/02	02-0882	2	IV	20			4550	4240	**3727**	14.98	**12.73**	1540	1455	**1279**	
B						IV	20			3930			13.04	**11.08**	1370			
C						IV	20						12.90	**12.90**				**25.25**

434A	M-5	7/24/02	8/21/02	02-0882	2	IV	20			1490	1480	1301	35.24	29.95	704	699.5	615	
B						IV	20			1470			34.46	29.29	695			
C						IV	20						31.16	31.16				59.10
435A	BR6	7/26/02	8/23/02	02-0711	2	V SP	19.6		1487	4100	4005	3520	13.49	11.47				
B						V SP	19.6		1487	3910			13.00	11.05				
C						V SP	19.6		1487				10.86	10.86				22.94
436A	M-9	8/1/02	8/29/02	02-0882	2	IV	20			4990	4760	4184	12.04	10.23	1620	1605	1411	
B						IV	20			4530			12.26	10.42	1590			
C						IV	20						10.70	10.70				23.58
437A	02-0833	8/6/02	9/3/02	02-0833	2	IV	20			3440	3450	3033	21.11	17.94	2130	2195	1929	
B						IV	20			3460			20.06	17.05	2260			
C						IV	20						16.64	16.64				20.51
438A	02-0833	8/7/02	9/4/02	02-0833	2	IV	20			4480	4715	4144	16.61	14.12	2780	2770	2435	
B						IV	20			4950			16.53	14.05	2760			
C						IV	20						13.73	13.73				19.66
439A	02-0833	8/5/02	9/2/02	02-0833	2	IV	20			1840	1810	1591	31.44	26.72	1540	1515	1332	
B						IV	20			1780			30.14	25.62	1490			
C						IV	20						26.75	26.75				31.45
440A	G5060	8/2/02	8/30/02	07-0665	7	V SP	17.8			7620	7425	6527	7.66	6.51	2790	2750	2417	
B						V SP	17.8			7230			8.96	7.62	2710			
C						V SP	17.8						8.03	8.03				17.38
441A	G5061	8/7/02	9/4/02	07-0665	7	V SP	17.8			5260	6250	5494	8.09	6.88	2710	3065	2694	
B						V SP	17.8			7240			8.24	7.00	3420			
C						V SP	17.8						6.74	6.74				12.60
442A	G4062	8/8/02	9/5/02	07-0666	7	IV DS		60.3		2570	2525	2219	23.83	20.26	1910	1790	1573	
B						IV DS		60.3		2480			28.66	24.36	1670			
C						IV DS		60.3					21.63	21.63				26.33
443A	F4755	7/23/02	8/20/02	02-0688	2	IV		50										
B						IV		50										
C						IV		50										
444A	FS-1	8/10/02	9/7/02	02-0711	2	V SP	19.6		1487	983	1001.5	880	51.03	43.38	555	581.5	511	
B						V SP	19.6		1487	1020			55.71	47.35	608			
C						V SP	19.6		1487				39.53	39.53				72.41
445A	M-18	8/16/02	9/13/02	02-0882	2	VI	20			3370	3470	3050	15.18	12.90	2130	1865	1639	
B						VI	20			3570			14.38	12.22	1600			
C						VI	20						12.16	12.16				25.53
446A	M-21	8/23/02	9/20/02	02-0882	2	VI	20			3680	4435	3898	13.49	11.47	1440	1440	1266	
B						VI	20			5190			14.80	12.58	1440			
C						VI	20						11.83	11.83				27.96
447A	02-0748	8/29/02	9/26/02	02-0748	2	IV DS		60		2690	2675	2351	20.79	17.67	1960	1935	1701	
B						IV DS		60		2660			22.79	19.37	1910			
C						IV DS		60					17.75	17.75				23.01
448A	02-M2016	8/14/02	9/11/02	02-2016	2					7530	7385.5	6492	10.75	9.14	3460	3560	3129	
B										7241			10.39	8.83	3660			
C													8.41	8.41				14.45
449A		9/19/02	10/17/02	02-0949	2	IV DS				1940	2000	1758	26.21	22.28	1310	1390	1222	
