

This article presents a methodology for the delivery of a Site Master Plan (SMP) for a pharmaceutical facility. It describes a three step execution and presents a list of issues that appear regularly during the development phase.

Site Master Planning

by Richard Larkin

Pharmaceutical manufacturing and research sites are complex investments, which must provide a cost-effective environment for a company to conduct its activities.

Often the site has developed in a piecemeal fashion over the years with new capital projects being subject to short term goals and pressures. This can result in a site which is no longer operating at peak efficiency (in terms of equipment utilization, utility supply and overall movements) and where the layout of individual buildings or the whole site needs improvement. Overall, the site may look very different from the ideal arrangement for a new site. However, there comes a point when a more fundamental reorganization and rationalization of the site becomes essential. This may be triggered by one of the following reasons:

- overall age of assets
- GMP deviations
- manufacturing cost pressures
- logistical issues and flows
- changes to product portfolio
- change of ownership (merger or acquisition)

This is the point at which a site will benefit from a Site Master Plan (SMP).

An SMP for an overall site or facility has to identify the business drivers and future site strategy for a defined period (say five to ten years), convert this into a technical brief (technology, space, support functions, etc.), and select the best overall arrangement to meet these objectives. It is of no value if the plan satisfies one activity (for example, production) if at the same time, it compromises other activities (such as logistics, QC space, etc.).

The SMP must be a holistic plan that addresses every issue and yet manages to obtain consensus agreement with both site and corporate management. A thorough SMP will encompass the following operational needs:

- production departments
- logistics, warehousing and material flows
- cost of goods and operating efficiency
- utility systems

It will also encompass the following site support features:

- personnel flows and practices (such as gowning)
- laboratories and QC compliance
- archives
- office and canteen areas
- site security and parking
- environmental and planning issues

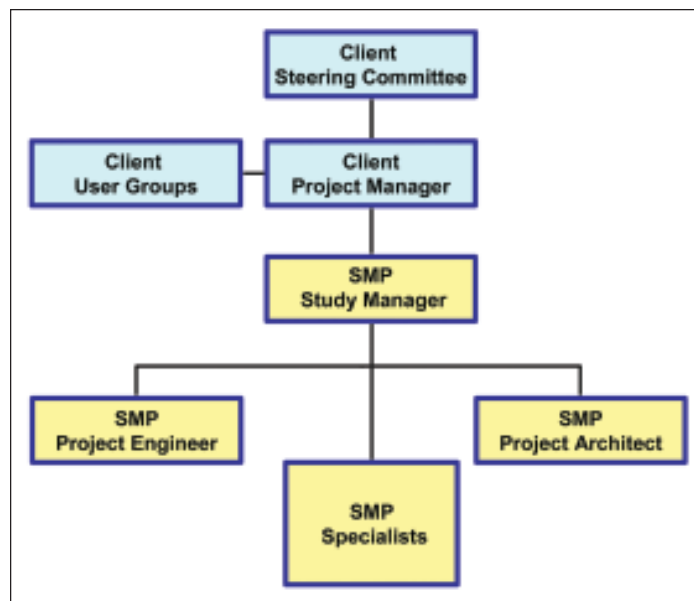


Figure 1. A typical SMP team organization chart.

As the SMP will be a key document for the future of the site, the execution of the study must follow a well structured and transparent methodology in which competitive schemes are compared and analyzed in an objective way. A record of the decision-making process is vital

