Technical Report of the Technical Consulting Team
to the Pinelands Commission

Appendix B to
Acting Executive Director's Report
on Proposed PCS Plan
Technical Consultants' Report (12/31/99

regarding
"Comprehensive Plan for
PCS Communications Facilities in the Pinelands"

December 31, 1999

1. Since August 1999, the consulting team (CT: Bruce Eisenstein, Ph.D., P.E.; Moshe Kam, Ph.D.; P. M. Shankar, Ph.D.) has been providing the members and the staff of the Pinelands commission (PC) with technical assistance in the area of mobile radio and telecommunications. This assistance was made in conjunction with the anticipated "Comprehensive Plan for PCS Communications Facilities in the Pinelands," and following previous consulting to the PC by the CT on matters of cellular telephony.

2. The CT reviewed technical and administrative information supplied by the PC and by the prospective PCS providers ("providers" in the sequel), *Sprint Spectrum LP* and *Omnipoint PCS Entrepreneurs, Inc.* The CT received reports from the providers regarding their extensive efforts to obtain industry-wide cooperation. In the opinion of the CT, the providers have demonstrated a *bona fide* effort to include in their plan all the eligible entities that are licensed to provide PCS services in the Pinelands. The CT is unable to assess the ramifications of future actions by PCS entities who failed to join the present plan.

3. The CT acquired or otherwise obtained background, technical, administrative and other information pertinent to the technical questions posed by the proposed plans of the providers. The CT participated in formal and informal meetings with members of the PC's staff, members of the PC, and representatives of the providers. The CT communicated extensively with representatives of the providers and the PC staff, in face-to-face meetings, and by phone, fax, and electronic mail. The CT participated in at least twenty five exchanges of information and meetings in the course of the preparation of the plan, including a forum open to the public, held on November 16, 1999. The CT has reviewed several drafts of the document entitled "Comprehensive Plan for PCS Communications Facilities in the Pinelands" ("the

plan") submitted by *Sprint* and *Omnipoint*, and a number of coverage maps, land-use maps, and topographical maps.

The CT bases its comments in the present report on the October 25, 1999 revision of the *plan*.

4. The CT requested and obtained extensive technical and administrative information about the emerging plan for PCS facilities in the Pinelands, including geographical and topographical maps; detailed lists of planned locations; heights of proposed and existing towers; and equipment that the providers have installed or want to install in the Pinelands; aerial photographs; radiation-level maps (ANET plots); output of computer models and design algorithms for microwave radiation and mobile telephony design (including all modeling assumption used); and lists of existing towers, installations, and apparatus available within and without the Pinelands.

5. The CT has obtained a formal statement from the providers regarding the tower heights that they have used in making ANET plots, and other calculations and experiments on which the *plan* is based. The default antenna height used in calculation and experimentation was 150 feet.

6. The CT reviewed information about the final suggested locations of sites that were moved in the process of planning, and requested, obtained, and examined ANET plots for these sites.

7. The CT has conducted independent experiments aimed to establish and maintain PCS communications from various locations within the Pinelands. These experiments were conducted in order to assess the realism of theoretical calculations made by the providers (including modeling assumptions), and in order to establish a base line for existing quality of service within the Pinelands. While not exhaustive, these tests served the CT to calibrate the information received from the providers and to assess the advisability of tower erection in sensitive areas - or in areas where the PC staff or the public expressed the need for extra caution. In addition, the CT has received from representatives of *Sprint Spectrum L.P.* the results of several field tests executed by their technical staff.

8. The CT has conducted independent sample calculations to ascertain accuracy of the information supplied by the providers.

9. The CT recognizes that design of a PCS grid presents a *coupled* tower-location problem. Towers are not erected in isolation, but depend on the location, height, and region-of-coverage of neighboring towers. Consequently, some systems are capable of covering a specific region in the Pinelands that others do not. It is not possible to deduce solely from the success or failure of one technical system to cover a given area within the Pinelands, that another technical configuration will or will not be able to provide coverage there. The CT notes that small changes in the locations of towers adjacent to a proposed tower are unlikely to make a material difference in the "needs analysis".