B						IV DS				2060			25.86	21.98	1470			
C						IV DS							11.10	11.10				27.98
450A		9/11/02	10/9/02	02-0748	2	IV DS		60		2060	2005	1762	27.81	23.64	1660	1610	1415	
B						IV DS		60		1950			27.45	23.33	1560			
C						IV DS		60					20.90	20.90				27.23
451A		9/19/02	10/17/02	02-0882	2	VI	20			4690	4530	3982	12.58	10.69	1520	1500	1319	
B						VI	20			4370			12.46	10.59	1480			
C						VI	20						17.03	17.03				24.15
452A		9/19/02	10/17/02	02-0711	2	V SP	19.6		1487	846	859	755	51.69	43.94	455	459	403	
B						V SP	19.6		1487	872			50.76	43.15	463			
C						V SP	19.6		1487				48.71	48.71				87.90
453A		9/5/02	10/3/02	02-0882	2	VI	20			4960	4850	4263	12.44	10.57	1620	1635	1437	
B						VI	20			4740			11.75	9.99	1650			
C						VI	20						9.81	9.81				23.54

454A		9/26/02	10/24/02	02-0949	2	IV DS		60		1890	1885	**1657**	30.79	**26.17**	1480	1425	**1253**	
B						IV DS		60		1880			30.76	**26.15**	1370			
C						IV DS		60					26.14	**26.14**				**32.59**
455A	Eclipse	9/17/02	10/15/02															
B																		
C																		
456A	Eclipse	9/17/02	10/15/02															
B																		
C																		
457A	Eclipse	9/17/02	10/15/02															
B																		
C																		
458A	Eclipse	9/17/02	10/15/02															
B																		
C																		
459A	STOK 02	9/28/02	10/26/02	02-0711	2	V SP	19.6		1487	941	927.5	**815**	48.76	**41.45**	497	490.5	**431**	
B						V SP	19.6		1487	914			48.26	**41.02**	484			
C						V SP	19.6		1487				41.95	**41.95**				**89.10**
460A	M-39	10/4/02	11/1/02	02-0882	2	VI	20			3550	3520	**3094**	13.85	**11.77**	1620	1590	**1398**	
B						VI	20			3490			14.98	**12.73**	1560			
C						VI	20						12.91	**12.91**				
461A	M-40	10/4/02	11/1/02	02-0882	2	VI	20			3680	3675	**3230**	15.49	**13.17**	1590	1545	**1358**	
B						VI	20			3670			15.10	**12.84**	1500			
C						VI	20						12.73	**12.73**				
462A	B-13	10/8/02	11/5/02	02-0711	2	V SP	19.6		1487	966	963	**846**	39.99	**33.99**	598	779	**685**	
B						V SP	19.6		1487	960			41.13	**34.96**	960			
C						V SP	19.6		1487				38.08	**38.08**				**75.31**
463A	B-13	10/8/02	11/5/02	02-0711	2	V SP	19.6		1487	773	820	**721**	41.97	**35.67**	555	587	**516**	
B						V SP	19.6		1487	867			41.80	**35.53**	619			
C						V SP	19.6		1487				37.76	**37.76**				**78.06**
464A	M-42	10/11/02	11/8/02	02-0882	2	VI	20			3250	3250	**2857**	13.93	**11.84**	1540	1550	**1362**	
B						VI	20						13.64	**11.59**	1560			
C						VI	20						10.16	**10.16**				
465A	M-42A	10/11/02	11/8/02	02-0882	2	VI	20			3220	3290	**2892**	13.33	**11.33**				
B						VI	20			3360			14.66	**12.46**				
C						VI	20						12.04	**12.04**				
466A	B-17	10/14/02	11/11/02	02-0711	2	V SP	19.6		1487	1100	1105	**971**	40.99	**34.84**	531	577	**507**	
B						V SP	19.6		1487	1110			38.03	**32.33**	623			