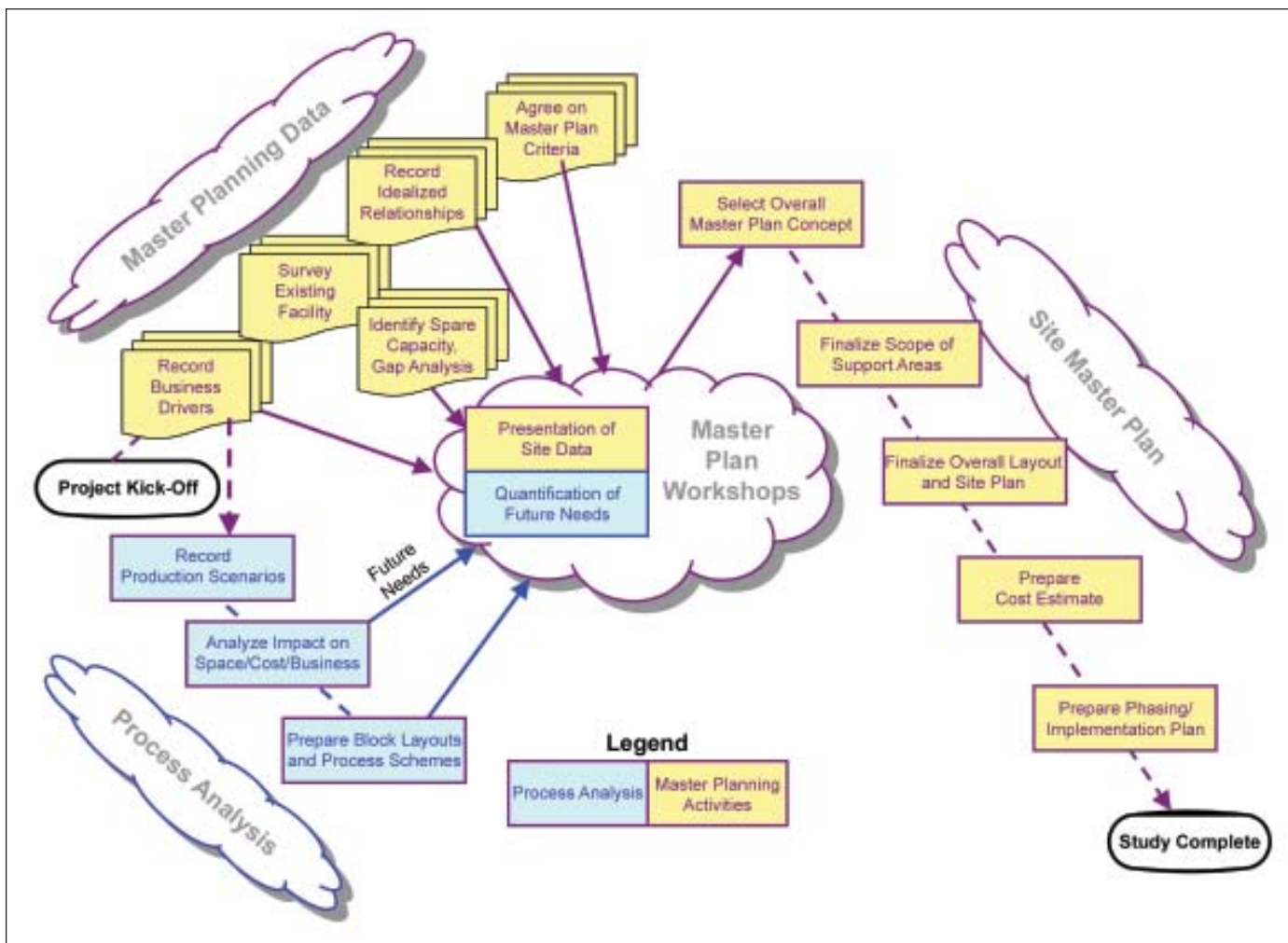


Figure 2. The overall steps of the SMP execution plan.

for reference, and to demonstrate this objectivity and 'best value' solution.

Many clients prepare their SMP 'in-house,' but others wish to use an external company to provide independent input.

This article outlines the author's experience in developing SMPs, including some of the typical issues encountered at pharmaceutical sites around the world.

The term Site Master Planning can be used to cover three distinct types of plan:

- **Green Field** Site Planning
- **Facility** Planning of an Existing Mature Site
- Individual **Building** Planning

The techniques described in this article are applicable to all three types of plan, but the examples are drawn from Facility and Building Planning.

The Vision

The bedrock that underpins any SMP is the future vision for the site. This must be provided by the client or owner, who will have a specific vision regarding the role of the site within

the overall corporate strategy. The vision also must incorporate the long range production plan.

Many sites have a stated vision for internal publicity and marketing, but often this requires further definition to form the basis of a detailed site plan. For instance, a site may declare a vision:

"To be a center of excellence for production of a certain product range."

However the SMP may need this vision to be further developed into:

"To be the center of excellence in sterile manufacture within the corporation with an annual capacity of xx million units/yr on a two-shift, six-days-per-week basis, but readily expandable to yy million units/yr by operating a third shift. The site is to have the flexibility to back up production from zz site, and be able to accept transfers from other sites. All obsolete equipment is to be replaced within a certain period. The site must target a 20% reduction in the cost of goods and site inventory is to be reduced to a target of ww days. The site is to address

all high and medium risk GMP issues...”