10. The CT recognizes that several different modulation and coding techniques are in use by PCS systems, and that several different radio-frequency hardware designs are employed. In particular, there are differences in the power levels transmitted and received by users of the different services; the same quality of service may require different signal-to-interference ratios in different systems. Some PCS systems are thus capable of using antenna towers that would be unsatisfactory for others, and some systems can use existing structures that are not appropriate for others. Determination of the needs of each PCS system depends its technical parameters. The CT took the pertinent technical parameters of each provider into account when reviewing the various tower-location alternatives.

11. The CT recognizes that limitations on type of licenses and other regulatory limitations may require facilities that would not be necessary from RF technical considerations. For example, regulatory issues may be binding in the determination of the final location of *Omnipoint* site 64 (see section 24.2 below). Furthermore, the CT recognizes that legal and regulatory requirements of coverage by the present providers may be different from those required from cellular telephony entities. In this regard, the CT notes that the present *plan* aims to provide comprehensive coverage for the main roads traversing the Pinelands, along with the adjacent communities, for a period of about five years from the present time. No representation is made by the plan for needs that may arise at later time.

12. The CT has examined each requested facility, including those planned on existing structures. In particular, the CT has examined each facility in the *height-restricted* and *least-number* areas. When appropriate, the examination included field tests (especially along route 322), and sample calculations to check both theoretical and field tests results. When appropriate, the CT has requested the providers to examine and supply information (including ANET plots) about alternative sites. The CT has retained the plots and field test results used in its examination of the new facilities.

    The CT has examined each facility and determined that it was needed in the sense that without this facility a gap in coverage will appear. Determination of need was done using a combination of the following: (1) standard RF propagation calculations (see for example Chapter 4 of V. K. Garg and J. E. Wilkes, *Wireless and Personal Communications Systems*, Prentice Hall PTR 1996, including references); (2) ANET plots; and (3) RF propagation experiments. The CT asked for ANET plots whenever one of more of the following conditions occurred: (1) alternative locations needed to be compared (especially on the boundary between *height restricted* and *least number* zones); (2) questions about preliminary calculations were raised; (3) there was preliminary evidence that actual propagation is different than theoretical predictions due to flora; and (4) other indications were given (by the PC staff or the public) that special caution is in order.

13. For every new facility[1] that could potentially be served from other existing or proposed locations, the CT requested and obtained ANET plots, or made its own RF power propagation calculations. Requested ANET plots detailed and analyzed the various options regarding the facilities in question, per the CT's specifications. The information requested by the CT included ANET plots *with and without* the proposed facility. In addition to the ANET plots, the potential for "using other existing or proposed locations" was assessed through field trips, examination of geographical maps and aerial photographs, and tower information supplied by the providers, the PC staff, and others.

[1] Namely a facility that would require a new tower not already in existence, nor already approved by the PC through the cellular telephony plan or other authorizations.

14. The CT obtained from the providers all the ANET plots and combinations of ANET plots that it has requested , and has secured all the information that it needed in order to make an informed recommendation.

15. NUMBER AND LOCATION OF TOWERS. The CT has formed the opinion that, within the known technical parameters that it has examined, and the best estimates of present and expected need for PCS systems along the main transportation routes and adjacent communities in the Pinelands, the present *plan* appears to satisfy both the demonstration of "need" and the "least number necessary" requirements per NJAC 7:50-5.4 (c) 1 AND 6.

16. Specifically, The CT has formed the opinion that, within the known technical parameters and the best estimates of present and expected need for PCS services within the Pinelands, the present *plan* appears to satisfy the "least number necessary" requirement in the areas designated as "least number" regions.

17. In rendering the opinions expressed in sections 15 And 16, the CT makes five related observations.

    17.1 The location and number of towers within the Pinelands are affected by the location and number of towers for PCS and other services inside and outside the Pinelands; the CT has examined the availability of facilities inside and outside the Pinelands in making its inquiries and recommendations.

    17.2 The "least number necessary" solution is near-optimal but not necessarily unique (there may be other technically equivalent solutions); however, any solution that provides for a similar level of service using the same technology is likely to be essentially similar to the solution proposed by the providers in the present *plan* - in terms of the number and general placement of antenna towers.