C						V SP	19.6		1487				32.43	**32.43**				**61.85**
467A	B-17	10/14/02	11/11/02	02-0711	2	V SP	19.6		1487	1160	1175	**1033**	40.98	**34.83**	633	619.5	**545**	
B						V SP	19.6		1487	1190			41.49	**35.27**	606			
C						V SP	19.6		1487				33.83	**33.83**				**65.03**
468A		10/11/02	11/8/02	05-0855	5	VI				5750	5945	**5226**	9.59	**8.15**				
B						VI				6140			9.30	**7.91**				
C						VI							8.87	**8.87**				
469A		10/11/02	11/8/02	05-0855	5	VI				5700	6235	**5481**	10.06	**8.55**				
B						VI				6770			9.77	**8.30**				
C						VI							8.44	**8.44**				
470A		10/11/02	11/8/02	05-0855	5	VI				5900	6140	**5397**	8.90	**7.57**	5440	5170	**4544**	
B						VI				6380					4900			
C						VI							8.41	**8.41**				
471A		10/11/02	11/8/02	05-0855	5	VI				5780	6165	**5419**	9.30	**7.91**	6270	6154.5	**5410**	
B						VI				6550			8.47	**7.20**	6039			
C						VI							7.74	**7.74**				
472A		10/14/02	11/11/02	05-0481	5	V SP	17.3		1280	1370	1325	**1165**	31.71	**26.95**	1080	1195	**1050**	
B						V SP	17.3		1280	1280			29.18	**24.80**	1310			
C						V SP	17.3		1280				28.38	**28.38**				**39.39**
473A		10/14/02	11/11/02	05-0481	5	V SP	17.3		1280	1520	1475	**1297**	31.50	**26.78**	1100	1090	**958**	
B						V SP	17.3		1280	1430			28.96	**24.62**	1080			
C						V SP	17.3		1280				28.11	**28.11**				**42.81**

474A		10/14/02	11/11/02	05-0481	5	V SP	17.3		1280	1410	1510	**1327**	29.13	**24.76**	1120	1250	**1099**	
B						V SP	17.3		1280	1610			31.95	**27.16**	1380			
C						V SP	17.3		1280				27.44	**27.44**				**40.79**
475A		10/14/02	11/11/02	05-0481	5	V SP	17.3		1280	1350	1340	**1178**	34.15	**29.03**	1150	1135	**998**	
B						V SP	17.3		1280	1330			29.70	**25.25**	1120			
C						V SP	17.3		1280				28.51	**28.51**				**42.26**
476A		10/17/02	11/14/02	05-0855	5	VI				6030	6245	**5489**	9.25	**7.86**	4460	4430	**3894**	
B						VI				6460			10.54	**8.96**	4400			
C						VI							9.00	**9.00**				**11.96**
477A		10/16/02	11/13/02	05-0855	5	VI				5840	5780	**5081**	9.31	**7.91**	4640	4710	**4140**	
B						VI				5720			10.40	**8.84**	4780			
C						VI							8.36	**8.36**				**9.86**
478A	A4001	10/17/02	11/14/02	02-0748	2	IV DS		60		4460	4420	**3885**	16.41	**13.95**	2870	2805	**2466**	
B						IV DS		60		4380			10.54	**8.96**	2740			
C						IV DS		60					13.04	**13.04**				**18.79**
479A	B 21	10/18/02	11/15/02	02-0711	2	V SP	19.6		1487	1040	999.5	**879**	54.02	**45.92**	533	515.5	**453**	
B						V SP	19.6		1487	959			53.40	**45.39**	498			
C						V SP	19.6		1487				47.79	**47.79**				**92.66**
480A	M 45	10/18/02	11/15/02	02-0882	2	VI	20			3620	3610	**3173**	14.86	**12.63**	1460	1475	**1297**	
B						VI	20			3600			14.18	**12.05**	1490			
C						VI	20						11.84	**11.84**				**25.45**