The Final Deliverable

A well structured SMP report will typically contain the following elements:

- Site Strategic Vision/Mission Statement
- Executive Summary, including:
 - critical issues addressed in the SMP
 - critical assumptions
 - key selection criteria used in the SMP development
 - overall site plan showing key phases of implementation
 - summary of key projects
 - overall cost and schedule, including key steps/trigger points
 - implementation plan
 - inclusions, exclusions, and outstanding issues
- Report on each department, including current status, future plans, and implementation strategy:
 - process operations (production, packaging, clean utilities)
 - GMP compliance
 - quality operations
 - flows and site infrastructure, including security
 - buildings and building services
 - site support areas
 - warehousing and logistics
 - utilities
 - environmental systems
- Project listing of all the significant capital projects required to deliver the SMP, including cost estimate (+/- 30%), implementation plan, and schedule
- drawings of the overall site, production building block layouts, and other more detailed plans to illustrate the SMP concept
- appendices, including a summary of the methodology used, and details of the alternative schemes that were adopted and rejected

The Execution Plan

The most critical element leading to a successful SMP is the team.

The study manager for the SMP consultant must have facilitation skills as well as a good technical knowledge of current industry practice. He or she also must be able to interface with the client's management team at the highest level and be able to present concepts and ideas in a simple and yet authoritative manner.

The study manager will need to be able to call on the support of technical experts in key disciplines including:

- GMP Compliance

- Automation
- Production Equipment
- Civil/Structural Engineering
- Environmental Engineering
- Architecture and Local Planning

However, the greatest threat to a successful SMP may come from a team that is drawn into excessive detail in the analysis of technical issues. Therefore, specialist input has to be carefully managed to focus on the key issues affecting SMP development.

A typical SMP team organization chart is shown in Figure 1. Note how the organization chart identifies the key client users who must represent key departments and guide the study to a result that will be acceptable to the overall client organization.

The SMP execution plan itself must be built on:

- a sound knowledge of the existing facility
- a clear and approved strategic vision for the site
- involvement of the key client representatives from every site department
- a clear and approved methodology for identifying and comparing different solutions

The overall steps also are illustrated in Figure 2. Essentially, the plan is executed in the following three phases:

- Phase 1 - Data Collection and Presentation
- Phase 2 - Development of Master Plan Options, Concept Identification Screening and Selection
- Phase 3 - Delivery of the Completed Plan

Phase 1 - Data Collection and Presentation (Current Operations)

The first phase of an SMP is devoted to data collection and analysis. This is a rather laborious, but vital, part of the study, as it provides the sound foundation for the development of the actual SMP.

Data should be collected from each site department, including key performance statistics such as:

- process utilization and equipment efficiency
- logistics, including current inventories and material flows
- GMP gap analysis
- utility capacity, utility demand (peak/average), reliability, and redundancy
- major site constraints, such as planning rules, environmental limits
- QC requirements and sample release statistics
- personnel flows and gowning issues
- site security and car park limits

Bear in mind that in this phase, the client team will be fully committed running the ongoing operation so the SMP team must target the information that it collects.