    17.3 The CT has used the criteria for "quality of service" outlined in sections 18-19 below in order to assess the need for new facilities. These are the same criteria used by the CT when it assessed earlier the quality of service for the Pinelands' Cellular Telephony plan.

17.4 The CT assumed and required that co-location opportunities be exploited to the maximum extent possible (see sections 20-23.)

17.5 The CT has examined the need for all facilities proposed by the *plan*, one-by-one and in combination, and has formed the opinion that all facilities as proposed in the *plan* are needed, one-by-one and in combination, to satisfy the required quality of service furnished by the providers to regular customers along the main routes traversing the Pinelands and the adjacent communities.

18. QUALITY OF SERVICE. The CT has formed the opinion that the parameters outlined in the *plan*'s Code Compliance section entitled "Level of Service" are the primary means to define quality of service at the present time. The CT has used these criteria, along with numerical values for them (see section 19), to form its opinions and recommendations.

18.1 The CT recommends that if future needs which were not foreseen by this *plan* are presented to the PC, the providers be requested to present the PC and its technical consultants with the values of *Signal to Interference Ratio at Audio*, *Dropped Call Rate* and *Blocked Call Rate*, as measured in areas that suffer from alleged substandard quality of service, and in comparable areas where an acceptable quality of service level has been established.

18.2 The CT further recommends that in that case the PC and its technical consultants assess the quality of service with respect to these parameters (and additional quality of service parameters that may emerge in time as mobile radio services expand.) Values of these parameters would then be assessed in comparison with their values in similar regions inside and outside the Pinelands, in comparison with the industry's norms and the prevailing technical standards, and in comparison with relevant standards regarding land lines.

19. As a basic yardstick for assessing future requests, the CT recommends at present that

19.1 *Signal to Interference Ratio at Audio* be deemed satisfactory if it is larger than or equal to 30dB in the 30-3400 Hz band;

19.2 *Dropped Call Rate* be deemed satisfactory if it is less than 1% over a period of 10 minutes; and

19.3 *Blocked Call Rate* be deemed satisfactory if it is less than 1% over a period of 10 minutes.

The CT asserts that it has used these numbers in assessing the need for facilities in this PCS plan, as well as in the previous Cellular telephony plan for the Pinelands. The CT developed these numbers on the basis of several sources, the primary being the following report of the Exchange Carriers Standards Association: Report no. 20, Committee T1 Telecommunications, September 1993: *Technology-Independent User-Oriented, Objective Assessment of Speech Transmission Quality*, document T1A1/92-021. The threshold levels offered by the providers on the ANET plots are convertible to signal to interference ratios at audio and outage probabilities.

20. CO-LOCATION. The CT agrees with the principles and methodology detailed in the *plan*'s Code Compliance section entitled "Co-location Policy."

21. The CT specifically agrees with the use of the term *service affecting interference* in the context of co-location. The CT recognizes that some level of interference is inevitable as a result of co-location, but once all other requirements for co-location have been met, *only service affecting interference could be a reason to reject a co-location request.*

22. The CT recommends that interference would be deemed *service affecting*, if and only if it causes at least one of the following: (i) a measurable reduction in the *Signal to Interference ratio,* but no less than 0.1dB; (ii) a measurable increase in the *Dropped Call Rate,* but no less than 0.05%; (iii) a measurable increase in the *Blocked Call Rate,* but no less than 0.05%.

23. The CT recognizes that the present co-location policy does not provide a complete step-by-step blueprint for the co-location procedure at each site. A detailed contract that follows the co-location policy would be needed at each site.

24. SPECIFIC FACILITIES

24.1 The primary technical issue raised by the CT during the preparation of the plan was the location of facilities along route 322. The CT is satisfied that, from a technical viewpoint, changes in location of facilities were made to minimize non-compliance with regulations - while providing adequate service along this road. This conclusion

was developed using ANET plots as well as the results of radiation-level field tests provided by Mr. Clement Poole of *Sprint*. The CT was informed that locations for all proposed towers along Route 322 were now identified such that all regulations are complied with.

24.2 Site 64. The CT has requested and obtained several ANET plots from Mr. Levitzky of *Omnipoint*. On the basis of these, the CT has arrived at the following opinions.