481A	M 47	10/18/02	11/15/02	02-0882	2	VI	20			3470	3580	**3147**	14.48	**12.31**	1500	1640	**1442**	
B						VI	20			3690			13.64	**11.59**	1780			
C						VI	20						13.20	**13.20**				**27.88**
482A	JT-33	10/22/02	11/19/02	02-0994	2	V				6550	6555	**5762**	9.51	**8.08**	4320	4335	**3810**	
B						V				6560			10.63	**9.04**	4350			
C						V							8.51	**8.51**				**10.63**
483A	JT-33	10/22/02	11/19/02	02-0994	2	V				6280	6240	**5485**	9.75	**8.29**	4600	4495	**3951**	
B						V				6200			10.08	**8.57**	4390			
C						V							8.59	**8.59**				**10.35**
484A	B6092V	10/23/02	11/20/02	05-0855	5	VI				6040	5815	**5111**	9.73	**8.27**	4130	4260	**3745**	
B						VI				5590			10.25	**8.71**	4390			
C						VI							9.25	**9.25**				**10.38**
485A	2	10/25/02	11/22/02	05-0481	5	V SP	17.3		1280				30.53	**25.95**	1210	1130	**993**	
B						V SP	17.3		1280				31.48	**26.76**	1050			
C						V SP	17.3		1280				27.79	**27.79**				**43.84**
486A	B6093A	10/23/02	11/20/02	05-0855	5	VI				5750	5586	**4910**	11.09	**9.43**	4060	3935	**3459**	
B						VI				5422			11.11	**9.44**	3810			
C						VI							9.76	**9.76**				**11.46**
487A	1	10/25/02	11/22/02	05-0481	5	V SP	17.3		1280				29.54	**25.11**	1410	1395	**1226**	
B						V SP	17.3		1280				28.93	**24.59**	1380			
C						V SP	17.3		1280				25.14	**25.14**				**35.43**
488A		10/21/02	11/18/02	02-1048	2	IV		50		2450	2365	**2079**	27.98	**23.78**	1430	1430	**1257**	
B						IV		50		2280			26.89	**22.86**	1430			
C						IV		50					25.58	**25.58**				**35.93**
489A	M-49	10/25/02	11/22/02	02-0882	2	VI	20						13.26	**11.27**	1760	1865	**1639**	
B						VI	20						13.25	**11.26**	1970			
C						VI	20						11.84	**11.84**				25.18
490A	M-50	10/25/02	11/22/02	02-0882	2	VI	20			4310	4337	**3812**	12.14	**10.32**	1940	1910	**1679**	
B						VI	20			4364			12.59	**10.70**	1880			
C						VI	20						11.13	**11.13**				**22.84**
491A	IR-112	10/31/02	11/28/02	05-0611	5	IV DS		60							1820	1880	**1653**	
B						IV DS		60							1940			
C						IV DS		60										**26.01**
492A	IX021	11/1/02	11/29/02	03-0640	3	IV	18.2								1130	1115	**980**	
B						IV	18.2								1100			
C						IV	18.2											**41.04**
493A	IX022	11/1/02	11/29/02	03-0640	3	IV	18.2								1260	1200	**1055**	
B						IV	18.2								1140			
C						IV	18.2											**39.40**

494A	IX008	11/6/02	12/4/02	03-0876	3	IV	19.7			5010	5010	**4404**	13.28	**11.29**	1870	1820	**1600**	
B						IV	19.7						13.78	**11.71**	1770			
C						IV	19.7											
495A	M-57	11/8/02	12/6/02	02-0882	2	VI	20			3360	3360	**2953**	14.80	**12.58**	1900	1785	**1569**	
B						VI	20						15.00	**12.75**	1670			
C						VI	20						13.10	**13.10**				**24.50**
496A	M-58	11/8/02	12/6/02	02-0882	2	VI	20			3440	3575	**3142**	15.51	**13.18**	1640	1815	**1595**	
B						VI	20			3710			16.31	**13.86**	1990			
C						VI	20						12.25	**12.25**				**20.31**