As a general rule - if the data in the SMP cannot be used,

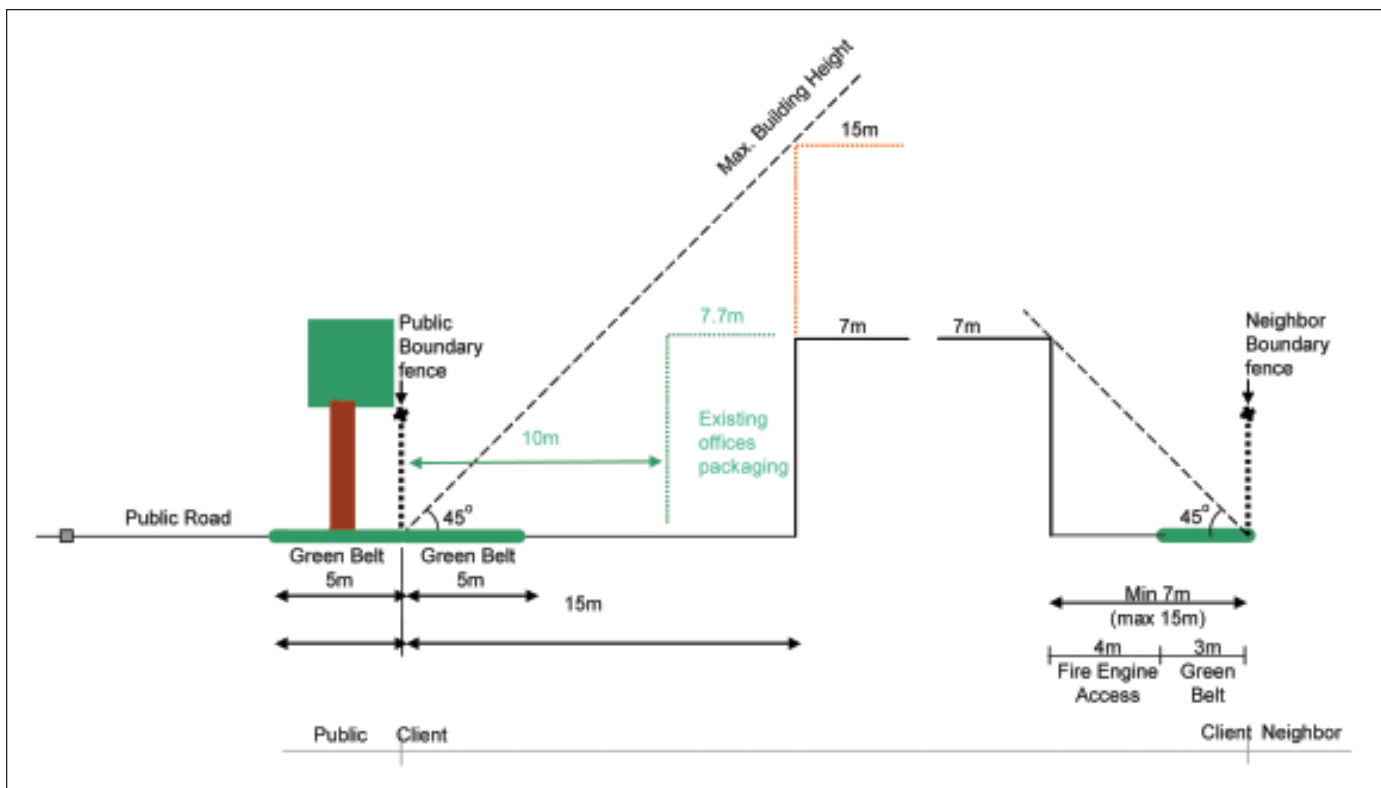


Figure 3. Typical presentation of boundary limitations.

then don't ask for it! For this reason, a set of generic data collection templates is invaluable to collect the information quickly and efficiently.

The best method of collecting the data is to plan a series of interviews with each individual department, and use the templates as the agenda for the meeting. In many cases, data will already be available in existing site reports and drawings, and this can be handed over to the consultant to extract the key data. It is not unusual that a follow-up meeting is required to collect more information on a specific topic that impacts on the SMP, but good preparation for the interview will ensure that this is infrequent. Clearly, during this phase, the consultant must be based at the site to be able to tour the

site and respond immediately to unavoidable changes in the client interview schedule.

Another key requirement for a successful SMP is the ability to present the data in a clear graphical manner so that all parties can assimilate the key issues. It is important to present the data to the client's team to gain confirmation of the key issues to be resolved in the SMP. Therefore, a 'presentation style' is essential with maximum use of illustrations and graphics.

The following examples may illustrate this approach:

Planning Rules

Planning setbacks and height restrictions can be shown in an illustration for easy reference - *Figure 3*.

Layout Issues and Constraints

Mark-ups of existing layout drawings can be used, not only to show the conventional issues such as materials and personnel flows, but also the location of significant issues such as:

- opportunities and constraints
- GMP compliance issues
- structural limitations, etc.

Production Issues and Efficiencies

When analyzing production departments, line performance must be presented in a simple graphical way. The following format proved useful on a recent SMP of a secondary pharmaceutical facility.

First, each line is coded to summarize its overall age and

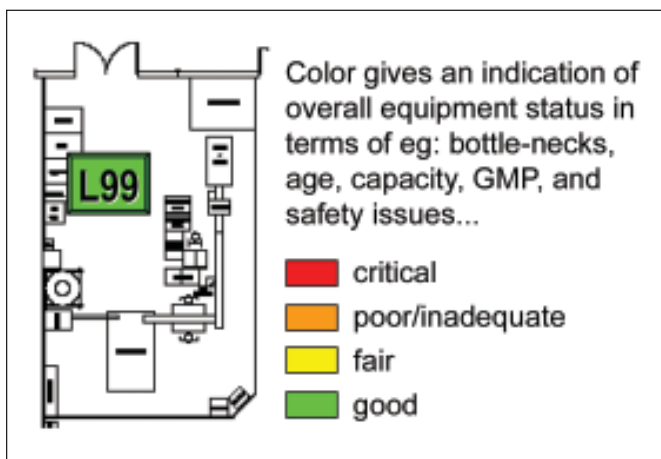


Figure 4. Example of a standard graphical format to show line performance.