24.2.1 The technical need for a site for *Omnipoint* between site *Sprint 39* in the East, and site *Sprint 38* in the West appears to have been established. Otherwise a coverage gap along Route 70 will be present.

24.2.2 The site originally offered by *Omnipoint* as 64 (and marked in its ANET plots as Old PL-5, latitude 39-57-25.7N longitude 74-25-10.7W) appears to solve the Route 70 gap problem; moreover, there is a permitted site at this location. However it is not the only possible technical solution.

24.2.3 The site marked on *Omnipoint*'s ANET plots as PL-5, latitude 39-57-49.2N longitude 74-25-43.8W - a cleared area within the Ft. Dix facility) appears to solve the Route 70 gap problem

24.2.4 The site marked on *Omnipoint*'s ANET plots as *Landfill* (located west of Sprint site 55 on Route 70, latitude 39-57-33.1N longitude 74-24-30.3W) appears to solve the Route 70 gap problem

24.2.5 The site marked on *Omnipoint*'s ANET plots as PL-5NR (latitude 39-56-54.6N longitude 74-24-47.2W) appears to solve the Route 70 gap problem.

24.2.6 The site marked on *Omnipoint*'s ANET plots as Town (latitude 39-57-37.0N longitude 74-23-35.0W) does NOT solve the Route 70 gap problem.

The CT was informed that the providers have proposed to locate the site at the *Landfill* site or at PL-5NR.

24.3 The CT understands that sites which satisfy current regulations for proposed tower 17 (as well as all other towers in the plan) have been identified.

25. COMMENTS BY THE PUBLIC

During the public hearing conducted by the PC on November 16, 1999 members of the public made comments on several sites. In addition, the CT has received and reviewed close to eighty (80) written comments on the plan. The CT has provided its observations on these comments in Appendix A.

Among the sites discussed in the public hearing and the written comments are the following

25.1 Site 64. Please see section 24.2 for the CT's comments on this site.

25.2 Site 62. This site was requested in order to cover a stretch of about ten (10) miles between facilities 22 and 35. This stretch of road cannot be covered from either site 22 or 35, alone or in combination. Moreover, there is at present no other existing facility which could provide coverage for this region. The CT possesses ANET plots with and without facility 62, which demonstrate a gap in coverage in the absence of facility 62. The CT therefore expresses its opinion that this facility is necessary.

25.3 Site 28. This facility was requested in order to cover a gap in service between facilities 2 and 26. Among the regions where coverage would otherwise not be available is a stretch adjacent to Hopewell Road. The CT has requested and received additional information (ANET plots) for this Based on these, and its own calculations, the CT has formed the opinion that site 28 is necessary.

Respectfully submitted,

December 31, 1999

Moshe Kam, Ph.D.,
for the Consulting Team

Appendix A: Comments by the public

1. The consulting team (CT) has reviewed all public response supplied to the CT by the staff of the Pinelands Commission (PC) with regard to "Comprehensive Plan for PCS Communications Facilities in the Pinelands". In this appendix, the CT offers its observations on these comments. The CT has limited its response to technical issues within the scope of its consultancy to the PC. When a comment of the public encompassed issues that are both within and without the scope of the CT's consultancy, the response was intentionally confined to issues within the scope of the team's consultancy.

2. **General themes**[1]

   2.1 Many of the writers to the Commission believe that the PC is empowered to deny the PCS providers *any* new towers in the Pinelands. Many writers object to towers in principle and offer the opinion that it is better not to have PCS service than to erect towers in the Pinelands. Our understanding is that limitations imposed by the 1996 Telecommunications Act do not allow such blanket denial of all new towers by the PC, and that solutions along these lines would require new legislation. [References PCSL 3, 5-11, 14-20, 22-25, 28-34, 37-41, 43-45, 47-49, 51-58, 60, 62-66, 68, 70-72.]

   2.2 Many of the writers to the Commission claim that the need for the new facilities has not been demonstrated. As indicated in our report to the PC, the CT has concluded that there is technical need for every facility that appears in the plan, in the sense that PCS service will not be available in an area which the provider is licensed to cover unless the proposed facility was implemented. The CT sought alternatives in all cases – especially the 'pygmy pines' areas.