497A	IX009	11/13/02	12/11/02	03-0898	3	IV	19.7			9560	9560	**8403**	7.26	**6.17**	4130	3985	**3503**	
B						IV	19.7						7.68	**6.53**	3840			
C						IV	19.7											
498A	IX010	11/13/02	12/11/02	03-0905	3	V SP	18.1			7750	8125	**7142**	8.64	**7.34**	3400	3495	**3072**	
B						V SP	18.1			8500			8.33	**7.08**	3590			
C						V SP	18.1											
499A	M-61	11/15/02	12/13/02	02-0882	2	VI	20			3420	3395	**2984**	14.28	**12.14**	1770	1830	**1609**	
B						VI	20			3370			13.53	**11.50**	1890			
C						VI	20						11.96	**11.96**				**20.51**
500A	M-62	11/15/02	12/13/02	02-0882	2	VI	20			3510	3480	**3059**	14.06	**11.95**	1680	1770	**1556**	
B						VI	20			3450			13.35	**11.35**	1860			
C						VI	20						12.13	**12.13**				**22.01**
501A	BR-22	11/18/02	12/16/02	02-0711	2	V SP	19.6		1487						601	604.5	**531**	
B						V SP	19.6		1487						608			
C						V SP	19.6		1487									**64.79**
502A	BR-22	11/18/02	12/16/02	02-0711	2	V SP	19.6		1487	1070	1060	**932**	45.05	**38.29**	599	608.5	**535**	
B						V SP	19.6		1487	1050			44.36	**37.71**	618			
C						V SP	19.6		1487				40.81	**40.81**				**64.46**
503A		11/13/02	12/11/02	05-0481	5	V SP	17.3		1280	2130	2180	**1916**	30.20	**25.67**	898	1009.5	**887**	
B						V SP	17.3		1280	2230			21.19	**18.01**	1121			
C						V SP	17.3		1280				20.13	**20.13**				**42.98**
504A	IX011	11/21/02	12/14/02	03-0905	3	V SP	18.1			9910	9871.5	**8677**	7.94	**6.75**	4650	4600	**4043**	
B						V SP	18.1			9833			7.89	**6.71**	4550			
C						V SP	18.1						5.94	**5.94**				**10.78**
505A	IC401	11/14/02	12/12/02	05-0554	5	II BD		50		2390	2315	**2035**	24.68	**20.98**	1830	1755	**1543**	
B						II BD		50		2240			26.24	**22.30**	1680			
C						II BD		50					20.83	**20.83**				**24.60**
506A		11/26/02	12/24/02	05-2072	5	IV				1800	1825	**1604**	31.44	**26.72**	1130	1135	**998**	
B						IV				1850			29.93	**25.44**	1140			
C						IV							26.51	**26.51**				**30.58**
507A	IX023	11/20/02	12/18/02	03-0611	3	II	19.3			5400	5495	**4830**	11.85	**10.07**	1530	1645	**1446**	
B						II	19.3			5590			11.90	**10.12**	1760			
C						II	19.3						10.03	**10.03**				**27.69**
508A	IX024	12/3/02	12/31/02	03-0640	3	IV	18.2			3990	3810	**3349**	18.91	**16.07**	1120	1145	**1006**	
B						IV	18.2			3630			18.96	**16.12**	1170			
C						IV	18.2						16.14	**16.14**				**34.25**
509A	IRCP3	12/4/02	1/1/03	05-0798	5	II	20			3160	3215	**2826**	15.94	**13.55**	1580	1530	**1345**	
B						II	20			3270			16.08	**13.67**	1480			
C						II	20						13.53	**13.53**				**25.23**
510A	IRCP2	11/20/02	12/18/02	05-0798	5	II	20			3120	3120	**2742**	15.59	**13.25**	1590	1540	**1354**	
B						II	20			3120			16.75	**14.24**	1490			
C						II	20						14.03	**14.03**				**26.96**
511A	G4063	11/1/02	11/29/02		7										826	877.5	**771**	