Equipment Features	Line #	L99
	pharmaceutical form	
	production complexity	
	age	
2004 Performances	volume	
	measured efficiency	
	efficiency target	
2006 Forecast	volumes	
	utilization	

Table A. Example of a standard table format to show line operating parameters.

condition, based on the site records and a visual inspection, using a standard format - *Figure 4*.

The operating parameters of the line are then summarized in a standard table - *Table A*.

Using this format, the available spare capacity and efficiency improvements can be readily identified as a basis for future planning.

Site Potential

An existing site may offer limited potential for extending existing buildings in certain directions, due to structural or space constraints - *Figure 5*.

Site Flows

Material and personnel flows are often the first items to be compromised as a site develops. The existing flows are best shown superimposed on the site or building layout so that the cross flows or areas of intense flow can be identified - *Figure 6*.

Utility Status

The demand and capacity of each utility system can be represented graphically for easy reference.

Scheme Selection Criteria

At this point, it is important to recognize that the SMP team will identify many potential options for the site, and that a structured selection methodology must be agreed with the client. This normally requires the team to identify the key issues and sort them into:

- Key issues (must have) - issues that must be resolved by any scheme
- Preferred (nice to have) - issues which the site should aim to resolve as far as possible

One proven method of identifying critical issues to be addressed is to hold a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis where the site's future outlook can be categorized against the four parameters:

- Strengths - to be built on
- Weaknesses - to be addressed

- Opportunities - to be exploited
- Threats - to be mitigated

SWOT analysis is best prepared in a workshop environment where the consultant and client user groups are encouraged to think laterally regarding the issues affecting the site.

The SWOT analysis provides a very useful basis on which to judge the success of a scheme.

Finally, the plan needs to review the status of any ongoing projects on the site and categorize them into:

- approved projects - assumed complete
- unapproved projects - which may be modified by the outcome of the SMP

Phase 2A - Development of Master Plan Options

The data collected during Phase 1 describes the existing site situation, and provides the base reference for Site Master Planning.

Before any SMP concepts can be generated, it is necessary to convert the strategic site vision/mission statement into its technical implications. For example, increased production may require not only more efficient production, but possible new production lines, additional or modified storage, extra QC samples analysis, more canteen and car park spaces, etc.

It also is vitally important that the SMP provides real cost savings for the site. For this reason, the SMP must generate production efficiencies by, for example, increasing the utilization of the existing equipment, and eliminating wasteful activities.

Significant costs can be built into site operations from inefficient flow patterns, such as long distances between gowning areas and operating departments and multiple handling of materials. For this reason, it can be useful to generate a series of idealized relationship diagrams that will guide the study team toward the most effective arrangement of functions. Figures 7 and 8 illustrate two typical drawings.

At the end of the data collection phase, the SMP team will have all the basic reference material that they will need to generate and compare alternative SMP schemes.

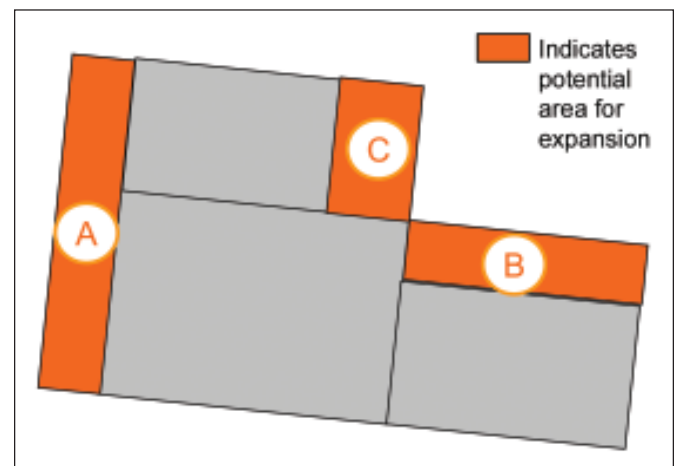


Figure 5. Sample diagram to show potential area for expansion.

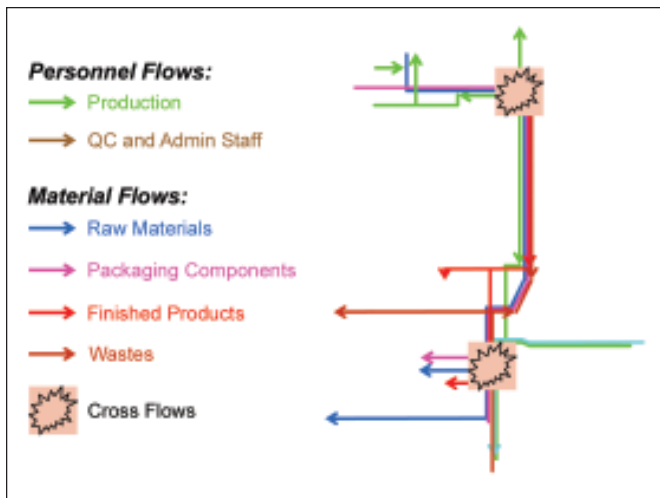


Figure 6. Existing flows shown superimposed on the site or building layout.