   The CT considered all facilities – individually and in combination with other existing or previously approved sites. Based on information that the CT received from the providers, the staff of the PC and the public, the CT sought the optimum use of existing facilities and of previously-approved facilities. [References PSCL 4, 10, 11, 21, 26, 27, 35, 42, 61, 74.]

[1] References are to the numbers of comments in the Pinelands Commission submission log, PCSL 1-76.

3. Specific issues

3.1 Letter from Mr. Craig Farrell (Reference PCSL 11)

3.1.1 Mr. Farrell comments on the qualifications of members of the CT. The CT comprises three individuals (Dr. Bruce Eisenstein, Dr. Moshe Kam, and Dr. P. M. Shankar) who possess extensive experience in design, design review, and teaching of design for mobile radio systems. Resumes of members of the CT, including past experience, licenses, government and industrial experience, and publication record, are on file with the PC.

3.1.2 Members of the CT do not have (nor did they have in the past) grants, contracts or any other commercial ties with the applying providers, except as regular residential customers of telephony services of some of the providers. To the best of their knowledge members of the CT have no business or commercial ties with any member of the PC or PC staff.

3.1.3 The CT is unable to understand the following paragraph in Mr. Farrell's letter, regarding the qualifications of Moshe Kam:

"if they (major cellular and PCS vendors in America - MK) are his customers, you cannot possibly hope for him to provide an unbiased opinion. If they are not his customers , then he probably does not know what he is talking about."

According to this paragraph there exist no individuals who can ever provide technical consultancy to the PC, since each and every potential consultant either served the providers as customers (in which case s/he is disqualified according to Mr. Farrell,) or did not serve them as customers (in which case s/he is disqualified again, according to Mr. Farrell.) The pool of consultants according to this comment is the empty set. We respectfully suggest that this conclusion is not particularly constructive.

3.2 Height of towers. Unless otherwise indicated, an antenna height of 150 ft was used in the CT's calculations and tests [Reference PSCL 11].

3.3 We are unaware of improvements in "tower technology" which would provide smaller and "better disguised" towers. The only way to reduce height at the present time is to decrease

coverage, which in turn would require the addition of several (lower) towers in the periphery of each reduced-height tower.

Increasing the range of a tower is possible at the present time only by making the tower taller or (possibly) by a radical redesign and replacement of all mobile phone sets used by subscribers. The CT did not consider this a viable alternative. [Reference PSCL 12, 61.]

3.4 Existing coverage and alternatives of coverage from existing structures have been considered by the CT (based on information received from the staff of the PC and other entities, including the public); full-scale ANET plots were requested and examined by the CT when (1) discrepancy between the CT's preliminary calculations and providers' data was discovered, (2) special restrictions or environmental sensitivity were indicated, or (3) possible alternatives were available. [Reference 36, 42, 50, 61.]

3.5 The CT's report spells out the criteria that the CT used for quality of service.

3.5.1 *Signal to Interference Ratio at Audio* was deemed satisfactory if it was larger than or equal to 30dB in the 30-3400 Hz band;

3.5.2 *Dropped Call Rate* was deemed satisfactory if it was less than 1% over a period of 10 minutes; and

3.5.3 *Blocked Call Rate* was deemed satisfactory if it is less than 1% over a period of 10 minutes.

[Reference PSCL 50].

4. Letters from the Pinelands Preservation Alliance

(November 22, 1999 PSCL 67; December 16, 1999 PSCL 76).

4.1 Claims regarding ANET plots (last paragraph on first page of PSCL 76) appear wrong. ANET plots requested by the CT represent radio frequency power levels that correspond to adequate quality of service as defined in CT's report to the PC. Thresholds on maps correspond to signal to interference ratios at receivers, and to outage probabilities. Sensitivity of ANET plot to accuracy of location of nearby plants is low, in the sense that shifts of ¼ mile in location of peripheral sites cannot "fill in" coverage gaps. ANET plots were requested by the CT only in those cases where a question arose as to exact area of coverage (see 3.4). For all other cases, elementary calculations based on accepted models

of RF propagation[2] demonstrated lack of coverage beyond any doubt. The CT did not burden the providers or the PC with requests for additional information when elementary calculations have shown lack of coverage beyond any doubt.

