



*A COMMERCIAL APPLICATION OF  
VIROSOIL™ TECHNOLOGY*

**CASE STUDY  
PELICAN GOLF COURSE  
QUEENSLAND, AUSTRALIA**

*“It is clear that the ViroBind™ reagent treatment effectively remedied the scalds and the Riley’s Super Sport Couch fairway grass has fully regrown, with no acid scalds reappearing...”*



*Areas of the fairway affected by acid scalding after treatment with ViroSoil™ Technology.*

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## INTRODUCTION

In May 2003, Virotec Global Solutions was approached by Club Pelican Golf, located on the Sunshine Coast of southern Queensland, Australia, to assess the use of Virotec's ViroSoil™ Technology to treat Acid Sulfate Soils (ASS) scalding on part of their golf course.

It was found that in constructing the course in 1999-2000, the property developer had dredged a canal and used a substantial quantity of potentially acid generating sand and clay to create a fairway. After construction, it was observed that large areas of the fairway would undergo acid scalding and would not support grass growth, as characterised by large bald patches of grey, waterlogged soil (see Figure 1). Despite several attempts to correct the acid scalding caused by oxidation of the ASS used in the centre of the fairway, the scalds had either not been corrected at all or had returned after rain events.

As they were in a highly visible part of this world-class golf course, it was deemed vital that the unsightly scalds be effectively treated with something more than a short-term, neutralising "fix". The acid scalds were not only unfavourable from a golfing point of view, but were visibly unattractive, with little or no grass being supported. Lime had been used on a regular basis to treat the scalds since the course was constructed, but it had rapidly washed away or leached from the soil profile during rainfall events. Consequently, the treatments had not provided a permanent or even semi-permanent solution for the scalds or for the treatment of the underlying potential of ASS.

Therefore a more sustainable solution was sought, which would not require repeated maintenance and would result in improved fairway appearance.

## BACKGROUND



*The fairway at Club Pelican Golf Course.*



*The Club Pelican Gold Course clubhouse.*

Club Pelican Golf is Australia's first golf course designed by world-renowned Australian golfer, Greg Norman. Constructed at a cost of \$50 million and opened in 2000, this spectacular 18-hole golf course is located near Golden Beach on Queensland's Sunshine Coast. Surrounded by national parks on two sides and Bell's Creek on another, the course blends perfectly with its coastal environment, cleverly incorporating the natural landscape to enhance the unspoilt beauty of the area. Club Pelican Golf also boasts one of the finest clubhouse and practice facilities in Australia.

The golf course covers an area of 45 hectares, and is composed of 6,359 metres of championship tees, utilising tift dwarf Bermuda greens, Riley's Super Sport Couch on fairways and Santa Anna Couch on the tees.

## ACID SULFATE SOILS

Most Acid Sulfate Soils throughout the world have developed over the last 10,000 years along coastal lowlands. These soil types have high levels of iron sulfides (typically iron pyrite,  $\text{FeS}_2$ ), which, when exposed to air, can oxidise to produce sulfuric acid. The production and release of sulfuric acid, even at relatively low levels, can have a major effect on surrounding land and waterways, and in extreme cases can cause destruction of aquatic habitats.



*Turf had previously been laid several times due to acid scalding.*

The conversion of potential acid sulfate soils (PASS) to actual acid sulfate soils (AASS) commonly produces pore water and soil leachate pH values of  $< 3.0$ . During PASS formation, sulfate in seawater is microbially reduced to sulphide, primarily as hydrogen sulfide, but other organo-sulfides are also produced, and in sediments the hydrogen sulfide can react with ferrous iron ( $\text{Fe}^{2+}$ ) to form iron sulfides (monosulfide black oozes, MBOs) with the end product being iron pyrite ( $\text{FeS}_2$ ). Later, when water levels are lower and the sulphides are exposed to air, oxidation can proceed rapidly because it is catalysed by bacteria, such as thiobacillus ferrooxidans.

Conditions necessary for oxidation include the presence of adequate moisture, adequate oxygen and the removal of oxidation products. The products of oxidation may react with the sediments in which they were produced, and natural neutralisation or “buffering” may occur due to the presence of calcium carbonates (e.g. shell), other carbonates, organic matter, or exchange with cations in the sediment clay fraction.

Conditions on the fairway at Club Pelican Golf had many of the hallmarks of a classic ASS environment. These include waterlogging, soft, fine clays, silts and estuarine sands, a grey hue to the soil, soil scalds, and yellow jarosite mottles or red iron oxide mottles can be seen in excavated soil. Low pH values can also enhance the mobility of ecologically hazardous trace metals, adversely affect plant growth, and result in damage to engineering structures (McConchie & Clark, 1996 and Clark & McConchie, 1996).