Phase 2B - Concept Identification Screening and Selection

During Phase 2, potential schemes are identified and screened with the intention that a single scheme will be selected at the end of Phase 2 for final development.

Generation of Alternate Schemes

Typically, the first activity is a brainstorming session when the team members identify all the potential alternatives. In the true tradition of brainstorming, no scheme is rejected at this stage unless it clearly fails to satisfy one or more of the 'must have' criteria, or fails to provide the basic functionality that is required.

A good way to involve all team members in a brainstorm session is to develop alternate layouts on a physical site plan; for an overall facility plan a 3D layout is very useful to show any significant topographical constraints.

Alternate facility layouts can then be developed using the following technique:

1. estimated footprints are calculated for all new buildings or departments
2. blocks (to scale) are created to represent these new footprints
3. alternative arrangements are created by locating the blocks on the layout and photographed for review and comparison against the success criteria

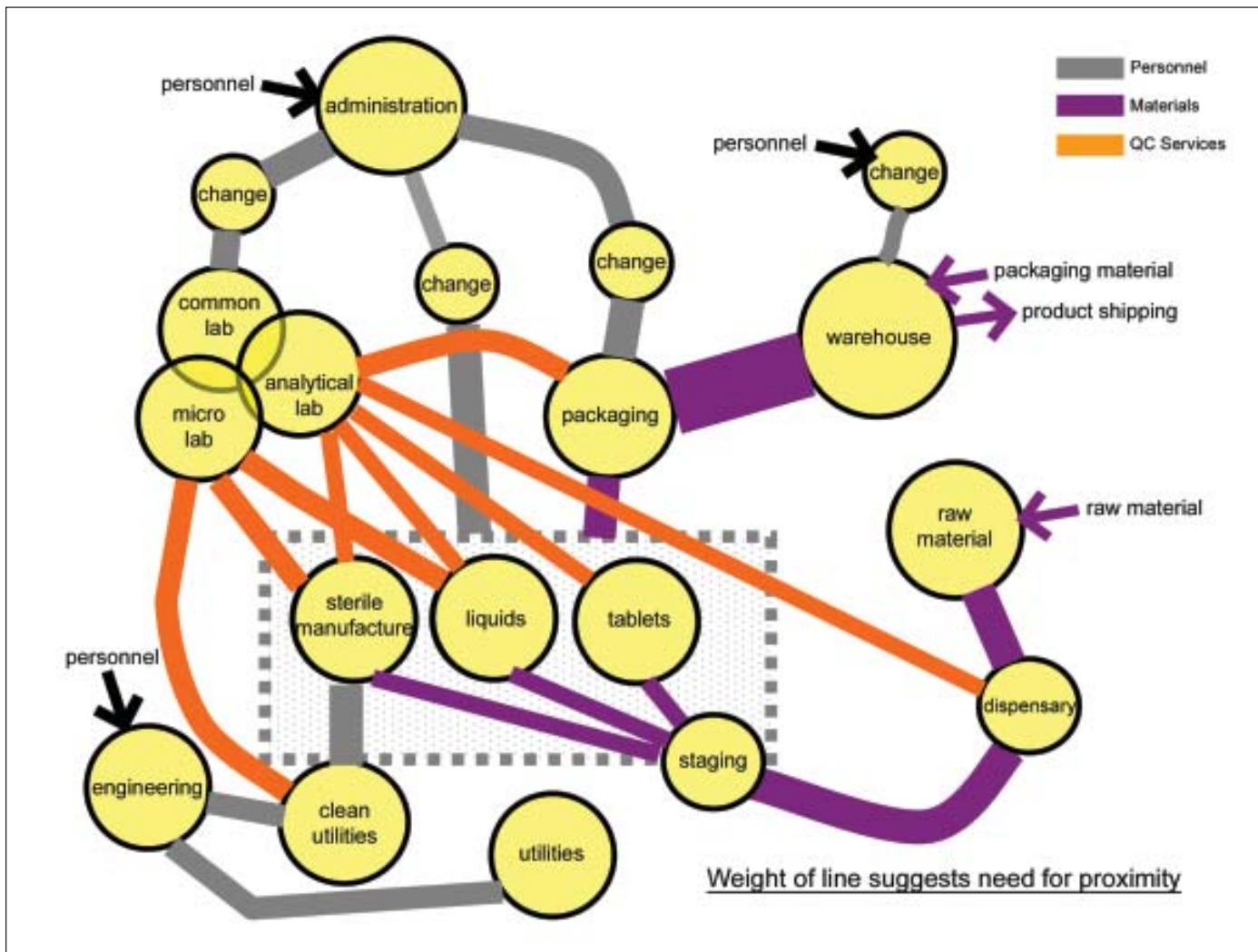


Figure 7. Overall site relationships diagram.

At this stage, it is quite acceptable and indeed preferable that the schemes are represented by simple blocks on the layouts. Typically, five to ten substantially different options would be generated.

Screening of Potential Schemes

The next step is to screen the preliminary options against the 'nice to have' criteria.

Some indication of comparative capital cost, operating efficiency, and schedule also are required at this stage to review the schemes.

There will undoubtedly be some individual features that appear in all the options, and these can be taken as 'fixed.' This will leave a number of open issues that require more detailed analysis before a final scheme can be agreed. For each open issue, it may be necessary to prepare one or more of the following supporting documents:

- dimensioned layout plans
- technology assessment