4.2 Claims regarding threshold levels on the first paragraph on page 2 of PSCL 76 appear wrong. Thresholds which the applicants use in their calculations correspond to signal to interference ratios in audio and outage probabilities, which the CT considered in order to determine quality of service. The CT's report explicitly indicates the required signal to interference ratio at audio. The CT based this number on minimum comprehensibility standards published in the mainstream literature[3].

In Pinelands' regions where the providers claimed that excessive absorption was suspected due to characteristics of the flora, field tests were conducted by the providers, and results were examined by the CT.

4.3 Claims regarding numerical criteria (on the second paragraph on page 2 of PSCL 76) appear wrong. The numerical criteria used by the CT are not new, as they have appeared already in the CT's report to the CP regarding the cellular plan. The numerical criteria are precisely the ones that the CT has considered for the present PCS plan in assessing quality of service. These criteria are recommended for future use as well.

4.4 Claims regarding the basis for the CT's numerical criteria (paragraph 3 of PSCL 76) appear unfounded. The CT has used as its primary source for these criteria a report of the Exchange Carriers Standards Association (Report no. 20, Committee T1 Telecommunications, September 1993: Technology-Independent User-Oriented, Objective Assessment of Speech Transmission Quality, document T1A1/92-021).

4.5 Claims regarding incompatibility of criteria between the cellular plan and the PCS plan (fourth paragraph of PSCL 76) appear wrong. The CT has used EXACTLY the same criteria for both plans, and the RF power threshold levels in ANET plots translate directly into signal to interference ratios in audio and to outage probabilities. It is incorrect that the CT's report on the cellular plan "never provided quantitative or qualitative measures" for

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[2] As described, for example, in Chapter 4 of V. K. Garg and J. E. Wilkes, *Wireless and Personal Communications Systems*, Prentice Hall PTR 1996.

[3] Such as the Exchange Carriers Standards Association document T1A1/92-021 "Technology Independent user-oriented objective assessment of speech transmission quality," 1993.

the three parameters. It did, and these same numbers appear in our present report (and are quoted in this appendix - see 3.5). It is incorrect that the PCS report does not link the criteria to the plan. On the contrary - the CT has used these very criteria to examine the PCS plan.

4.6 Regarding comments in PSCL 76 about the level of details in the CT's report - if the PC requires a more detailed technical report, which will provide detailed site by site propagation calculations, ANET plots, and, when applicable, results of field tests and detailed rationale, the CT has the technical capabilities to prepare and supply such report. In the CT's understanding the compilation of such a detailed site-by-site technical report, including an essay on criteria and technical background, was outside the scope of its consultancy. The CT was requested to examine the proposed sites and provide the PC with a summary opinion of the technical need for each site and of the plan individually and for all sites collectively, and to examine technical alternatives in order to maximize compliance with Federal and State regulations. The CT has provided this information in its report.

The CT will entertain a request for an expansive theoretical technical treatise on the subject, but does not anticipate any changes in its recommendations as a result of compiling such treatise.

The CT will make public any information received by the CT during the fulfillment of the CT's obligations to the PC, and which the PC would request.

4.7 On page 3 of PSCL 76, it is claimed that the plan is designed to "serve roads, not communities." In the CT's opinion the present coverage plan provides "adequate service" as required by the CMP. Moreover, it requires a smaller number of new towers in the Pinelands than any plan with a more expansive coverage goal. A more expansive coverage goal would result in a plan with at least all the towers proposed in the present PCS plan, and probably more.

5. Letter from Parker McKay and Criscuolo (November 15, 1999)

(Reference PSCL 1, Site 28)

This letter concerns site 28 in Evesham township. In response to this letter and to comments made by the public earlier, the CT has requested and obtained ANET plots describing joint coverage by sites 2, 47 and 26 (but not 28), as well as joint coverage by sites 2, 47, 26, and 28. The plots (centered at *long.* 74 51' 44.9; *lat.* 39 47'31.0) do demonstrate a coverage gap within a residential area in Evesham, adjacent to Hopewell road.

6. We have no specific comments regarding PSCL 1, 13, 59, 69 and 75.

Respectfully submitted,

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