## CHROMIUM REDUCIBLE SULFUR METHOD FOR DETERMINING ASS

The Chromium Reducible Sulfur (CRS) method for determining the reduced inorganic sulfur content of soil has been deemed preferable to methods based on oxidation using hydrogen peroxide (Clark, Lancaster & McConchie, 1996). Methods involving oxidation by hydrogen peroxide for the determination of reduced inorganic sulfur are subject to interference by even minor amounts of sulfate minerals and organic matter, resulting in inaccurate determinations of reduced inorganic sulfur contents.

For example, in the presence of even minor amounts of gypsum, methods involving oxidation using hydrogen peroxide have been shown to underestimate reduced inorganic sulfur contents by up to 0.167% sulfur, whereas in the presence of organic matter these methods overestimated reduced inorganic sulfur contents by up to 0.077% sulfur for each percent of organic carbon (Sullivan et al.). The resulting errors in the determination of reduced inorganic sulfur by hydrogen peroxide methods are often larger than the action criteria that are currently used to identify acid sulfate soils. Consequently, there is a risk of misidentification of ASS (either false positive or false negative) for soils with low reduced inorganic sulfur contents when hydrogen peroxide methods are used.

In contrast, results from the CRS method do not appear to be affected by interferences from either gypsum or organic matter, and this method appears to be more suitable for the determination of reduced inorganic sulfur in soils than methods based on oxidation using hydrogen peroxide. Because the soil at Club Pelican Golf was likely to contain large amounts of organic matter, it was determined appropriate to use the CRS method for assessing sulfide concentrations in the clay and sand components of the soil.

**TABLE 1: RESULTS OF ASS ASSESSMENT PRIOR TO TREATMENT**

Sample	Soil Texture	CRS (%S)	Soil pH	TPA (kg lime/m <sup>3</sup> )	TAA (kg lime/m <sup>3</sup> )
Clay	Medium	0.063	4.8	2.3	0.0
Sand	Coarse	0.009	5.4	0.4	0.0

## THE PROJECT

Virotec was commissioned to treat approximately 300 square metres of acid scalded fairway. The project was jointly undertaken by personnel from both Virotec and Club Pelican Golf. Employing the CRS method, Virotec investigated the acid generating potential of the acid scalded areas and determined that although the sand component of the fairway was not acid generating, the clay component was acid generating.

As shown in Table 1, it was found that the sulfur percentage of the clay component of the fairway was 0.063, with anything over 0.05% representing the presence of ASS in clay, whereas the sand component was just 0.009, with anything over 0.02% representing the presence of ASS in sand. Soil pH was on average 5.1 prior to treatment; a soil pH of 5.5 is generally considered to be the minimum acceptable value.



*Mixing the ViroBind™ reagent into the sand and clay of the first treatment area by rotary hoe.*

The total potential acidity (TPA) of the clay component was equivalent to 2.3 kg of lime per m<sup>3</sup> of clay, but the total actual acidity (TAA) of the clay was 0.0; the total potential acidity (TPA) of the sand component was equivalent to 0.4 kg of lime per m<sup>3</sup> of sand, but the total actual acidity (TAA) of the sand was 0.0. The fact that most of the acidity was potential acidity accounted for why the pH values were not substantially lower than those measured.

This finding indicated that acid is being actively produced and that the scalds were formed when surface evaporation concentrated the acid in just mildly acidic groundwater that was driven upwards in the capillary fringe zone of the soil. The fact that the appearance and severity of scalds was apparently linked to rainfall events further confirmed this theory.

To rectify the problem, it was decided that the turf on the fairway would be stripped off (see Figure 2), so that Virotec's patented ViroBind™ reagent could be applied to the affected soil profile at

a blending ratio to be determined by Virotec's computerised ASS treatment model, and the turf would be replaced together with some fresh top soil over the project area. The treatment areas would be monitored but largely left to weather for six to eight months and then re-sampled to assess the ASS characteristics of the soil.

Virotec supplied preliminary soil and site surveys, the shipping and handling of ViroBind™ reagent, the initial investigative program for defining the scope of acid sulfate soils, and ongoing soil sampling and monitoring. Club Pelican Golf was responsible for preparing the project area, spreading and rotary hoeing the ViroBind™ reagent into the soil profile, re-profiling the amended soil layer and replacing the turf and top soil, and any other responsibilities in relation to managing and maintaining the project area.



*Mixing the ViroBind reagent into the sand.*

Three treatment areas were identified, with the first (in the foreground of Figure 3) being an area of substantial acid scalding to which the ViroBind™ reagent was applied as a layer at a depth of about 100mm and mixed lightly by rotary hoe. The second treatment area (in the back-ground of Figure 3) was a similar size area where ViroBind™ reagent was thoroughly mixed with the clay and sand components to a depth of approximately 200mm. The third treatment area (to the left in the background of Figure 3) was a control area that was simply stripped and re-turfed with no addition of ViroBind™ reagent. The surrounding fairway, which still had many areas of scalding, served as a further control area where no disturbance to the turf or soil occurred.