- materials and personnel flows
- block layouts of new or expanded departments
- projects listing and cost (+/- 30%)
- schedule and draft implementation plan

These open issues are then presented again to the site team in a workshop forum with an analysis and recommendation for client review and approval. At this point, it should be possible to select the SMP scheme.

Phase 3 – Delivery of the Completed Plan

As the concept for the SMP has now been established, the final phase comprises the development of the concept into final quality deliverables. This will include a project listing, identifying all the individual projects that together make up the whole plan, plus a level 1 schedule to show the overall links of the projects and the projected dates for achieving various milestones. Most schemes will include phasing that must be clearly and logically presented. Each project also should typically be costed to an accuracy of +/- 30%.

The impact of development on utility systems is best represented as a series of charts showing the future predicted demands and the trigger points for future capacity increases - *Figure 9*.

The final SMP report must be a high quality document, suitable for presentation at the highest management level, including presentation style drawings to demonstrate:

- overall site plan
- production building floor plans
- personnel and material flow diagrams
- staged implementation drawings
- 3D CAD architectural impression of the site development

- *Figure 10*

How Long Does a Master Plan Take?

There is no standard schedule for the completion of an SMP,

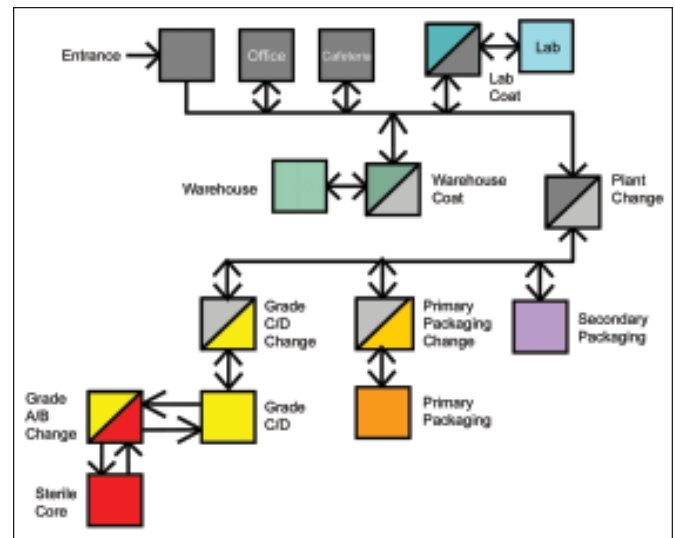


Figure 8. Ideal change regime.

as the duration will be influenced by both the extent and complexity of the SMP and also the availability of key client resource to participate in the key workshops and presentations. What is important is that the key steps in the SMP must be followed in a logical, sequential manner, and that a reasonable schedule is agreed in advance. Once the dates for key management reviews have been fixed, these will be difficult if not impossible to reschedule once the SMP has started.