B															929			
C																		**48.28**
512A	BR-24	11/2/02	12/20/02	02-0711	2	V SP	19.6		1487	1010	978.5	**860**	43.71	**37.15**	585	606	**533**	
B						V SP	19.6		1487	947			39.21	**33.33**	627			
C						V SP	19.6		1487				34.71	**34.71**				**60.53**
513A	BR-24A	11/22/02	12/20/02	02-0711	2	V SP	19.6		1487	972	982.5	**864**	40.10	**34.09**	573	568.5	**500**	
B						V SP	19.6		1487	993			40.95	**34.81**	564			
C						V SP	19.6		1487				35.50	**35.50**				**62.55**

514A	02-1042	11/25/02	12/23/02	02-1042	2	II		50		3450	3545	**3116**	16.13	**13.71**	2510	2540	**2233**	
B						II		50		3640			15.25	**12.96**	2570			
C						II		50					13.33	**13.33**				**16.80**
515A	M-64	11/26/02	12/24/02	02-0882	2	VI	20			4260	4100	**3604**	11.39	**9.68**	1930	1940	**1705**	
B						VI	20			3940			12.79	**10.87**	1950			
C						VI	20						10.09	**10.09**				**20.25**
516A	M-65	11/26/02	12/24/02	02-0882	2	VI	20			4790	4790	**4210**	12.31	**10.46**	1890	1850	**1626**	
B						VI	20						12.85	**10.92**	1810			
C						VI	20						10.60	**10.60**				**19.44**
517A	BR-32	12/3/02	12/31/02	02-0711	2	V SP	19.6		1487	1120	1110	**976**	41.49	**35.27**	498	539	**474**	
B						V SP	19.6		1487	1100			39.64	**33.69**	580			
C						V SP	19.6		1487				37.59	**37.59**				**66.20**
518A	BR-32A	12/3/02	12/31/02	02-0711	2	V SP	19.6		1487	1110	1070	**941**	41.51	**35.28**	557	564	**496**	
B						V SP	19.6		1487	1030			39.64	**33.69**	571			
C						V SP	19.6		1487				36.41	**36.41**				**63.30**
519A	BR38	12/6/02	1/3/03	02-0711	2	V SP	19.6		1487	950	921	**810**	49.74	**42.28**	518	522	**459**	
B						V SP	19.6		1487	892			46.40	**39.44**	526			
C						V SP	19.6		1487				40.60	**40.60**				**74.80**
520A	BR38A	12/6/02	1/3/03	02-0711	2	V SP	19.6		1487	955	912	**802**	48.51	**41.23**	552	508	**447**	
B						V SP	19.6		1487	869			46.39	**39.43**	464			
C						V SP	19.6		1487				42.85	**42.85**				**73.79**
521A	BT25	12/14/02	1/11/03	02-0941	2	V	18.3								2720	2665	**2343**	
B						V	18.3								2610			
C						V	18.3											**15.13**
522A	BT25A	12/14/02	1/11/03	02-0941	2	V	18.3								3280	3280	**2883**	
B						V	18.3											
C						V	18.3											**14.08**
523A		12/9/02	1/6/03	05-0481	5	V SP	17.3		1280	1530	1550	**1362**	29.24	**24.85**	839	872.5	**767**	
B						V SP	17.3		1280	1570			30.49	**25.92**	906			
C						V SP	17.3		1280				26.83	**26.83**				**49.18**
524A			1/6/03												885	905	**795**	
B															925			
C																		
525A			1/6/03												725	728	**640**	
B															731			
C																		
526A			1/6/03												1210	1105	**971**	
B															1000			
C																		
527A			1/6/03												891	911	**801**	
B															931			
C																		

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