## RESULTS

After eight months, as shown in Table 2 (see overleaf), it was clear that the ViroBind™ reagent treatment had effectively remedied the scalds and the Riley's Super Sport Couch fairway grass had fully re-grown, with no acid scalds reappearing.

This observation was confirmed by laboratory analysis of soil samples taken after eight months, which indicated that the oxidisable S content of the soil and the total potential acidity of both the lightly mixed and fully mixed treatment areas had been significantly reduced. Acid scalding continued to occur in surrounding areas of the fairway that had not been treated (e.g. to the right of Table 2 which can be seen overleaf).



*Top soil being applied to the area prior to turf being laid.*

In the first treatment area, CRS had been reduced to 0.003% at 100mm and 0.014% at 300mm and TPA was equivalent to just 0.1 and 0.7 kg of lime/m<sup>3</sup> respectively. In the second treatment area CRS had been reduced to 0.006% at a depth of 200mm and TPA was equivalent to just 0.3 kg of lime/m<sup>3</sup>. The fact that there was a greater percentage of S and higher TPA value at 300mm than at 100mm in treatment area one, tends to confirm the proposition that even the ASS at depth was improved by the addition of ViroBind™ reagent, and that potential acidity was greater at depth than on the surface of the fairway.

**TABLE 2: RESULTS OF ASS ASSESSMENT OF FIRST AND SECOND TREATMENT AREAS AFTER EIGHT MONTHS**

Treatment Area	Treatment Depth (mm)	CRS (%S)	Soil pH	TPA (kg lime/m <sup>3</sup> )	TAA (kg lime/m <sup>3</sup> )
1	100	0.003	9.61	0.1	0.0
1	300	0.014	6.78	0.7	0.0
2	200	0.006	9.43	0.3	0.0

It was also concluded that the treatment layer in both treatment areas would have created a favourable condition on the surface of the fairway, because any groundwater coming to the surface would have to pass through the ViroBind™ reagent and thus be neutralised before concentrating at the surface, thereby eliminating the tendency to kill fairway grass.

**TABLE 3: A COMPARISON BETWEEN AVERAGE PRE AND POST TREATMENT DATA**

Component	CRS (%S)	pH	TPA (kg lime/m <sup>3</sup> )
Untreated	0.036	5.1	1.3
Treated	0.0076	8.6	0.36

By the eighth month it was also observed that the control plot, which had been dug and reurfed but not treated, had also not re-scaled. It was unclear why this would occur other than possible residual effects from the contiguous second treatment area or the soil in this plot had lower levels of TPA than the other treated areas. However, by the ninth month there was clear evidence that the Riley's Super Sport Couch was beginning to die around the edges of the untreated plot, and that latent ASS were again becoming active. Clearly, some of the acid in the untreated plot was taken up by the new topsoil and thus it took time for the acid to affect the plants.

## CONCLUSION

The application of Virotec's ViroSoil™ Technology to the ASS and acid scalded areas of Club Pelican Golf resulted in the successful elimination of scald areas and a reduction of potential acid sulfate soil impacts to the fairway. This conclusion was confirmed by soil analysis eight months after treatment.

While ongoing monitoring will confirm the longer term benefits of the application of ViroBind™ reagent to the fairway, it has been confirmed that this reagent, unlike lime, does not readily leach from soil, and therefore the potential for the scalds to return in the future has been minimised. Moreover, it has been found elsewhere that the ViroBind™ reagent actually serves as a good rooting medium for tree and grass growth and increases the nutrient retention capacity of highly leached sandy and clay soils, and it is therefore expected that the fairway at Club Pelican Golf will continue to benefit from good grass growth.

## TESTIMONIAL

*“After repeated attempts to solve the acid sulfate soils problem we faced at Club Pelican Golf, we turned to Virotec Global Solutions because of their track record in addressing this problem at other locations in Queensland. We had tried liming the fairway several times with little or no long-term effect, and we were desperate to come up with a more permanent solution because these acid scalds were in a highly visible part of the fairway, and many golfers complained about both the look and the poor golfing performance of this area.*

*After applying the ViroBind™ reagent to the main ASS hot spots, we re-turfed the area and waited to see what would happen. To be honest, in either a positive or negative direction, nothing much did happen for quite some time. We thought this was probably due to the drought and not much groundwater rising from below the fairway to activate the ASS. We waited for quite some time. While the scalds didn't return, the control plot looked pretty much the same as the treated areas. So while we were happy to not have the scalds, it appeared that by just lifting the turf and exposing the soil for a period of time we got the same result as applying the reagent.*

*However, after about the ninth month, it became obvious that grass on the control plot was beginning to die off while the treated areas looked as healthy as the best part of our course. We are happy with this result and will continue to monitor the performance of the site.*

*We can recommend that this approach seems viable to treat ASS, particularly if it were applied to dredge spoils before there are used in golf course construction or property development.”*

### **BEN MARSHALL**

Head Groundskeeper  
Club Pelican Golf



Area treated with ViroSoil™ Technology shows no signs of scalding after 8 months.

## REFERENCES

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