Durations of between six weeks and six months are quite possible, but a reasonable starting point for a SMP is a three

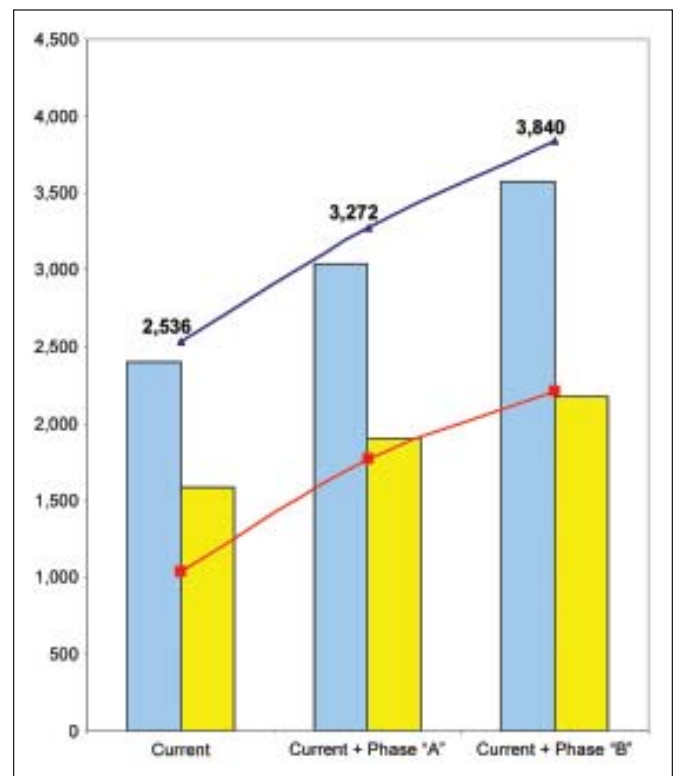


Figure 9. Chart example to show future predicted demands and trigger points for future capacity increases.



Figure 10. 3D CAD architectural impression of the site development.

to four month duration split equally between the three phases - *Figure 11*.

Experience (It's Not Rocket Science, But...)

It is often said that, "Master planning isn't rocket science," and this is certainly true.

What it takes, most of all, is a sound knowledge of issues affecting pharmaceutical research and manufacture, an interest and ability to analyze information and extract the key issues, and the desire to listen to opinions and facilitate the 'best overall' scheme.

This article concludes with the following 'top ten' issues that appear regularly in master plans:

1. the need to improve operating efficiency and reduce cost of goods
2. poor material and personnel flows
3. excessive inventory of materials stored on site
4. the need to plan future expansion and replacement of ageing assets without disrupting ongoing operations

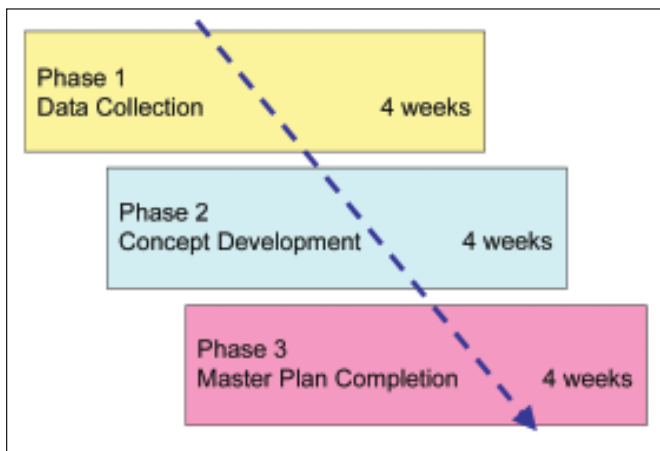


Figure 11. Typical master plan duration.

5. GMP compliance issues
6. space for expanding QC activities and archives
7. lack of suitable space for meeting rooms and training
8. eating and rest rooms within the 'pharmaceutical zone'
9. environmental impact, for example, boundary setbacks, on-site waste water treatment, and solid waste collection/disposal
10. site security and insufficient car parking spaces

About the Author



Richard G. Larkin, MA, FIChemE, is Principal Consultant and Co-founder in 1987 of the Pharmaceutical Division of Foster Wheeler, the international engineering, procurement, and construction contractor based in Reading, UK. In this role, he has provided pharmaceutical engineering design and consultancy to many of the world's leading pharmaceutical companies, including Pfizer, Glaxo SmithKline, Sanofi-Synthelabo, and Eli Lilly. He has personally developed the site master planning expertise for Foster Wheeler, and regularly manages site master plans for pharmaceutical clients. Larkin has been an active member of ISPE for more than 15 years. A member of the South-East UK Chapter, he has presented papers on containment and engineering topics at ISPE seminars and led the Pharmaceutical Innovations course for ISPE in 2002 in Birmingham, UK. He can be reached at e-mail: richard_larkin@fwuk.fwc.com.

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